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Doing Science Their Way

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DOING SCIENCE THEIR WAY:
AN ETHNOGRAPHIC STUDY OF SIXTH GRADE GIRLS' ENGAGEMENT WITH SCHOOL SCIENCE

By

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ABSTRACT

As national attention is focused on science education, it is important to understand the experiences of girls. The under representation of girls in science, technology, engineering, and mathematics and current achievement and performance gaps indicate that gender is an important category of analysis. From the perspective of social cultural anthropology employing the field research techniques of ethnography this study focuses on the experiences and perspectives of 6^{th} grade girls in a moderately-sized East Coast city as they construct meaning through active engagement in a science classroom. Active engagement is defined as participation and interaction during group activities. The study analyzes the ways in which girls change roles and incorporate social interaction during science activities to create their own unique engagement in science.

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CHAPTER 1

INTRODUCTION

Historical Overview

In the late 1980s, support for educational standards at federal and state levels influenced many reform efforts in the United States. Educational standards in core academic subjects became a way to specify levels of content knowledge and the process or performance skills that are necessary for students to master. In science education, supporters of educational standards believed attainment of specified levels of mastery would lead to scientific literacy (Dowson, McInerney, & Van Ettten, 2007).

According to the American Association for the Advancement of Science (AAAS), science literacy includes the knowledge, skills, attitudes, understanding, and habits of mind Americans need to function in U.S. society. In 1985 the AAAS developed *Project 2061*, a long-term initiative advocating changes in the American educational system to promote scientific literacy for all Americans. The three phases of this initiative focus on 1) the establishment of a conceptual base for reform, 2) the development of action plans, and 3) the implementation of these plans into educational practice (AAAS, 1994).

The publication of the book, *Science for All Americans*, at the end of Phase I of Project 2061 in 1989, represented a multi-disciplinary collaboration involving input from scientists, mathematicians, engineers, physicians, philosophers, historians, and educators to addresses the issue of scientific literacy as the conceptual base for reform. One of the defining features of this report is the belief that scientific literacy is important for all Americans (AAAS, 1990). *Science for All Americans* further describes the person who attains scientific literacy as:

> One who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes (AAAS, 1990, p. xvii).

The prescribed recommendations in *Science for All Americans* apply to all students, "regardless of their social circumstances and career aspirations" (AAAS, 1990, p. xviii), and especially "to those who in the past have largely been bypassed in science and mathematics education: ethnic language minorities and girls" (AAAS, 1990, p. xviii). Additionally they write,

> Race, language, sex, or economic circumstances must no longer be permitted to be factors in determining who does or who does not receive a good education in science, mathematics, and technology. To neglect the science education of any (as has happened too often to girls and minority students) is to deprive them of a basic education, handicap them for life, and deprive the nation of talented workers and informed citizens – a loss the nation can ill afford (AAAS, 1990, p. 214).

Science literacy for all citizens in a society that is greatly impacted by science and technology is significant. Science literacy allows people to make informed decisions about global and local problems through an understanding of the interconnectedness and implications of technological, cultural, and social developments. Regardless of career choice citizens need to be able to assess differing perspectives based on evidence, cost-benefit-risk assessments, and other scientific habits of mind in the face of increasingly complex problems and solutions (AAAS, 1990, xiii-xiv).

Benchmarks for Science Literacy developed from Project 2061. Published in 1993, *Benchmarks for Science Literacy* represents another guide to assist schools and teachers with science education. *Benchmarks* acknowledged that to reach all students, the basic curriculum, teaching practices, and other parts of the school system would need to be changed (AAAS, 1993).

In 1995 the National Research Council (NRC) published the *National Science Education Standards* (NSES) with the goal of "encouraging policies that will bring coordination, consistency, and coherence to the improvement of science education" (NRC, 1996, p. 12). In a Call to Action at the beginning of the NSES, Bruce Alberts, then President of the National Academy of Sciences, and Richard Klausner, Chairman of the National Committee on Science Education Standards and Assessment, reiterated the importance of scientific literacy for individuals and the society as a whole. They emphasized the value of scientific knowledge and understanding as a precursor to participation in critical national and international discussions. They stressed the importance of having a strong foundation in scientific processes such as critical thinking, creative problem-solving, and cooperative teamwork to address both small- and large-scale issues (NRC, 1996).

The framers of the NSES included a vision of equity that had been advocated previously in *Science for All Americans*:

> The intent of the *Standards* can be expressed in a single phrase: Science standards for all students. The phrase embodies both excellence and equity. The *Standards* apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science. . . . all students can develop the knowledge and skills described in the *Standards*, . . ." (NRC, 1996, p. 2).

The NSES based standards on the premise that "all students can achieve understanding of science if they are given the opportunity" (NRC, 1996, p. 20). Inclusion of diversity and equity issues can be found in components of all the NSES. Among these are the Teaching Standards that require teachers to "recognize and respond to student diversity" [Teaching Standard B] (NRC, 1996, p. 32) and to "display and demand respect for the diverse ideas, skills, and experiences of all students" [Teaching Standard E] (NRC, 1996, p. 46). The Assessment Standards required assessment practices to "be reviewed for the use of stereotypes, for assumptions that reflect the perspectives or experiences of a particular group . . .," and to be "set in a variety of contexts, be engaging to students with different interests and experiences, and must not assume the perspective or experience of a particular gender, racial, or ethnic group" [Assessment Standard D] (NRC, 1996, p. 85). The Program Standards required "all students [to] have equitable access to opportunities to achieve" [Program Standard E](NRC, 1996, p. 221) and the System Standards required equitable science education policies [System Standard E] (NRC, 1996, p. 232). The Standards also advocated the distribution of resources so that disadvantaged students are given the same opportunities to learn as advantaged students (NRC, 1996).

Advocates have always maintained that the implementation of academic standards benefits all diverse groups within the educational system (Dowson et al., 2007). They point to the emphasis on equity, which highlights the importance that is placed on decreasing existing achievement gaps among diverse student groups categorized by ethnicity, race, gender, language, exceptionality, and socioeconomic levels, and which focuses attention on the underrepresentation of diverse groups in science, technology, engineering, and math careers.

Despite the emphasis on equity as a defining principle, many scholars have challenged reform efforts such as the National Science Education Standards and Project 2061 as not directly addressing the issues confronting diverse students in the classroom. They question whether the Standards fulfill the promise of science for all Americans. Rodriguez (1997) acknowledges the well-intended goals of the standards but faults the National Research Council for not strongly addressing the ethnic, socioeconomic, and gender differences that encompass successful reform. His review of the standards finds that although traditionally marginalized groups are well-represented in the document's photographs, ethnic minorities and females are, in his words, "made invisible within the text of the Standards" (Rodriguez, 2003, p. 23). According to Rodriguez (2003) the use of ambiguous language when referencing equity issues leads to the failure of the standards to identify the historical, institutional, and social reasons for the importance of equity. The lack of context serves to provide guidelines without a "road map for education reform" (p. 23). Rodriguez (2003) asserts that by not acknowledging the actual challenges teachers face in teaching for diversity, the NSES make it difficult for any transformative action to occur in science classrooms.

Eisenhart et al. (1996) commend the inclusive vision articulated by Project 2061 and the National Science Education Standards. However, they view the implementation guidelines as too narrowly focused and agree with Rodriguez (2003) that widespread interest and access to science will not occur if obstacles to teaching diverse students are not addressed. They view the approach taken by the AAAS and NRC as too narrowly focused and conservative in nature that only addresses equal opportunities and equal access for underrepresented groups as a form of compensatory strategy. Eisnehart et al. write, "Compensatory strategies treat disadvantaged persons according to their special needs but they do so in a way that requires the disadvantaged to measure up to a standard already set by the advantaged group" (Eisenhart et al, 1996, p. 274). The Standards' emphasis on key concepts and conventional practice limits the effectiveness of attracting or retaining underrepresented groups (Eisenhart et al., 1996).

Lee (1999) defines what she sees as an "assimilationist perspective" in the NSES and Project 2061, which views science as universal knowledge and bases educational reform on providing students with equal access to educational opportunities in the classroom. This perspective suggests that providing equal educational opportunities to students from diverse backgrounds allows them to learn the accepted scientific way of knowing, thereby becoming members of the existing scientific community. Lee (1999) argues that true equity goes beyond equality and strives to equitably distribute social goods, such as rights and access to knowledge for all students, including traditionally marginalized groups. She believes the assimilationist perspective does not promote equity, because it does not value alternate ways of knowing based on students' language, culture, gender, and socioeconomic background (Lee, 1999). Barton (1997) writes, "Students of science quickly learn that if the prescribed ways of engaging in science do not make sense, feel right, or connect to their experiences, then they are the ones who are wrong or intellectually deficient" (p. 147). This understanding may lead to avoidance and resistance to science (Barton, 1997).

Dowson et al (2007) argue that teachers and administrators have limited professional development for assisting all students to meet academic standards through the development of new curricula and instructional practices. By not providing what Rodriguez (2003) refers to as a roadmap for teachers, the establishment of the standards will have limited effect on students.

The implementation of science standards in schools emphasizes the importance placed on scientific literacy for all students as future citizens. The NRC's identification of excellence and equity in the NSES extends to several groups whose science education has been neglected in the past such as ethnic/racial minorities and girls. Many scholars (Eisenhart et al., 1996; Lee, 1999; Rodriguez, 1997, 2003) criticize the NSES for not directly addressing diversity in the classroom. However, the acknowledgement of diversity in the NSES indicates the belief in the importance of a quality science education for all students. Gender remains important when examining the implementation of standards and science education. Research into the experiences of girls as they engage in science is significant to understand the ways they approach science in classroom contexts. Research of this nature helps to inform teacher awareness, knowledge, and understanding of the dynamics that underlie girls' interest and participation in science.

Research Problem

As departments of education use the National Science Education Standards to guide academic content and instruction, it is important to understand how girls participate in school science. The term "girls" is used in this study to describe early adolescents because this is the expression the participants used to self-identify. In this study, the girls are viewed as sharing what Fine (1979) calls an "ideoculture." He writes,

> Ideoculture consists of a system of knowledge, beliefs, behaviors, and customs shared by members of an interacting group to which members can refer and employ as the basis of further interaction. Members recognize that they share experiences in common and these experiences can be referred to with the expectation that they will be understood by other members, and further can be employed to construct a social reality. The term, stressing the localized nature of culture, implies that it need not be

part of a demographically distinct subgroup, but rather that it is a particularistic development of any group in the society (p. 734).

In this view, culture has permeable boundaries and multiple influences. Unlike conventional and traditional perspectives, where culture is identified as relatively enduring, internally coherent, clearly bounded, and uniformly meaningful, group settings, such as schools, allow a group of girls to come together within the context of a classroom to act and make sense of their world in certain ways that are connected to the specific situation of learning to do science (Eisenhart, 2001). This localized interpretation of culture allows the experiences of girls engaged in activities in a science classroom to be examined.

This study focuses on the experiences and perspectives of 6th grade girls as they construct meaning in a science classroom through active engagement defined as participation and interaction during science group activities. Activities are defined in this study as the self-initiated tasks students engage in as they explore a scientific topic in a teacher-guided classroom environment. These activities include asking questions, developing procedures to carry out experiments, making observations, taking notes, recording data, making diagrams, analyzing findings, drawing conclusions, and sharing information.

The questions that guide this research include:

- How do girls engage in science at school?
- What do girls reveal about themselves when engaged in the act of doing school science?

Participants include 10 girls participating in group work in one of two 6th grade classes at City Charter, an urban charter school emphasizing a strong curriculum in math, science, and technology and located in a medium-sized city in the Northeast. The school includes kindergarten through the 12th grade organized into elementary, middle, and high school. The 6th grade class consists of 12 girls and 12 boys, mostly divided between two main demographic groups – Hispanic and African-American. With the exception of a group of three girls who always worked together, the other groups were more fluid, with girls working with different girls during the course of the academic year.

Data collection occurred two times a week during science class from September 2009 to June 2010. Fieldwork techniques included participant observation with field notes that served as the primary data source. Individual and group interviews were also conducted. Digital audio recordings captured group work and all interviews.

Until the 2009-2010 academic year, 6th grade at City Charter was included in the middle school. In a cost-cutting measure at the end of the 2008-2009 year, the 6th grade was moved into the elementary school. Instead of changing classes for different subjects, the 6th graders would follow the same single teacher model of the elementary school.

This research was planned as a study of 6th grade students in a middle school that followed different groups of girls in more than one class. In middle school, teachers usually conduct classes in one content area of their specialization. Instead of one 6th grade class, Ms. Julie Brooke, whose 6th grade students are the participants in this study would have had several different science classes of 6^{th} graders. The impact of this change on both the teacher and the students affected this study.

As a middle school teacher, Julie was attuned to the flexibility and rhythms of middle school scheduling. Being placed back into an elementary school setting without sufficient preparation time for the change disrupted her teaching of science since she now had to deal with the preparation, teaching, and testing for all academic content areas of the curriculum (Interview, June 21, 2010).

The change also affected the students. The 6^{th} grade girls expected to be moving into the middle school of City Charter. At the end of 5^{th} grade, many girls realized the change was not going to occur. Reactions varied. Some expressed disappointment even when asked almost a year later about their feelings about 6^{th} grade staying part of elementary school. Melanie reminisced,

> I was mad . . . because I wanted to switch classes cause like 6th grade, the whole thought of 6^{th} grade is like 'OHHHHH . . . middle school, you switch classes, you have a lot of teachers, you see different people, and it's like, you feel like, not mature, but like you have that feeling that you're older already because you feel like almost in high school – I switch classes already and like . . . it's just I think I was mad. I was really frustrated cause I was like looking forward to switching classes and stuff and spending time with different kinds of friends, but now I'm stuck in the same class with the same people, same teacher, same things . . . (Interview, June 15, 2010).

Similarly, Tyrah voiced her excitement at the anticipated freedom, “It would be fun because we’d never got to switch classes before so everyone got excited” (Interview June 15, 2010). Clarissa didn’t “like staying in one class all day” (Interview, June 15, 2010), and Jenna remembered being “mad, heated . . . It’s terrible because we got to stay in these seats all day” (Interview, June 15, 2010). Only Gabriella expressed relief at not being part of the middle school. She felt she needed another year to prepare for the hectic, multiple classroom schedule (Interview, June 15, 2010).

The decision to continue the study using only girls in one class was based on several factors. First, Julie’s strong focus on science as discovery and her emphasis on self-contained group work provided a context for science learning. Her awareness of gender differences created a supportive atmosphere for girls in the classroom. Second, studying girls in one class meant all girls experienced the same social and educational environment in the classroom, that is, their relationships, interaction, and socialization occurred within a self-contained area.

Overview of Subsequent Chapters

The focus of this study is on the interaction that takes place among girls when they are engaged in school science, not the science activities themselves. This study examines how girls do participate in science. It does not seek to measure science learning or achievement. Chapter Two describes the theoretical perspective the research follows in the study of group work in science classrooms. Chapter Two presents an overview of previous research on girls and science education, as well as the effects of early adolescence on girls and the rise of the middle school as a way to meet the needs of the girls' developmental stage. Chapter Three details the research setting and participants and provides a description of the ethnographic methods used in the data collection and data analysis phases of this study. Chapter Four describes and discusses the girls' interaction with each other as they engaged in each group science activities. Chapter Five discusses the implications of the study as it relates to science education and engagement of girls in classroom groups and activities.

CHAPTER 2

REVIEW OF LITERATURE

Theoretical Perspective

Progressive Educational Ideology

Fetterman (1998) writes, “Theory is a guide to practice; . . . the researcher’s theoretical approach helps define the problem and how to tackle it” (p. 5). Educational ideology and learning theory are significant to consider, because theoretical models guide assumptions about knowledge, education, teaching, and learning.

Dewey’s (1938, 1944) approach to education and his views on the continuity of experience form a theoretical perspective for this study. Dewey’s stance on education reflected the progressive ideas of the late nineteenth and early twentieth centuries. Proponents of progressive education criticized the “one size fits all” model of instruction and advocated for a change in the nature of education. According to Cremin (1964) progressive education has no clear-cut definition. He writes, “None exists, and none ever will; for throughout its history progressive education meant different things to different people, and these differences were only compounded by the remarkable diversity of American education” (Preface, p. x).

To Dewey (1944) “education is a constant reconstruction or reorganization of experience which adds to the meaning of experience” (p. 76). Experience to

Dewey is not static but a moving process that links the past to the present to the future. The dynamic union of past experiences and present activity constantly reshapes, reconstructs, and reorganizes the meaning of experiences so that new possibilities and future directions of subsequent experiences are developed (Garforth, 1966). Dewey (1938) writes, "From this point of view, the principle of continuity of experience means that every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after" (p. 35).

Dewey defines the concept of interaction in experience. According to Dewey (1938), internal and external conditions continually interact during the process of experiencing. Rather than occurring solely within an individual's body and mind, "[a]n experience is always what it is because of a transaction taking place between an individual and what, at the time, constitutes his environment, . . . whatever conditions interact with personal needs, desires, purposes, and capacities to create the experience which is had" (Dewey, 1938, pp. 43-44).

Dewey's view of education places value on the individual's experiences. Gender was not directly addressed by Dewey at the time. However, in this research, value is placed on the experiences girls bring to the science classroom. Girls come to school with their own unique needs, capabilities, and personal stories shaped by specific gender experiences. The experiences girls bring impact the way they do school science and also affect the ways they interact within the science classroom.

Dewey (1938) believed school should contribute to the intellectual and moral growth of a student by creating conditions that lead to curiosity, initiative, and future growth in new directions. It is the role of the teacher to evaluate the experiences of a student, understand the direction they are moving, and organize the external conditions to create opportunities for growth based on these experiences.

School can either sustain or frustrate growth. Dewey (1938) criticized education that placed sole blame on the student who failed to learn in the prescribed manner. He writes,

> No question was raised as to whether the trouble might not lie in the subject-matter or in the way in which it was offered. The principle of interaction makes it clear that failure of adaptability of material to needs and capacities of individuals may cause an experience to be non-educative quite as much as failure of an individual to adapt himself to the material (pp. 46-47).

This research examines how the distinctive experiences girls bring to school affect their engagement in school science and influence their participation in group activities.

School, according to Dewey, is also a social environment where students interact and associate with each other in the process of learning. The teacher, who also participates in the school environment, uses his/her wisdom of experience to set up the conditions that encourage and strengthen certain student actions through expectations, demands, approvals, and condemnations. But the school cannot be isolated from those experiences students bring from home and the neighborhood (Dewey, 1938, 1944; Garforth, 1966). The personal experiences and needs of girls do not disappear when they enter the classroom. Dewey believed teachers should engage learners by using student interests to guide the subject matter and promote exploration by encouraging students to find answers to their own questions. In this way, students acquire a deeper understanding of the subject matter and stronger thinking skills (Kohn, 1998).

Dewey (1944) believed schools should develop a child's ability to think. According to Dewey, the development of thinking involves five stages. The first stage, *problem* or *situation*, refers to an actual predicament where the child tries to do something in a trial and error capacity. Dewey (1944) writes:

> An individual must actually try . . . to do something with material . . . , and then note the interaction of his energy and that of the material employed. This is what happens when a child at first begins to build with blocks, and it is equally what happens when a scientific man in his laboratory begins to experiment with unfamiliar objects (p. 154).

The child learns through the process of doing something because the situation demands thinking; the kind of thinking which leads to a perceptible result and connected to the actions taken. Dewey (1944) further explains that experience leads to learning when a problem has developed from a child's situation or personal experience.

The second stage, *data*, refers to the information or resources students need to work out the specific problem at hand. The teacher's role consists of presenting a new problem that challenges students' thoughts without overwhelming or discouraging them. Students must see connections with familiar observations, readings, or former experiences. In other words, students use their own personal experiences as well as the experiences of others to work out the problem. They select what is appropriate (Dewey, 1944).

The third stage in the development of thinking involves suggestions, inferences, preliminary explanations, or *ideas*. These ideas predict future results. Ideas illuminate the creativity of the student. This inventiveness evolves from putting the familiar in a new context when working through the problem.

The fourth and fifth stages, *solutions* and *applications*, refer to the final stages of the development of thinking. Solutions, an intermediate step in learning, represent proposed consequences that direct further observations, procedures, and experiments. Applications refer to a student's opportunity to test his/her ideas by acting on those same ideas. The ability to think expands as the student interacts with the environment in an attempt to secure the validity of his/her solutions (Dewey, 1944).

Dewey (1956) emphasized problem-solving in education that would begin with the experiences of the learners. He believed the child's experience and the subject-matter known as the curriculum were not in direct opposition to one another. He disagreed with extreme positions that stated either, "The child is the starting-point, the center, and the end" (p. 9) or "Subject-matter furnishes the end and it determines method" (p. 8). Rather, he viewed both positions as related to one another in the process of education and explained the interaction between the two as continuous reconstruction and adjustment. Dewey (1956):

> Abandon the notion of subject-matter as something fixed and ready-made in itself, outside the child's experience; cease thinking of the child's experience as also something hard and fast; see it as something fluent, embryonic, vital; and we realize that the child and the curriculum are simply two limits which define a single process (p. 11).

Dewey emphasized the importance of placing students' experiences at the core of learning while creating conditions to encourage intellectual and moral growth. Students do not learn in isolation; rather, they are members of a community of learners who help each other construct meaning (Oxford, 1997). Understanding the relationship between girls' experiences and their interaction with school science better enables educators to create conditions that promote engagement, participation, and learning in the classroom.

Developmental Theory

Since Dewey, progressive education has been influenced by a developmental model of learning. Developmental theory with its assumptions about education and learning informs this study. Departing somewhat from Dewey's insistence on individual-environment interaction, Darling-Hammond and Snyder (1992) write, "The developmentalist looks primarily within the organism for an explanation of how and why it learns, . . ." (p. 49). Nonetheless, they echo Dewey when they write, construction of knowledge happens as children adapt to their physical and social environment (Darling-Hammond & Snyder, 1992).

According to Darling-Hammond and Snyder (1992), Piaget is one of the most influential contributors to the developmental perspective among others. Piaget described the process of learning as connecting one's mental constructs or conceptual structures with one's experience in the physical and social environment. Knowledge is not an accurate representation of reality but rather results from an interpretive and adaptive process that the learner constructs. Developmentalists identify learners as actively participating in the construction of knowledge (Darling-Hammond & Snyder, 1992; von Glasersfeld, 1996). The individual learner organizes and develops structures that reorganize earlier concepts and perspectives (Fosnot, 1996), what Dewey called the reconstruction of experience.

Piaget's theory of cognitive development describes development from birth to adulthood as a series of discrete, sequential stages with characteristic types of cognitive processes at each stage. Each stage builds on the previous stage. In the first stage, *sensorimotor*, a child (birth to approximately two years of age) lacks the ability to form concepts so the world is defined by primarily by perceptions and manipulations. In the second stage, *preoperational*, the child (approximately two to seven years) uses actions, images, and words to identify and represent objects and events but perceptions still dominate. The third stage consists of *concrete operational* reasoning and occurs between the ages of seven to twelve years. An individual moves past perceptions and begins to deal with objects and events on a conceptual basis. Categories, spatial relationship, and classifications become mental constructions that can be used to process content. The fourth stage which occurs from the age of approximately twelve years and older includes *formal* *operational* reasoning and involves abstract thinking. Individuals use mental structures to process information (Garry & Kingsley, 1970; Wavering, 1995).

According to Piaget, a learner actively adapts to the social and physical environment through assimilation and accommodation. Assimilation occurs when an individual organizes new experiences according to his/her existing cognitive structures. Accommodation occurs when new experiences cannot be assimilated into existing cognitive structures so new possibilities are explored leading to the construction of new patterns. Reflection on these patterns results in accommodation (Fosnot, 1996; Wavering, 1995).

Most of Piaget's work focused on cognitive development in individuals. However, he also noted the importance of social interaction on learning (Fosnot, 1996). Vygotsky, on the other hand, approached learning primarily through the belief that ideas are constructed through communication with others (Oxford, 1997). Although children's learning begins early in life, Vygotsky (1978) believed "school learning introduces something fundamentally new into the child's development" (p. 85). School learning encourages intellectual processes. The teacher, as well as, peers guide and provide assistance that helps students to learn by extending and challenging the learner's initial conception through refocusing and redirection to new ideas (Fosnot, 1996; Oxford, 1997).

Vygotsky uses the concept of the Zone of Proximal Development (ZPD) to describe the area of potential learning that learners can reach with the guidance of more knowledgeable others (Fosnot, 1996; Oxford, 1997). Vygotsky (1978) defines ZPD as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). The ZPD is a form of learning through social interaction since it occurs through negotiation between the learner and teacher and/or other fellow students (Oxford, 1997).

The work of Piaget and Vygotsky contribute to the foundation for constructivism, that is, a theory of knowledge and learning. Although a distinction between cognitive and social constructivist perspectives is made, cognitive and social constructivism in this study are seen to complement one another. Cobb (1996) writes, "Each of the two perspectives, . . . tell half of a good story . . . learning is both a process of self-organization [cognitive] and a process of enculturation [social] that occurs while participating in cultural practices, frequently while interacting with others" (p. 45).

Learners in an environment affect each other. In this way, rather than fixed ideas and immutable concepts, each learner adopts and assimilates ideas and concepts in different ways and on different occasions (Hashway, 1998; von Glasersfeld, 1996). In other words, shared meaning and shared knowledge are relative terms. von Glasersfeld (1996) writes,

> The conceptual structures that constitute meanings or knowledge are not entities that could be used alternatively by different individuals. They are constructs that each user has to build up for him- or herself. And because they are individual constructs, one can never say whether or not two people have produced the same construct. At best one may observe that in a given

number of situations their constructs seem to function in the same way, that is, they seem compatible (p. 5).

Cobb (1996) believes taking into consideration the cognitive and social constructivist perspectives when research is conducted in the classroom. From this perspective, researchers locate individual learners in the social setting thus better enabling the researchers to make sense of the dynamics of the classroom.

Developmental theory emphasizes a learner's background, interests, and past experiences as factors in the construction of knowledge. In this study the issue of gender-influenced classroom experiences must be addressed since the learners are girls.

Gender Perspective

There is no one particular feminist theory addressing girls and their experience in schools. *Socialization* theorists point to the inferior educational experiences in families, schools, and communities that girls receive. Thompson (2003) writes, "Treat girls as rational and capable individuals, socialization theorists argue, and girls will prove themselves just as smart, independent, confident, and creative as boys" (p. 22). Socialization theorists emphasize gender neutral classrooms where boys and girls have the same educational opportunities and experiences. The influences of gender, race, or class on learning are usually not considered (Thompson, 2003).

Gender difference theorists criticize the idea of a gender neutral social order as one that forces girls to adopt male perceptions of success based on male experiences. They prefer a classroom that promotes different ways of knowing and learning for girls based on their experiences (Rosser, 1997). Relational values traditionally associated with women and rationalistic values traditionally associated with men should be equally valued. Education should not be modeled on what has been successful for boys. Education should be sensitive to the gender of the student. (Thompson 2003).

Other gender difference theorists, such as Belenky, Clinchy, Goldberger, and Tarule (1997) and Gilligan (1993), value characteristics and qualities traditionally associated with women that heighten women's place in the order of things (Bohan, 1997). Gilligan (1993) questions the focus on male experiences. She writes,

> [T]here is a tendency to construct a single scale of measurement, that scale has generally been derived from and standardized on the basis of men's interpretations of research data drawn predominantly or exclusively from studies of males, psychologists have tended to regard male behaviors as the 'norm' and female behavior as some kind of 'deviation' from that norm" (p. 14).

Gilligan (1993) stresses the importance of including women's voices when speaking about human lives. This study examines girls' experiences in a science classroom and brings their voices front and center.

Belenky et al. (1997) describe five "epistemological perspectives from which women know and view the world" (p. 15). The first, *silence*, refers to the experience of being voiceless, passive, and listening to an all-powerful authority. One of the women interviewed for the study states, "I had trouble talking. If I tried to explain something and someone told me that it was wrong, I'd burst into tears over it. I'd just fall apart" (Belenky et al., 1997, p. 23).

The second perspective is *received knowledge.* Knowledge is understood in polarities. Women receive and reproduce knowledge, but do not create knowledge. Knowledge comes from an external authority with whom they do not identify. The focus of learners in this perspective is listening (Hofer & Pintrich, 1997). Belenky et al. (1997) write, "women who rely on received knowledge think of words as central to the knowing process. They learn by listening. . . . these women feel confident about their ability to absorb and to store the truth received from others" (p. 42-43).

The third perspective is *subjective knowledge*. At this stage, women view knowledge as personal and subjectively known (Belenky et al., 1997). Belensky et al. (1997) writes, "Truth, for subjective knowers, is an intuitive reaction – something experienced not thought out, something felt rather than actively pursued or constructed" (p. 69).

The fourth way of knowing, *procedural knowledge*, requires the application of objective systematic procedures of analysis for knowledge. The emergence of a woman's inner voice leads to self-assertion and self-definition. Belenky et al. (1997) refer to women "beginning to hear themselves think" (p. 85). One of the woman interviewed for the study succinctly stated, "Right now I'm busy being born" (Belenky et al., 1997, p. 76).

The fifth and final perspective identified by Belenky et al. (1997) is *constructed knowledge.* In this stage, women view knowledge as contextual. They also view themselves as an integral part of knowledge construction. Belenky et al. (1997) call this "reasoned reflection."

The work of Belenky et al. (1997) included adult women at the theory-building stage and brought to the forefront women's attributes, values, and ways of knowing. Critics of gender difference theory point to several issues. Structural theorists who focus on power and privilege as sanctioned by laws, standards, practices, and institutions stress that not all women share the same interests and that models of gender difference do not acknowledge the diverse situations of women. Critics suggest that gender difference theory not only universalizes women's experiences but identify experiences that are "natural" to women (Thompson, 2003). Bohan (1997) writes, "The experiences attributed to women, portrayed as contributing to their 'nature,' are not timeless and universal but are socially, historically, and politically located; . . . To presume that all women judge, think, or relate, in a characteristic and universal manner denies the contextuality . . ." (p. 34). Supporters maintain that there is no connection between gender difference theories and assumptions about women's biological nature. Thompson (2003) writes, "The point, in other words, is not to defend 'feminine' values as intrinsically female but to recognize the importance of values that have been ignored or disparaged *because* they are associated with women" (p. 26).

There is a need to understand how girls engage in science when participating in a single-gender groups with limited oversight or direct intervention by the classroom teacher. The purpose of this study is to examine the ways one group of 6th grade girls engage, participate, and interact when doing science activities in a particular classroom setting.

Girls come to the classroom setting as individuals with their own unique needs, capabilities, and personal stories shaped by specific life experiences. They do not lose their individual personalities when they come together; they become a unified working group with specific characteristics of their own. They also interact within the physical and social confines of a specific context and setting. The setting is more than just a space that provides the physical framework; it also provides a place where relationships among the girls develop. Girls also carry with them a view of science and gender that has developed from their previous informal and formal experiences with science and society. Identifying these girls' science practices makes more explicit the ways one group of students function within the context of a science classroom.

Working in Groups in the Science Classroom

Teachers widely use group work among students as one form of instruction in the science classroom. The use of this instructional practice rests on the theoretical perspectives that emphasize the social nature of learning. According to Dewey (1938) school is a social environment where students interact with each other in the process of experiencing. Working in groups presents specific opportunities for students to learn from one another through interaction and peer explanation and teaching (Ogden, 2000).

Teachers use different strategies to implement and manage group work. One such strategy is cooperative learning, a structured activity where the teacher identifies goals, rewards, roles, materials, and guidelines while at the same time emphasizing the interdependence and accountability of the team (Oxford, 1997). When effectively used by the teacher, cooperative learning maximizes group interaction and team communication that positively impacts students' cognitive learning, attitudes towards school, and social development (Sharon, 1980), making it an important strategy for engaging students in school science.

According to Oxford (1997), there are three approaches to cooperative learning that share the same principles but offer different frameworks. The first, the *lesson-planning approach*, represents the most universal of the frameworks and may be used in any grade with any subject. Its organized sequence consists of five decision points that identify objectives, determine assignments and materials, specify goals and tasks, monitor activities, and evaluate teams.

The second, the *structural approach*, includes "the use of sequences of organized, content-free, repeatable classroom behaviors, known as 'structures'" (p. 446). Unlike activities which are related to content, many learning structures may be used during a class. Structures include methods that lead to team building (e.g. cooperative learning), division of labor (e.g. delegation of tasks), communication enhancement (e.g. mini-presentations), concept building, project development, and review of content.

Group Investigation, one such cooperative learning structural approach, bases its model on Dewey's work. Group inquiry and discussion guide data collection and interpretation of information. Students cooperatively identify topics to study and problems to solve in which individual contributions are integrated into a group product. The group's work then becomes part of a class perspective on the topic (Sharon, 1980).

The third approach of cooperative learning differs from the other two because it involves a model that is developed by external, usually commercial providers. This approach utilizes published cooperative learning packages that correspond with aspects of the school curriculum (Oxford, 1997).

Teachers use "collaborative learning" as a second strategy in the implementation of group work. This type of learning differs from cooperative learning, emphasizing acculturating learners into knowledge communities rather than improving cognitive and social skills. Collaborative learning is rooted in social constructivism. Students become part of the learning community through classroom and group activities, modeling and guidance by the teacher. Interaction with members of the group and other members of the class are involved. Reflective inquiry and dialogue with others moves students toward acculturation into the knowledge community (Oxford, 1997).

A successful collaborative learning environment is one in which students reach a shared understanding of goals and tasks. Building shared understanding is a key to collaborative learning. Järvelä and Järvenoja (2011) write, [T]he intrinsic effort of an individual to understand what the other means drives cognitive and dialogic activities that in turn enable cognitive changes in this individual. . . . Being able to understand the perspective of another individual and being motivated to engage the ability are critical for navigating most social situations" (p. 2).

Cooperative and collaborative learning represent two formal instructional strategies used widely in classrooms when students work in groups. Since this study examines group work, it important to understand the different ways students, and in this case girls, participate in science activities. There are many ways in which students interact in the classroom (as this study will show). Interaction among students in the classroom does not always follow the "formal" guidelines of cooperative and collaborative learning. "Informal" interaction among students and especially girls may not enhance cognitive skills (as suggested in cooperative learning) nor acculturates girls into a knowledge community (as suggested in collaborative learning) but it is a way for students and teachers to communicate, engage, and make meaning with each other (Oxford, 1997). In this study, girls interacted before, during, and after assigned science activities. Informal interaction as practiced by the girls highlighted the social aspect of learning.

The importance of interaction in social situations for learning is not new. Lave and Wenger (1991) describe learning as a process that occurs through participation in an interactional context which is characterized by differences of perspectives among members. According to Lave and Wenger, learning is a situated activity, but "learning is not merely situated in practice . . . , learning is an integral part of generative social practice in the lived-in world. . . . Legitimate peripheral participation is proposed as a description of engagement in social practice that entails learning as an integral constituent" (p. 35). In other words the social environment provides a learning "curriculum" through which opportunities for engagement are created. The broader social setting provides the context, access, activities and possibilities for understanding. Through legitimate peripheral participation students working in groups acquire the knowledge and skills to become part of what Lave and Wenger identify as a “community of practice” where participants engage in social relations, activities, and practices within a context of shared understandings and group identity (Lave & Wenger, 1991; Olitsky, 2007).

The success of communities of practice in the classroom depends on the quality of student interactions. In an effective community of practice, participants acquire broad access to a wide range of resources that include other students, information, resources, and opportunities. Scaffolding (adjusting support and guidance as needed) is provided by the teacher as well as other students at higher levels of skill so experts and novices engage in social interaction and subsequent learning (Lave & Wenger, 1991; Olitsky, 2007).

Kurth, Anderson, and Palincsar (2002) describe the negative effects of an unsuccessful community of practice whereby an African American middle school girl identified as Carla did not achieve the sense of belonging and social membership necessary for effective learning opportunities. The examined group consisted of two European-American high achieving students (female and male) and two lower achieving students (female and male) from non-mainstream populations. Although Carla was engaged with the material, her relationship with the other students in the group never reached the level of interaction necessary for a successful community of practice. In subsequent group work with students, the researchers found that Carla’s engagement with science changed.

Carla showed little interest in figuring out the explanations for herself

> during the final activity. Whether her prior experience had led her to conclude that these tasks were best left to other students, we do not know. We do know that she accepted a role affording her fewer opportunities to practice scientific explanations (Kurth et al., 2002, p. 21).

Communities of practice evolve not from a teaching curriculum where the teacher provides the meaning but from a learning curriculum where students share situated opportunities and make meaning together. Placing students in groups does not guarantee they will acquire the skills, knowledge, and language for successful participation and learning. The teacher must create and continually maintain classroom conditions that foster membership, interaction, and the proper context for learning to take place (Lave & Wenger, 1991; Olitsky, 2007). In the 6th grade classroom at City Charter, the teacher allowed the students to decide membership in the groups, resulting in the sense of belonging and social membership that Kurth, Anderson, and Palincsar (2002) described as necessary for learning. The solidarity and enthusiasm experienced by students in these groups also created a positive learning environment.

Olitsky (2007) employs Randall Collins' (2004) concept of interaction rituals to describe successful communities of practice in an eighth grade urban science classroom. According to Collins (2004), an interaction ritual (IR) is a mechanism with four primary conditions. The required conditions include group assembly, barriers to outsiders, mutually-focused attention, and shared mood. The successful mix of conditions leads to four main outcomes that include group solidarity, emotional energy (confidence, enthusiasm) in the individual, identified symbols (visuals, words, gestures) of social membership, and "the sense of righteousness in adhering to the group (p. 49). All of these conditions and resulting outcomes lead to a learning environment that emphasizes participation as a way of learning.

Olitsky (2007) uses the concepts of mutual focus, group solidarity, and emotional energy when she examined the classroom conditions and teacher practices that lead to successful interaction rituals. In one example student solidarity and emotional energy shifted during a class exercise. In the beginning when the teacher drew a simple sketch of a familiar football quarterback to describe momentum problems, the students created a successful IR by mutually focusing on sports and the teacher's perceived lack of drawing ability. Group solidarity and emotional energy were especially high when the teacher allowed side conversation among students. The emotional energy and mutual focus dissipated within the class when the mathematics part of the problem began.

In another whole class activity where the same students balanced chemistry equations, students' emotional energy remained high. Olitsky (2007) writes,

> Issues that related to these differences in outcomes between the two whole-class IRs included whether the mutual focus for the IR was centered on science, the level of challenge of the problems, the role of the teacher, the types of participation solicited form students, whether there were viable roles for students within collective, science-related activity, and the level of risk for students participating, as the students were more tolerant of each other's mistakes when the teacher was out

of the field (p. 54).

When addressing whether successful IRs can lead to longer lasting interest in science, Olitsky (2007) writes, “Rather than focusing primarily on issues of content or on the quantity of student participation, teachers may benefit from considering how various instructional approaches and classroom conditions influence whether the interactions surrounding science allow for emotional and physical entrainment and are experienced by students as successful” (p. 54). During the exercise with the football analogy, students indicated they did not feel any closer to science, yet they viewed balancing equations as fun.

Students see fun as an essential element of engagement. Schmakel (2008) examined the perspectives, beliefs, and recommendations of seventh-grade students on instructional practices and classroom environments to find fun as motivation for student involvement. Using essays, focus groups, and interviews of students in four ethnically-diverse Midwestern urban schools, Schmakel identified fun, interest, challenge, and group work among several motivational instruction constructs.

According to student participants, fun in schoolwork included making schoolwork and instruction more enjoyable through the inclusion of competitive activities and learning games that help with memorizing, reviewing, understanding, and studying. Motivation through interest referred to making instruction and learning materials more relevant and engaging so students could connect with the classroom and academic content through creative and varied activities. Students wanted appropriate mental challenges and responsibilities with “less bookwork, less repetitive work, more mental work, and more activities in which they had to figure things out" (p. 736). The teacher at City Charter used different science activities including experiments, posters, presentation, dioramas, and other projects during the year to successfully engage students.

The identification of instruction constructs of fun, interest and challenge identified by Schmakel (2008) contribute to what Olitsky (2007) identifies as high emotional energy behind motivation. Environments and activities that students perceive as fun, interesting, and challenging are more likely to lead to the development of successful interaction rituals. Using Collins' (2004) theoretical framework, Olitsky (2007) posits that people choose "which activities to purse and to which groups to belong . . . based on people's tendencies to maximize levels of emotional energy" (p. 35). High emotional energy and successful interactions lead to learning.

Students in Schmakel's (2008) study also described the benefits of working in groups, which led her to identify group work as another instructional approach that increased motivation. Students mentioned group work as a way to increase understanding and interest in academic content and improve learning. They also enjoyed working in groups because of the opportunity for social interaction. Both high- and low-achieving students described how students work better and are more interested in lessons and content when they are working together, confirming Dewey's (1938) view of the value of social interaction in learning. The girls in this study considered social interaction during group work to be important and enjoyed the relaxed atmosphere of the classroom.

Teachers continue to use group work as an instructional practice in their classrooms to increase student interest, comfort, and participation in science. When successful, group work gives students new opportunities to be members of new types of communities that incorporate social and academic skills and encourage them to develop new knowledge. But the quality of student experiences in groups depends on factors, including the attitudes of students toward both the academic task and others in the group. Putting students together for group work does not guarantee peer interaction and cooperation. Students enter groups with their own experiences and assumptions. To create viable student groups that lead to positive social and academic outcomes requires an understanding of the students and the ways they interact when they are placed together in a group. In this study, girls were allowed to choose with whom to work which led to group solidarity and high emotional energy. During the academic year, most students worked within single-gender groups. Although the membership of certain groups was consistent throughout the year, some girls moved between groups creating a more fluid membership but still leading to group solidarity.

Girls and Science Education

Researchers continue to examine gaps between the interest, participation, and achievement of boys and girls in science classrooms. Research in science education shows that girls face many barriers, including those found at the classroom level as well as those at the larger societal level that "portray science as masculine and girls as incapable of meeting its challenges" (Barton et al., 2008, p. 71).

Classroom Factors

Classroom factors consist of elements that a teacher controls. These elements include classroom instruction styles and strategies, formal and informal assessment of students' achievement, and interactions between the teacher and students as well as among students.

The ways science is presented in the classroom influences girls' interest and participation. According to research on gender differences, classroom instructional styles favorable to females include emphasis on cooperation, empowerment, and awareness of power dynamics. Feminist pedagogy describes these styles as creating a less hierarchical and more student-centered community in the classroom, which supports exploration of disagreements without defensive reactions. This perspective suggests that to create a more equitable classroom, educators must identify unequal power relations in classroom discourse and interactions and intervene in these practices to allow engagement by male and female students (Middlecamp, 2006; Shackelford, 1992; Schacht, 2000).

There is little agreement about the approach to be taken in order to engage girls in science. One perspective advocates the establishment of science environments that are less hostile for girls where cooperation is the norm and social relationships are an integral part of that cooperation. The other perspective favors teaching girls to feel more comfortable with competition, argumentation, and the dichotomies of right/wrong. A third view suggests a combination of both strategies (Shakeshaft, 1995).

Another aspect under scrutiny for gender disparity in the classroom involves assessment of student achievement. Stereotyped perceptions of girls and science participation exist. Spear (1989) examined responses from 89 secondary school science teachers in England on a mailed questionnaire that inquired about differences between the work of boys and girls. An equal number of physics and biology teachers participated. Seventy-two percent of the teachers admitted they could recognize differences, even though a greater number, eighty-five percent noticed differences between the written work of male and female students.

The characteristics attributed to girls' work indicate teacher perceptions about gender specific features. The characteristic listed by over ninety percent of the teachers centered on the appearance of the written work. They described girls' work as neat, detail-oriented, and well-presented. However, comments about this feature were both complimentary and critical. Girls' work tended to be devalued. One respondent wrote, "Too much concentration on the drawing of a diagram; little thought given to the importance of the diagram" (Spear, 1989, p. 275). Another noted, "[G]irls' work is 'uncritical, including unnecessary detail, not appreciating the essentials'" (Spear, 1989, p. 275). Researchers identified the context – positive or negative – in which the comment was mentioned for both girls and boys. Teachers in this study associated girls' work with certain behavioral traits, such as being conscientious and well-presented, while valuing boys' work for their understanding of the content and the accuracy of their work.

Teachers also intentionally and unintentionally control many elements related to classroom dynamics that have a direct and indirect influence on science interest and participation by girls in the science classroom. In a study with 25 physics teachers, 16 males and 9 females in 25 high schools in Israel researchers examined teachers' perceptions of gender differences in physics classes. Analysis of semi-structured interviews revealed a lack of awareness about the gender specific differences and a lack of knowledge about creating gender-inclusive classrooms. Sixteen out of the twenty-five teachers including five female teachers thought no problem existed in gender specific differences in physics participation. One male teacher replied, ". . . Whoever wants to can. Those who don't want to, probably have their reasons" (Zohar & Bronshtein, 2005, p. 68).

In the study, interviewers supplied teachers with actual participation rates before asking about the reasons for these differences. Forty-eight percent of the teachers gave responses that were grouped by career expectations, explaining that girls do not view physics as a career compatible with motherhood. Forty-four percent cited girls' attitudes towards mathematics, with most teachers connecting this view with inherited biological factors and low self-efficacy (the belief that one cannot master a situation) of girls. A belief in biological factors existed in both male and female responses. One female teacher explained, "A girl needs to be an outstanding genius, maybe not really a genius but extremely talented to have the same high achievements as most boys obtain easily" (Zohar & Bronshtein, 2005, p. 71).

An American study of student science discussions in a high school physics class found similar attitudes among male students who were unaware of gender inequities in their classrooms. Boys perceived their more assertive language style as an indication that they better understood the teacher's concepts. One male student stated, "Girls don't seem to grasp the concepts as the guys do. . . Because they're the ones asking most of the questions" (Guzzetti & Williams, 1996, p. 4).

Classroom dynamics and relationships among students also influence girls' interest and participation in science. Researchers have examined the correlation between equal opportunity of participation and equity of status by studying small group interaction, including single-sex and mixed groupings. Jovanovic and King (1998) studied six science classrooms. All teachers in the examined fifth to eighth grade classrooms in Illinois were chosen based on exemplary hands-on-teaching methods and sensitivity to gender equity in the classroom. Boys and girls equally displayed active leadership behaviors, such as directing activities and explaining concepts. At the end of the school year, these students possessed positive perceptions of their science ability regardless of their gender.

However, with the exception of those girls who were active leaders, Jovanovic and King (1998) found girls' perceptions of their science ability decreased over the course of the academic year. They also noticed that girls and boys experience small groups differently. Boys in mixed-gender groups handled or manipulated the equipment more often than girls. The researchers describe three students in a male-dominated group where the boys ignored the girl's suggestions and attempts at participation.

> Stacey attempted to manipulate the materials, but, each time she moved a piece of the material, David or Damien would move it back to its original position. Finally Stacey stopped trying and accepted her role as assistant.

> She handed material to the boys and followed their directions about which pieces of material to look for. Eventually, she sat back and observed while the boys finished the activity (Jovanovic & King, 1998, p. 492).

She (Stacey) finally stopped actively participating and accepted a passive role in the activity (Jovanovic & King, 1998).

Guzzetti and Williams (1996) observed differences in participation stating that “merely putting students into small groups did not facilitate females’ participation in instructional activity or talk about that activity” (p. 6). Girls voiced their opinions more and felt more comfortable in small all-female groups. One student reflecting on single-gender groups reported, “No one dominates the group. You don’t feel threatened that you will say something stupid” (p.7). Small single-gender groups allow girls who infrequently participate in whole class discussions to receive feedback on their ideas (Rafal, 1996).

Girls may also demonstrate non-gender behavior in single gender groupings. In a study of four fifth- and sixth-grade girls engaged in a small group science activity, Rafal (1996) observed the interaction that occurred. Small groups allow students more opportunities to participate in discussion and to benefit from distributed knowledge when compared to the whole class. By examining the nature of the group interaction, Rafal (1996) observed both collaborative, cooperative discussion as well as assertive, competitive, and aggressive talk. These findings counter the common beliefs that girls communicate through collaborative and affiliative styles and that boys use more competitive and adversarial styles (Rafal, 1996).

Communication being a significant part of the learning process, classroom discussion serves as an important dimension of science education. Students participate in both whole class and small-group interactions. Although the teacher is an authority figure in the class, the behavior of male students impacts female participation in the classroom. In a two-year study of student interactive discussions in a high school physics class, female students believed male students, not the male teacher, influenced the disparity in the girls' classroom performance. One girl stated, "I don't really notice Mr. Williams treating them [boys] differently or anything. . . I definitely notice a difference, and I think it's more student invoked, it that's the right word, because Mr. Williams doesn't treat us any different but the guys get a cocky attitude" (Guzzetti & Williams, 1996, p. 8).

Classroom instructional materials may also dissuade girls from engagement with school science. The Girls into Science and Technology project (GIST) in Great Britain (1979-1984) examined gender stereotyping and girls' underachievement in physical science and technical subjects. One of the developers cited four aspects of science that could be construed as male friendly. These aspects include (1) attitudes of teachers and student, (2) visuals found in books and other resources, (3) abundance of males in scientific and technical fields, and (4) the emphasis on a narrow conception of science (Kelly, 1985). The final report emphasized the need for a "girl-friendly" science, which includes:

(a) removing any masculine bias in the form of illustrations, language and examples;

(b) linking experiments with other types of activity which girls enjoy, e.g. discussion and creative writing;

(c) emphasising [sic] the applications of science to everyday life *before* introducing difficult ideas, concepts and theories;

(d) starting with topics familiar and interesting to girls yet leading to an understanding of all aspects of science (Kelly, 1985, p. 137).

Ford et al. (2006) found certain resources in school science were not used and viewed the omission of written texts in science instruction as a barrier to girls' interest and entry into science. In reaction to poor quality textbooks, science educators have excluded written work (e.g. reading) in the teaching of science that removes a possible connection with activities that girls consistently enjoy.

In a study examining the science reading of third-grade girls in the eastern United States, researchers asked girls their preferences from a predetermined list among different genres of books. Girls chose books about animals as their favorite genre, with most citing non-fiction books about a variety of animals. Although the researchers considered animal books a subset of science books, girls did not share this perception. Only forty-six percent of interviewed girls stated they like to read science books. Girls strongly connected science books with school science. To connect an enjoyable activity such as reading with science, educators need to examine how and what kind of science texts to incorporate into the curricula (Ford et al., 2006).

Attitudes, interactions, and relationships as well as instructional strategies impact how girls experience and engage in school science. These influences operate within a larger social context that exists outside of the classroom and school and impacts the experiences of girls and boys.

Societal Factors

Societal influences in the larger community influence girls and their engagement with school science. Many boys feel comfortable in science class because they come to school with more informal science experiences that allow them to be more familiar with science as it is currently taught in schools. Many boys also enter school familiar with tools and mechanical objects. Their toys tend to include vehicles, tools, building kits, and other science-related items that require manipulation of objects. In this way boys have more opportunities to develop spatial visualization skills that aid them when participating in school science (Shakeshaft, 1995; Tindall & Hamil, 2004). Linn and Hyde (1989) write, "On balance, males compared with females report substantially more informal experience with physical science" (p.22). Although participation and exposure to science outside school in clubs and other programs does not always lead students to be more interested and comfortable with school science, boys are perceived as having had more science-related experiences outside of school than girls (Lee, 2002).

Girls engage in informal science experiences outside of school, however their actions and tools are not considered to be related to science. Few people view cooking and experimenting with recipes as science. Kitchen, garden, art, and personal care equipment are not traditional science tools (Shakeshaft, 1995). Additionally, many girls' toys and activities promote opportunities for verbal and interpersonal development – attributes that are not always utilized in school science (Tindal & Hamil, 2004). The type of out-of-school experience in which boys and girls participate subsequently impacts engagement and achievement. Hamilton (1998) found that results of multiple choice and constructed-responses on science tests varied across content and format for both male and female high school students. She found the largest gender differences involved visual and spatial reasoning that required application of outside knowledge. Boys did better on these questions, while girls did well on questions related to the knowledge taught in the classroom. Tindal and Hamil (2004) write that girls do well on linear and right and wrong testing. They thrive when they can synthesize information and make connections.

Gender identification is an influence on science engagement. Lee (2002) writes, "[P]ersons' significant relationships shape thought and behavioral patterns, producing ideas about self that are played out in subsequent social interactions" (p. 351). He further states, "Identities are persons' internalization of their role expectations. Roles and identities form the nexus between the social and the psychological; when internalized, roles are called identities" (p. 352). Social factors influence the self-concept of girls.

Lee (2002) surveyed 320 high-achieving high school students across the United States at nine universities and a private high school participating in a summer science enrichment program. He focused on social relationships, science involvement, and science identity to examine how social relationships and experiences affect girls' participation in science and technology activities. He found new social relationships in the program gave girls a stronger science identity. Relationships in the program influenced boys' science identities less, because boys' sense of their science ability was centered on previous activities and home relationships. Moreover, girls' science identities were found to change more easily over time (Lee, 2002). The strong influence of relationships and educational context on girls' inclination to do science may suggest an influence of socialization of girls into different interaction styles.

Guzzetti and Williams (1996) observed the influence of social interaction styles in the classroom. Girls and boys participated differently in whole class discussions of refutation, a type of inquiry training, used in classrooms. Boys answered questions more often in an aggressive style that included interruptions and loud vocalizations. Girls spoke less and phrased their refutations as questions. Students employed these interaction styles in small mixed-gender group discussions (Guzzetti & Williams, 1996), which served to reinforce the girls' gender roles as conciliators.

Contextual Factors

Some researchers and educators consider the historical and present nature of science practice to be the cause of girls' disinterest and non-participation in school science. They believe the way science is currently practiced with emphasis on analysis and objectivity link Western science with the way masculinity is socially constructed (Kelly, 1985). Boys who adopt the traditional male characteristics and are assertive, curious, and active tend to do well in school science (Tindal & Hamil, 2004).

The practice of science is viewed by some researchers as masculine since science is traditionally associated with power. The feminine characteristics of caring, involvement, personal relationships, and emotion are different from the qualities commonly associated with the conduct of science. In this view girls may be reluctant to participate in a field which by its very practice or has been associated with masculine characteristics (Kelly, 1985).

Some researchers see a need for a shift in thinking about science education. They challenge the idea of objectivity and question the positivist view that "there is an objective, solitary way of doing science that results in independent unbiased knowledge" (Barton, 1998, p. 10), since "science is . . . a human endeavor and subject to human biases, social conditions, and ambitions" (Barton, 1998, p. 10).

Critics of this perspective define science as a human endeavor and believe it should not be subject to questions about "the nature of objectivity, the construction of facts, and the biases and values that shape scientific interpretations of nature" (Nelkin, 1996, p. 93).

The development of gender inclusive science education has potential for creating engagement with and for girls. Barton (1998) describes four aspects of a gender-inclusive science curriculum. First, scientific knowledge is situated in society to reveal the cultural impact on its development and acceptance. Second, scientific knowledge needs to reflect its interactive and complex nature. Third, contribution by women and minorities needs to be included. Fourth, multiple ways of knowing should be used and accepted when studying science.

The gap in interest, participation, and achievement between male and female students in science cannot be explained by any single factor; rather, it involves multiple and overlapping factors. Studies over the last thirty years suggest that the influences that impact the science education experiences of girls include individual classroom practices, social beliefs, and cultural structures.

The most significant criticism of studies of girls and science relates to the perspective of science and gender as simple one-dimensional concepts. Science represents a multifaceted discipline with numerous fields, specializations, and individual subjects. The often repeated statement that women are underrepresented in science ignores the reality that in the past thirty years women have achieved academic degrees in high numbers in the fields of life science (molecular biology, plant physiology, ecology, zoology, and botany), social science, and medicine (Rosser, 2000). The danger of generalizing science to fields of physical science, engineering, computers, and applied mathematics in which women *are* underrepresented – leads to or may be a symptom of a devaluing of women's science work and interests. Rosser (2000) writes, "Other studies provide supporting evidence that helping others and doing something worthwhile for society serve as powerful motivators to attract women to science in general, and to the biosciences and health in particular" (p. 19). Rosser believes that these gender-specific choices are based, not on biological influences, but on gender socialization and the traditional feminine role of helping others. In summary, the choices of women and girls must be viewed within a social context.

Gender does not represent a homogeneous category. Examination and analysis of the influences of gender in science must include the perspectives of race, ethnicity, class, ability, and other identifying factors. Often the experiences of girls are viewed through a single lens. If gender is viewed as a social construct, then science interest, choices, and participation are influenced by the social factors and relationships within girls' lives.

Non-Mainstream Populations of Girls

Girls, from non-mainstream populations, including students of color, students learning English as a new language, and students from low income communities, face additional challenges. Although African-American girls from low income urban centers are academically doing better than African-American boys in science classes, they still face fewer learning opportunities compared to mainstream students. Many urban schools with student populations that are multicultural and multilingual have fewer educational resources, receive lower funding, and are located in low-income areas (Barton et al., 2008; Lee & Luykx, 2005).

Girls from non-mainstream groups may also have cultural habits and beliefs that differ from the accepted school-endorsed mainstream white traditions. As an example, Brickhouse et al. (2000) describe the situation African-American girls face in the classroom. They write that African-American women are not always silent participants in their communities, which may carry over into the classroom. This cultural way of being creates dilemmas for African-American girls, who may be viewed as "loud" compared to white students from traditional middle-class white communities. The African-American girl is then presented with two competing models and ways of being that she must acculturate within.

Lopez (2003) recounts reminiscences from Latina women who learned to "prize so-called feminine traits, such as conformity, silence, and passivity" (p. 54). She recalls, "When asked about problems with teachers, Rosy was perplexed: 'Me personally? I was a really good student and very quiet,' indicating that she equated her own silence with being an exemplary student" (p. 54). Not only was traditional ladylike behavior emulated, but it was equated with academic achievement.

For girls from non-mainstream populations, their racial, ethnic, and gender positions in society influence their concept of self. The challenges associated with membership in these marginalized groups become part of the process. The marginalization of girls based on race, ethnicity, gender, and income affects girls in several ways. To Thomas and Rodgers (2009), gender, racism and discrimination impact the mental health, academic achievement, and self-esteem of African-American and Latina adolescents. Discrimination may also lead to anxiety. Awareness of different racial, cultural, or gender-related values may lead to conflict.

Positive gender, racial, and ethnic identity is important for girls from non-mainstream populations as protection from discrimination, racism, and negative stereotypes. Positive identity leads to positive self-esteem, which is an important factor in psychological well-being and academic achievement (Thomas and Rodgers, 2009).

Response to the challenge of being part of two marginalized groups, Hispanic or African-American and female differs among the communities. In the African-American community, the emphasis is placed on self-determination, strength, and assertiveness in girls to counteract challenges. In the Latino/a community, a combination of self-reliance and adherence to traditional gender roles is emphasized. These conflicting ways of being add to the struggle of Latina girls as they attempt to reconcile the traditional values of their community with the academic goals of the mainstream white traditions (Thomas & Rodgers, 2009).

The success of girls from non-mainstream populations may depend on their resilience in the face of oppression and discrimination. Thomas and Rodgers (2009) define resilience as “a dynamic process encompassing positive adaptation within the context of significant adversity . . . [It] entails contextual factors, including family, community, and environment that contributes to the daily living experience of youth” (p. 119).

This resilience is relied upon because when school science ignores ways of knowing associated with linguistic and cultural knowledge, the disconnect between gender and science becomes magnified. Aikenhead and Jegede (1999) write, “To acquire the culture of science, students must travel from their everyday life-world to the world of science found in their science classroom” (p. 274). They refer to this “travel” as “cultural border crossings,” that is characterized as a spectrum of “smooth” to “impossible” transitions. Students who experience a smooth crossing find a good match between the culture of science and their worldview. Students who experience a gap between their family, community, and worldviews on one side and school science on the other find it virtually impossible to successfully cross and become disengaged from science (Aikenhead & Jegede, 1999).

Lee and Luykx (2005) stress the need for cultural congruence, which occurs when teachers use inclusive curricula, culturally-sensitive instruction, and appropriate interactional approaches in the classroom. For non-mainstream girls, teachers must link school science to their culture and their gender experiences in order to facilitate participation and engagement, especially when the students' ways of knowing and cultural values are different from the way science is taught in the classroom (Lee & Luykx (2005).

The way students engage with science depends as well on their view of themselves or their identity. Aikenhead and Jegede (1999) emphasize that to be successful, students must travel between worlds by shifting "from being one person in one context to being another person in a different context, without losing [their] self-identity as the same person [they] remember in [their] most familiar world" (p. 273).

Girls from non-mainstream populations face many of the same challenges that confront all girls, including difficulties caused by classroom, social, and contextual influences. They must also confront the reality of belonging to a second marginalized group, with the accompanying discrimination that is attached to membership in a non-mainstream ethnic, racial, or linguistic group. Although the communities to which these girls belong create certain coping and surviving mechanisms, their cultural ways of being may conflict with the mainstream traditions required for success in school.

Early Adolescence

For 6th grade girls, challenges in school occur at a time when they are entering adolescence, the process in human development that exists between childhood and adulthood. Adolescence, especially the early years, is marked by physical growth, biological maturation, and changes in cognitive, social, and psychological needs. Height and weight rise, body composition changes, muscle strength increases, and sexual maturation start to occur. Although factors such as heredity, nutrition, hormones, illness, socioeconomic status, family size, and exercise affect the rate of personal growth, all adolescents experience changes in these years (Walker & Lirgg, 1995).

Walker and Lirgg (1995) write, "[T]he changes that take place within every adolescent are so strongly related that a shift in one aspect of development is almost certain to bring about variations in others" (p. 53). These changes affect not only how an adolescent is perceived by others but also how that adolescent constructs a view of him or herself. On the social front, the individual is viewing and relating to others in new ways while simultaneously turning inward on an emotional level and becoming aware of deeper feelings. Bowers (1995) writes,

> According to constructivism, young adolescence is not only a time of *finding* oneself in relation to the rest of the world but is a time of *producing* oneself as a unique individual with a distinct part to play in that world. To do this, the early adolescent engages in two main actions: *interpretation* of event, experiences, and information on one hand, and *making choices* based upon those interpretations,

on the other (p. 82).

This social and emotional development takes places in three dimensions – cognitive, affective, and behavioral. On the cognitive level the young adolescent asks, *how do I see myself?* This question addresses personal identity but includes group as well as ethnic and racial identity.   The affective dimension includes issues of both self-esteem and self-efficacy. Self-esteem refers to the degree of satisfaction or dissatisfaction that is felt by the person in the process of their developing self-concept. The young adolescent asks, *How do I feel about myself?* Self-efficacy refers to the belief of the person's competence and ability to achieve despite difficulties. The young adolescent asks, *Do I believe I am capable of being successful?* The behavioral dimension includes the choices, conduct, and actions that are made based on the meaning or values that are important. The young adolescent asks *How do I choose to act?* (Bowers, 1995).

Peer groups and friends become significant during this time of identity formation. Interaction with peers and closeness with friends helps the young adolescent discover his or her identity as well as his or her place in the larger society (Hurd, 2000).

In recent decades, educators have recognized and acknowledged the transformative changes occurring in young adolescents' lives by embracing the middle school model. The concept of an American junior high school (grades 7-9) dates back to 1910 when reformers called for a specialized school for young adolescents. Citing the large number of students who dropped out of school between sixth and eighth grades to enter factories, child welfare advocates sought to keep children in school. On the other hand, social efficiency advocates believed that a junior high school would serve society by providing vocational training as well as “Americanization” education to the large number of immigrant students attending American schools (Beane, 2001).

In the 1950s, with a large influx of “baby boomer” generation of students in the elementary schools, reformers began to re-examine junior high schools. Early adolescence occurred at an earlier age range (10-14 years) than previously acknowledged, leading to discussions of young adolescent development and the need for separate schools (Beane, 2001). In 1956, Gruhn and Douglas described the following six functions for the junior high schools of the 1950s: *integration* of learning experiences, *exploration* of specialized interests and abilities, *guidance* of students, *differentiation* of instruction, *socialization* of students, and *articulation* of education program (Brough, 1995). Each of these functions created a learning environment that acknowledged the social and physical changes of young adolescents by focusing on the needs and interests of young adolescents.

In 1960, educators began to re-examine the junior high school model. Instead of having a separate identity with unique functions, junior high schools had become smaller versions of high schools. In the late 1960s and 1970s the concept of a school for young adolescents based on their developmental and educational needs took hold again in the middle school movement (Hurd, 2000). The ideal middle school was envisioned as:

(a) focusing on the needs of early adolescents;

(b) providing individualized instruction;

(c) stressing the intellectual components of the curriculum;

(d) emphasizing inquiry, discovery, and learning how to learn;

(e) providing many exploratory experiences;

(f) offering health and physical education programs appropriate to the age group;

(g) placing an emphasis on values throughout all courses; and

(h) educating teachers in the special competencies needed to work effectively with the early adolescent (Hurd, 2000, p. 19).

W. M. Alexander, known as the father of the modern middle school movement, described the characteristics of exemplary middle schools, specifying certain organizational, administrative, curricular, and instructional structures. These include characteristics developing from the needs of young adolescents as well as an established system for school planning and evaluation. The curriculum should provide basic learning skills, personal development activities, guidance, and emphasis on continuous student progress. Other characteristics include interdisciplinary teacher units, flexible student groupings, flexible scheduling, a guidance program, and a variety of teaching strategies (Dickinson, 2001).

Middle school advocates recognized the significance of creating special schools for ten to fourteen year old students, with educational environments that meet the developmental needs of young adolescents, and acknowledge the growing independence and emerging sense of self of these learners (Pittman, 2001). The flexible scheduling and student groupings, the emphasis on learning how to learn, and the availability of varied experiences in classes was seen to serve the needs of adolescent girls, whose lives are being impacted by physical growth, maturation, and changes in social needs.

The social nature of learning is extremely importance for 6th grade girls entering adolescence who are relating to others in new ways. Girls from non-mainstream populations face additional challenges from belonging to a second marginalized group. Using progressive educational ideology, developmental theory, and a gender perspective as guides, this study examines girls' engagement with school science through their participation and interaction during group activities. The use of group work among students in the science classroom builds on the theoretical perspectives that emphasize the social nature of learning.

Using the research literature as a starting point, this study focuses on the activities and interaction that takes place among 6th grade girls as they are engaged in school science. This study extends the previous research that has been conducted on girls and science education by examining how girls participate in school science by focusing on the experiences and perspectives of 6th grade girls as they construct meaning in a science classroom.

CHAPTER 3

METHODOLOGY

Qualitative Research in the Ethnographic Tradition

The nature of the initial question, "How do girls engage in science when participating in small groups?" lends itself to qualitative research. According to Patton (1990) a qualitative research study supports several interconnected themes. The researcher conducts the study as a naturalistic inquiry with no manipulation or attempt to control conditions and no predetermined constraints on outcomes. Furthermore, the researcher follows an exploratory approach to analysis by allowing general patterns to emerge from specific observations.

Compared to quantitative hypothesis-driven research, qualitative research requires the researcher to get closer to data sources through fieldwork, so that more detailed descriptions of participants' perspectives and experiences are represented fully. This more direct contact with participants within their natural environment allows "possible description and understanding of *both* external behaviors and internal states (worldview, opinions, values, attitudes, symbolic constructs, and so on)" (Patton, 1990, p. 47). Additionally, the qualitative researcher maintains a more holistic perspective, focusing on the setting as a whole. This perspective requires understanding the changing dynamics of the social environment (Patton, 1990).

Four aspects of this research study place it in the category of ethnography. First, small working groups of girls engaged in science activities are viewed as social units. According to Erickson (1984) "'Ethnography' . . . means 'writing about the nation'; 'graphy' from the Greek verb 'to write' and 'ethno' from the Greek noun *ethnos*, usually translated in an English dictionary as 'nation' or 'tribe' or 'people' " (p. 52). Second, emphasis is on the girls' meanings of events. In ethnography, the unit of study for an ethnographer may be any social network regardless of size, treated as a group entity which is described and interpreted using local meaning and the points of views of participants (Erickson, 1984). Long-term participant observation and ethnographic analysis are the third and fourth aspects of the research. Ethnography involves the observation, description and interpretation of events and as such is guided by a point of view that involves reflection and analysis. Although the researcher enters the field with a theoretical point of view and initial questions, the setting influences the inquiry process so that perspectives and questions evolve in the field.

Strauss and Corbin (1998) define methodology as "a way of thinking about and studying social reality" (p. 3). They write,

> The importance of this methodology is that it provides a sense of vision, where it is that the analyst wants to go with the research. The techniques and procedures (method), on the other hand, furnish the means for bringing that vision into reality. . . . Just as painters need both techniques and vision to bring their novel images to life on canvas, analysts need techniques to

help them see beyond the ordinary and to arrive at new understandings of social life (p. 8).

The techniques and vision to which Strauss and Corbin (1998) refer may be applied to ethnography. Wolcott (1997) writes, "Ethnography refers both to the research *process* and to the customary *product* of that effort – the written ethnographic account" (p. 328). He explains, "I suggest that the real mystique surrounding ethnography is not in 'doing fieldwork' but in doing the mindwork that must occur before, during, and after the fieldwork experience in order to bring the ethnographic process to fruition" (p. 328). This study of 6^{th} grade girls employs ethnography as a method to qualitative research that incorporates field research techniques common in ethnography (process) and interpreting data using a perspective (product) informed by prior work in anthropology (Wolcott, 1997).

Emphasis is on the culture or "the concepts, beliefs, and principles of action and organization" of the group (Goodenough, 1976, p. 5). According to Goodenough (1976), culture is revealed through the social interaction of individual people within the studied group "as they pursue their various interests and try to deal with their various problems of living – problems that involve the necessity of choosing among conflicting goals, competing wants, and long-range as against short-range concerns" (p. 4). The social relationships that develop within a group of girls engaged in science is viewed as a cultural group who interact, make choices, and engage in activity of doing science.

The ethnographer studies culture through the explicit behavior of people as they interact in different social relationships and social situations. Culture is the content and meanings revealed through the interaction, not the interaction itself (Fine, 1979). Wolcott (1991) writes, "[T]he cultural knowledge that individuals acquire . . . allows them to engage with others in effective and socially acceptable ways, and thus to communicate culturally" (p. 262). The ethnographer discovers how culture works after continued study of the beliefs and practices of a community that lead to understanding the implicit meaning in the interactions through inferences in speech, action, and gestures. Understanding comes not only from observing what people do and say but also from the violation of cultural rules (Lloyd and Duveen, 1992; Wolcott, 1991). Wolcott (1991) writes, "As linguists do, we also infer it from observing 'errors' of behavior, as when tacit social conventions, like unstated grammatical ones, are overgeneralized or inappropriately applied"(p. 266). Meaning is continuously constructed within constantly changing social and environmental conditions (Fine, 1979).

Doing ethnography in a school setting poses certain challenges due to the fact that conducting ethnography in schools in situationally different. Certain ethnographic principles in fieldwork and analysis are followed and adapted. The girls are part of a classroom that exists in a school that is part of a complex society. Girls attend school only certain parts of the day during certain times of the year. Although much of the interaction may seem commonplace and the school setting familiar, the ethnographer in the classroom must step back and view the setting from an ethnographic point of view. Instead of making the strange familiar as in traditional ethnography, an ethnographer in a school must notice and examine the obvious and taken-for-granted aspects of a classroom and as Erickson (1984) describes, make “the familiar strange” (p. 62).

Research Setting and Participants

The present study is based on research conducted at City Charter, an urban charter school located in a medium-sized city in the Northeast. Initially opened in 1998, the school includes 648 students in kindergarten through twelfth grade in two connected well-maintained buildings. An annual lottery process for available openings determines admission. Almost 75% of those students are eligible for free or reduced-price lunch (Information Works, 2009).

City Charter started as an enrichment program with the goal of getting students of color to excel in science, technology, engineering, and math (STEM). According to the principal, City Charter has operated as a liberal arts school for many years but is currently in the midst of a major transition as it moves towards developing a curriculum that is “interwoven and embedded with STEM culture and STEM standards” (Interview, June 17, 2010).

The selection of City Charter and this particular class was based on several criteria. First, the school emphasizes an academic approach for college-bound students, with a strong curriculum in math, science, and technology. According to the principal and classroom teacher City Charter is known in the community as an alternative to the other public schools, with smaller class size, parental involvement, and a diverse and dedicated staff (Interviews, June 17, 2010; June 21, 2010). Second, the teacher – Ms. Julie Brooke – of this particular class focuses on science as discovery, emphasizing group work in a self-contained class. She described the importance of hands-on exploration as “there’s a learning value in what they’re doing, the actual doing of things . . . when they make things, they’re actually learning . . .” (Interview, June 21, 2010). Third, 6th grade is a crucial time for girls as they undergo physiological, psychological, and social changes, especially in their relationships with other girls. Fourth, City Charter is an urban school with a large percentage of students of color. Since many research studies focus primarily on the experiences of white female participants, it is important to examine the experiences of girls whose science interest, participation, and choices are influenced by different social and cultural factors within their lives.

According to data available from Information Works (2009), demographics for the student population at this school are 48% Hispanic, 37% African-American, 10% White, 3% Native American, and 2% Asian. No students receive bilingual education services and only 5% receive special education services in the form of support within the general education curriculum. In the 2008-2009 academic year, 27% of 5th graders were proficient in mathematics, 52% were proficient in reading, and 38% were proficient in writing as measured by the New England Common Assessment Program (NECAP). The percentage of students proficient in reading at City Charter was the same as the proportion of similar students statewide while the percent proficient in mathematics and writing was less than the proportion of similar students statewide. The 6th grade participants in this study were part of that 5th grade group. City Charter has met all targets as mandated by the No Child Left Behind Act (Information Works, 2009)

The study was conducted in one of two 6th grade classes at the school during the 2009-2010 academic year. The class consisted of 24 students, 12 girls and 12 boys. The class was primarily divided between two main demographic groups – Hispanic- and African-American. During the year, two boys transferred out of the school but two additional boys from the waiting list took their places so the same number of girls and boys remained. None of the girls left the class or school during this time. The study focused on 10 girls and the working groups they formed during science class. The girls included four African-American girls, four Hispanic American girls, and two girls who are biracial. Most of the girls had been at the school since kindergarten with all but one attending the school for several years. With the exception of one group of three girls who always worked together, the other groups were more fluid with girls working with different girls during the course of the year. Occasionally, a boy would be included in a working group, but mostly the self-selected groups were all female. Although the students were aware of a study being conducted in their classroom, they were intentionally not told that the target group was girls. All students and their parents or guardians were asked to sign Assent or Permission Forms (see Appendix A for sample assent and permission forms).

The teacher, Julie, who is white, has been teaching since graduating college over thirty years ago, the last nine at City Charter. She emphasized a “sense of discovery” as one of her favorite aspects about science and believed that learning was not just about finding the right answer. She wanted students to learn how to think and to discover things through their own exploration. She described how she learned. “Rather than giving me directions as to how to use an I-Pod, just let me handle it and talk to me. I’ll figure it out” (Interview, June 21, 2010). Julie believed students learned during their own investigations.

The following excerpt describes her approach to science.

> Kids . . . you need to give them a chance because if you come on as the expert telling them everything, there’s nothing for them to learn. They have to reach for it and struggle with it a bit. I think that’s really, and sometimes what they find out is more important than what you might have thought. They’re the scientists (Interview, June 21, 2010).

Julie’s philosophy influences how she conducts her classes. She realizes the importance of motivation and what she terms the “creative factor” in getting students to like what they are doing. To Julie, teaching science means presenting the material in such a way that students enjoy and want to pursue what they are doing. If not, the teacher risks turning students away from science and as Julie stated, “you’ve really cut off a large part of education for them” (Interview, June 21, 2010).

Julie’s genuine excitement about science and discovery as described in the following excerpt also impacts her classroom approach to science.

> With studying insects, . . . bring on the insects! I want to see those insects, I wanna watch them jump around and talk about it. What makes them move this way, what’s the advantage, what’s the disadvantage? Put them in the container with the maple leaves and the grass and see where they go. Why do they like this one or that one? (Interview, June 21, 2010).

Julie brought this excitement to the science classroom and created an atmosphere that encouraged student exploration and participation.

Students sat at desks or tables that were configured differently during the year in an attempt by Julie to find an arrangement that worked best with the students. Seating arrangements throughout the year included rows, table groupings, and U-shaped configuration of desks (see Appendix B for sample seating arrangements). Since none of the desks or tables had interior shelves, students used plastic bins for their school supplies. They used hallway lockers for their personal belongings. Students entered and exited through a door at the front of the classroom. A large whiteboard with student work on one side and the teacher's desk and computer on the other occupied the front wall. Another computer station with a printer was located at the back of the room flanked by a table with a whiteboard on one side and bookshelves on the other. Student work hung on the walls. The side wall with windows had a reading area with pillows in one corner while the opposite wall included additional bookshelves, equipment and supply storage, and a sink that served as a staging area for some of the science lab work. Posters filled the walls.

Science class included teacher lectures, class discussions, hands-on activities, and group work. The sixth grade curriculum focused on Life Science topics, although this year two additional subject areas, simple machines and geology of rocks, were included.

Role of the Researcher

Ethnographers enter the setting with the goal of understanding the “emic” or insider perspective. Although traditional ethnography has always been concerned with the meanings participants ascribe to their behavior, it should be noted that this research may be identified as an “insider” to gender research in that I can identify myself with the participants of the study. Although a connection through gender may confirm “insider” status, other factors such as age, education level, ethnicity, class, and race do not (Foley et al., 2000).

As a female, I bring certain experiences and knowledge to the topic of gender and science education. My distinctive experience affects the questions asked and the selection of certain topics in any discussion. Additionally by only examining groups of girls, this study situates girls at the center of the research and emphasizes the distinct experiences of girls and their way of knowing in science groups.

There is no agreed-upon methodology of feminist research. Harding (1987) writes, “[W]omen come only in different classes, races, and cultures: there is no ‘woman’ and no ‘woman’s experience’ . . . there is no one set of feminist principles or understandings beyond the very, very general ones to which feminists in every race, class, and culture will assent” (p.7). Similarly, Shackelford (1992) writes, “One must recognize at the onset that feminist pedagogy relies, like feminist theory, on ideologies, epistemologies, and methodologies that are negotiated and changing (p. 570).

Recognition of the cultural beliefs and behaviors of researchers promotes the belief that the standing of the researcher is part of the research. By allowing critical scrutiny, the researcher accepts the subjectivity inherent in all social science research and, therefore, according to Harding (1987) "increases the objectivity of the research and decreases the 'objectivism' which hides this kind of evidence from the public" (p. 9). Furthermore, Gross (1992) in her description of feminist theory as it relates to research identifies a commitment on the part of feminist researchers to acknowledge that research is written from a specific point of view and "that the knower always occupies a position, spatially, temporally, sexually and politically (p. 365). With this point of view, the researcher entered the classroom to study what happens when 6^{th} grade girls work in groups in the science classroom.

Data Collection

The collection of data at City Charter occurred two times a week during science class from September 2009 to June 2010. Several ethnographic research techniques were used in this study.

Participant observation is the primary tool of ethnography, and the primary source of data collection for this research which took place twice a week during a one hour science period for 36 weeks. Wolcott (2008) labels participant observation "firsthand experience" in the setting among participants and defines it as information gathering that comes through human senses, specifically sight and hearing. In traditional ethnography, the participant observer becomes totally immersed in a culture by living and working in a community for an extended period of time (Fetterman, 1998). A participant observer becomes involved in ongoing events by being immersed in daily routines (Emerson, Fretz, and Shaw, 1995).

Ethnography of students in a school setting differs in two significant ways. First, total immersion was impossible. In the role of participant observer, I was not continuously immersed in the girls' culture as in traditional ethnography but participated selectively over a period of time. Second, no assumption of equality in status existed between the researcher and students since one must acknowledge the differences in age, educational attainment, physical maturity, race, and ethnicity.

The initial challenge was to establish open and trusting relationships with all of the students. Julie prepared the class for the study by telling the students that a visitor interested in science education would be spending some time in the classroom and that they had been chosen from students throughout the state. During the first visit, introductions were made and students were allowed to ask questions. Inquiries focused more on the researcher than on the study itself. A connection was made when the students discovered that the researcher was originally from the same large Northeastern city in another state where many of the students had lived and still had relatives. A discussion of familiar neighborhoods between the students and the researcher occurred.

Gaining the trust of students continued for the first few weeks of the study. Although students are conscious of their behavior in a school setting, the informal nature of small group activity allowed some freedom of expression among students. The students seemed to understand right away that their conversations and actions would not have negative consequences or be judged. Small digital audio recorders captured much of the group work. Using two audio recorders allowed the activity of more than one group to be recorded at the same time. The researcher stayed near one of the recorders. The other remained on a table among another group of girls. Although complete field notes do not exist for the second group, the absence of the researcher allowed the girls to do less self-censoring and offered the researcher a different perspective on what was happening. After observing the class dynamics for a few weeks at the beginning of the year, the researcher decided against videotaping because the fluid movement of students would have required a wide-angle lens which would have not provided the type of data collection needed.

Understanding social meanings represented another challenge during observation. Difficulty in understanding the current jargon of the students took time. The culture of 6^{th} grade students is markedly different from adult culture, even within the same ethnic and racial groups (Fine, 1987). Assumed understanding because "all adults have passed through childhood" can lead not only to miscommunication but misinterpretation (Fine, 1987, p. 243).

Research Phase I

Field notes were the principal data source. Detailed field notes were kept during class then typed and interpreted each evening after the visit. A continuous reflective process of observation and revised interpretation guided the process as brief "asides" clarified, explained, and interpreted particular events in the setting and "commentaries" tracked the researcher's experiences and reactions to what was happening (Emerson et al, 1995).

Bateson (1972) refers to this process as “a combination of loose and strict thinking” (p. 75) and identifies it as “the most precious tool of science” (p. 75). It allows the researcher to identify preliminary themes and test those connections by further observation in the field or in this case the classroom. By finding or not finding data to support those themes, the researcher then questions his or her original thinking. New or revised themes are identified that are again tested through observation and other techniques in the field observation. Bateson (1972) writes, “it led me into wild ‘hunches’ and, at the same time, compelled more formal thinking about those hunches. It encouraged looseness of thought and then immediately insisted that that looseness be measured up against a rigid concreteness” (p.75).

The writing of field notes closely followed Emerson et al’s (1995) description:

> In general, writing field notes from jottings is not a straightforward remembering and filling in; rather, it is a much more active process of constructing relatively coherent sequences of action and evocations of scene and character. . . . In turning jottings and headnotes into full notes, the fieldworker is already engaged in a sort of preliminary analysis whereby she orders experience, both creating and discovering patterns of interaction. This process involves deciding not simply *what to include* but also *what to leave out,* . . . (p. 51).

The use of field notes allowed the researcher to observe, record, and interpret what was happening in the setting and then verify that interpretation by returning to the field to observe whether the analysis explains what was happening (Patton, 1990). Preliminary interpretation of the field notes allowed a more nuanced understanding of what was occurring among the girls within the groups and an initial identification of the different ways girls were engaging in the science activities. This preliminary interpretation led back to the field to observe the girls with a particular analytic lens.

Processing of field notes occurred throughout the data collection period but a more detailed analysis took place every two months with open coding as described by Emerson et al. (1995). Line-by-line coding allowed the researcher to start to identify the ideas and issues suggested by the data by noting a phrase to describe the process of what was happening in the setting. At this point in the analysis, small segments of the daily field notes were categorized into a large number of concepts that included what the girls were doing (action) and how the girls were relating to one another in both speech and activity (interaction).

Coding was not aimed at connecting segments of data but rather identifying and naming observations that represented the action and interaction that were taking place (Emerson et al., 1995). Through open coding the researcher created descriptors that focused on the how the girls engaged in science and how they interacted with each other. At this stage, “action” coding included general descriptions of what they girls were doing during assigned science activities. Some of these descriptors included: reshaping science activity, solving problems, pursuing personal interests, exhibiting high energy, moving around, working on personal projects, being proactive, being practical, and engaging in off-task behavior. "Interaction" coding included descriptions of how girls interacted with each other during assigned science projects. These descriptors included: talking about non-science topics, personalizing engagement, sharing experiences, engaging in chitchat, joking and teasing, working together, and jointly embellishing activity. Through open coding, the practices of the girls during group science activities began to emerge. Questions began to develop that focused more specifically on what was happening among girls during these classroom science activities. *How were the girls modifying the activities? How did this modification relate to them? What topics did the girls discuss during science work? What problems beside the basic science work did they solve? What was going on when they began to joke?* More codes developed while others became more specific.

The process of memoing began during this phase. Unlike the asides and commentaries written about a day's events, these memos usually focused on events across several days. The researcher used these memos to re-examine earlier interpretations of data with new information. The researcher wrote these memos to explore general patterns and link different events (Emerson et al., 1995). One such memo focused on the integration of personal conversation into science activities. This memo highlighted the socialization that occurred when the girls engaged in science activities. This emerging pattern was to become the focus of subsequent observations.

Research Phase II

Individual interviews began in the second half of data collection when initial patterns began to emerge. Group interviews were conducted to verify the meaning of events in the setting. Allowing participants to express their beliefs and feelings openly led to a better understanding of the meaning that was being constructed by the girls. Mishler (1986) believes meanings develop during interviews as questions and responses are shaped by both interviewer and respondents. Seidman (1998) also values open-ended questions that allow researchers "to build upon and explore their participants' responses to those questions. The goal is to have the participant reconstruct his or her experience within the topic under study" (p. 9).

Although Seidman (1998) emphasizes the need for a researcher to develop a relationship where the participant is viewed as a "fellow person," he acknowledges that social identities such as race, ethnicity, gender, class, hierarchy, status, linguistic differences, and age affect the relationship between the participant and the researcher (p. 80). He writes, "Interviewers and participants are never equal. We can strive to reduce hierarchical arrangements, but usually the participant and the interviewer want and get different things out of the interview. Despite different purposes, researchers can still strive for equity in the process" (p. 92).

One-to-two formal interviews with 10 girls occurred. Each interview lasted about 10-15 minutes. Interviews were conducted in the hallway or main foyer area of the school building. Group interviews with the girls were also conducted. The group interviews consisted of asking the girls to describe sixth grade, to describe "sixth graders," and to describe themselves. All interviews were audiotaped. The individual interviews were more specific to the classroom. The questions asked followed the types outlined by Spradley (1979) including descriptive questions aimed to encourage the girls to talk about significant features of the classroom such as describing some of the things that go on during group work and structural questions that required explanation from the girls and allowed the researcher to discover how participants organized their knowledge using their own terms in the classroom such as what girls were talking about when they were doing group work (see Appendices C and D for interview questions and preliminary analysis).

The interviews supplemented the observations by filling in gaps of information and offered insider views of the girls' participation. Interviewing only started after fieldwork had begun so questions that were developed were based on knowledge and experience gained in the field.

As more field notes were reviewed during this phase, the researcher began to focus on reoccurring patterns and connect events and observations. The broad categories from Phase I began to be combined into more narrowly focused categories. The descriptors for these categories included adapting science activities, assimilation of interests, personalizing activities, engaging in non-project related activities, multitasking, and connecting science with the personal. Field notes were sorted into themes and re-coded accordingly (Emerson et al., 1995). As patterns became clearer, the researcher returned to the field with a narrower analytical lens looking at how science activities were changed by the girls and how they connected science activities with their personal lives.

Research Phase III

After the identification of broad themes, the researcher employed focused coding to connect data and find patterns of activities. Integrative memos represented the most analytical form of memoing. At this point, the researcher identified primary themes and subthemes and discarded some earlier themes (Emerson et al., 1995). This phase involved reviewing data and additional coding of field notes as patterns began to repeat themselves. Findings were corroborated as field notes, audio recordings, and interviews were compared and recoded. During this time, the story of group work began to emerge through the voices of the 6th grade girls.

Creating Theory From Field notes

The use of coding and memoing is also used with "grounded theory" approach. Glaser and Strauss (1967) describe grounded theory as "the discovery of theory from data systematically obtained from social research" (p. 2). Strauss and Corbin (1998) describe grounded theory as linking data collection, analysis, and theory together in a close relationship. They write, "A researcher does not begin a project with a preconceived theory in mind . . . Rather, the researcher begins with an area of study and allows the theory to emerge from the data. Theory derived from data is more likely to resemble the 'reality' than is theory derived by putting together a series of concepts based on experience or solely through speculation . . ." (p.12). The researcher working within a grounded theory approach is sensitive to the words and actions of participants as well as flexible throughout the collection and analysis process (Strauss& Corbin, 1998).

The researcher employing an ethnographic approach also pays systematic attention to field notes as data. Similar to the grounded theorist, the ethnographer develops and extends analytic categories by continuing to make comparisons across the data. As with grounded theory, the goal of fieldwork is to generate theory that is relevant to the observed activities in the setting (Emerson et al., 1995).

Emerson, et al. (1995) suggest that "grounded theorists focus on the 'discovery' and modification of theory . . . But such an approach dichotomizes data and theory as two separate and distinct entities; it avoids seeing theory as inherent in the notion of data in the first place" (p. 167). According to Emerson et al. (1995) ethnography allows a more continuous interplay between data and theory "whereby theory enters in at every point, shaping not only analysis but how social events come to be perceived and written up as data in the first place . . . . the ethnographer creates rather than discovers theory" (p. 167). The ethnographers' assumptions, interests, and prior analyses of the field notes enter into every phase of data collection. The ethnographer selects certain incidents to describe and emphasizes one participant's perspective on an event. The ethnographers' relationship to the field notes is important. Emerson et al. (1995) write,

> Rather than simply tracing out what the data tell, the fieldworker renders the data meaningful. Analysis is less a matter of something emerging from the data, or simply finding what is there; it is more fundamentally a process of creating what is there by constantly thinking about the import of previously recorded events and meanings (p.168).

However, the qualitative researcher must maintain a stance of neutrality toward findings while at the same time acknowledging personal bias and selective perception. Patton (1990) writes, "Systematic data-collection procedures, rigorous training, multiple data sources, triangulation, external reviews, and other techniques . . . are aimed at producing high-quality qualitative data that are credible, accurate, and true to the phenomenon under study" (p. 56).

Trustworthiness

Issues of trustworthiness in this study were addressed using four constructs proposed by Lincoln and Guba (1985). The first, *credibility,* refers to the soundness of the findings. Lincoln and Guba (1985) suggest several methods to ensure credibility. Prolonged engagement requires the researcher to invest significant time at the setting to understand the "culture" being observed, build trust with participants, and recognize misinformation and distortions introduced by participants. Data for this study was collected through persistent observation for an entire academic year. This prolonged engagement allowed the researcher to identify and focus on significant elements in the setting until identified patterns began to repeat themselves. Multiple sources of data were used which allowed corroboration of findings (Lincoln & Guba, 1985; Marshall & Rossman, 1989).

The second construct according to Lincoln and Guba (1985), *transferability*, refers to the generalizability of the findings to other settings. Although the establishment of transferability cannot be directly specified, thick description of the data is provided to "enable someone interested in making a transfer to reach a conclusion about whether transfer can be contemplated as a possibility" (p. 316). The issue of transferability is addressed by identifying the parameters of the research and describing how data collection and analysis is guided by established models and procedures (Lincoln & Guba, 1985; Marshall & Rossman, 1989).

The third construct, *dependability,* refers to the reliability of the findings with the participants in the setting. Since the social world constantly changes, it is impossible to assess under what conditions the finding can be replicated. This study maintained transparency of all procedures and decisions through the maintenance of organized and detailed notes and memos that describe methodology and analysis decisions (Lincoln & Guba, 1985, Marshall & Rossman, 1989). The dissertation committee, especially the member of the committee who serves as methodologist reviewed both the process of the inquiry by which information was collected and the product or findings, interpretation, and recommendations to ensure that they are supported by data.

The fourth and final construct, *conformability*, refers to objectivity. A researcher brings experiences and knowledge to a study. Distinctive personal experience affects the questions asked and the choice of what is significant. This researcher checked interpretation through the constant reviewing of data and examination of different interpretations (Lincoln & Guba, 1985; Marshall & Rossman, 1989).

All raw data such as written field notes, notes taken during interviews, and any actual documents are identified. Personal notes relating to motivations and expectations are also marked. Schedules and observation protocols are available (Lincoln & Guba, 1985).

Trustworthiness was addressed throughout the research process by clearly identifying the parameters or boundaries of the setting and participants, following a prescribed method of data collection and analysis, and providing in-depth descriptions of the variables and interactions occurring within the observed setting as part of the data (Lincoln & Guba, 1985; Marshall & Rossman, 1989).

CHAPTER 4

FINDINGS

Analysis

During group work the girls in the study engaged in certain practices in science class that allowed them to maintain interest in the activities while satisfying particular social and cognitive needs. The practices enabled the girls to include their social selves within classroom science groups so that the activity merged both the social and school spheres. Collins (2003) writes,

> School is the place where the personal meets the academic. Obviously, course work is of paramount importance in an adolescent's school life, but because middle and high schools are also places where girls develop into young women, the impact of the hundreds of social interactions they have during the course of any day cannot be ignored (p. 64).

Group work in the classroom allows a certain freedom of expression that doesn't always exist during teacher lectures or whole class discussions. When participating in group work, girls engage in multiple activities and discussions that reflect not only classroom expectations but social interaction and concerns.

Three practices of these 6th grade girls, engaged in group work in science class are described, illustrating the ways these girls merged the doing of classroom science with their social lives. The practices are identified as 1) *expanding science activity* to pursue interests and satisfy needs, 2) *modifying science activity* to personalize engagement, and 3) *merging science and non-science talk* to build enthusiasm for involvement.

Expanding Science Activity

The teacher Julie encouraged her students to meaningfully engage with the science concepts by providing open-ended questions to explore. The girls participating in this study did not just follow a linear sequence of steps while exploring a science problem. The phrase *expanding science activity* refers to the way girls digressed from the assigned project while at the same time continuing to be engaged in science-related talking and activity. The girls connected to science in a unique and unanticipated way while at the same time pursuing an academic interest and fulfilling a social need. As a result, their engagement in science intensified.

To understand the concept of expanding a science activity, it is described as stepping off the assigned path or improvising and returning to the path again to refocus attention on the science activity. The assigned project moves forward while the girls incorporate discussion that allows their social interests to be met. Sometime students use non-science classroom resources to deal with an unexpected occurrence, even if the perceived problem is not scientifically relevant to the outcome of the project.

One of the first Life Science units covered in early fall at the beginning of the school year involved plants. The curriculum called for Wisconsin Fast Plants™ from the Carolina Company to be used to explore different aspects of plant growth. The students made beesticks as part of the unit to investigate pollination and the relationship between bees and plants. Students constructed beesticks by inserting toothpicks into the thoraxes of dried bees. In their groups, the students rolled their beesticks over plants until pollen collected on the bees. Students then rolled the beesticks over other plants so the pollen was deposited on those plants. The following excerpt conveys what occurred during the construction of the beesticks and pollination of the plants.

> The plant trays are distributed to the students. Each student in the group has her own tray with several plants. Julie hands out dead dried bees. Each student enthusiastically examines the bees. Tyrah picks up one of the bees with a pair of tweezers. Erika holds three of the bees in her hand. Gabriella has her shirt pulled up over her nose and mouth. Suddenly, students start to excitedly hold their noses as other students start to notice the pungent odor of the dried bees. Julie asks the class to draw a diagram and label the parts of the bee. In one group, Tyrah, Clarissa, and Renee are coloring the bottom of their trays with magic markers instead of drawing their diagrams. When asked the reason for coloring, they reply that the scented markers cover the odor of the bees which makes it less distracting. They continue to color their trays. They announce to the other students that the markers are really working to cover the odor. Soon other girls and some of the boys in other groups start to color their trays. When Tyrah, Clarissa, and Renee are finished coloring their trays, they turn their attention to the drawing of the diagrams (Field notes, October 8, 2009).

There are several aspects of this activity that contribute to an understanding of how girls engage with science. The girls digressed from the assigned science activity by postponing the drawing of the diagrams until they had solved the problem of the bees' odor. Solving the problem required the girls to identify the source of the smell (problem), determine possible solutions (hypothesis), test one of the solutions (experiment), and share the results with others (conclusion – "It works!"). Although this activity might be perceived as a non-related, off-task activity, the girls viewed it as a necessary procedure enabling them to continue with the activity once the problem had been solved. Although the girls behaved in a gender specific way by reacting to the awful smell, their reaction resulted in proactive behavior that solved the problem at hand.

At times the girls expanded the science activity becoming more efficient at the task at hand. During the Plant Unit, students exposed their plants to different environmental conditions to establish what variables would affect the plants' growth. Gabriella and Lesley decided to add highlighter pen ink to the water to see if the added ink would increase or hinder growth of the plants.

> Lesley opens the highlighter marker at the felt tip end to get to the ink directly. She struggles to pull the tip from the pen which does not easily dislocate. Most of the ink flows onto her hands which are stained yellow. She pours the rest of the ink cartridge into the soil of her plant. Gabriella does the same thing. They need additional ink, so they collect other highlighter markers. However, instead of continuing to pull the felt tip from the container, Gabriella starts to construct a device. She finds a long

> thin balloon and attaches a funnel-like device that she constructs from various available materials on her desk. She then proceeds to pour water and then highlighter ink into the balloon. Once the water and ink are mixed, Gabriella and Lesley pour the fluid onto the soil by squeezing the bottom of their invention in much the same way as a baker uses a hand-operated pastry bag. Proud of their ingenuity, Gabriella smiles and says, "It's messy but it's an experiment." Later, at the end of the activity, as the girls clean their work space, Lesley whispers to Gabriella, "Did you get into trouble?" (Field notes, October 13, 2009).

Although Gabriella and Lesley did not have to construct a device to proceed with the assigned activity, they wanted to find an easier way to add the water and ink to the soil. The girls' participation with the impromptu experiment indicated an ease and confidence with trying things that were neither directed nor required. Julie allowed her students freedom to explore but required them to complete the science activities. Gabriella and Lesley were aware that their activity was not part of the assigned tasks as noted by Lesley's concerned question about "getting in trouble." This expanded science activity became the hallmark of group work. Gabriella, Lesley, and others never proceeded from point A to B to C but rather moved in a non-linear path with digressions from point A to C, completing the assignments in their own unique ways.

Gabriella and Lesley valued the time spent on these additional experiments, although sometimes they were not related to the assigned science activity in any way. One day, as the class was leaving the classroom for school dismissal, Gabriella described the whiteout fluid she had concocted. Explaining that she had tried adding water when she was low on whiteout, she described making her own solution by combining glue for thickness and color, hand lotion for thickness, Soft Scrub Cleanser® for the scent, and various other available ingredients for additional scent and thickness. Although her new invention worked, it also disintegrated paper, so she wasn't happy with it (Field notes, February 25, 2010).

This self-directed experiment was not an isolated incident; rather it was a part of continuous, expanded set of science activities that occurred whenever there was extra time. Although Gabriella gave up the idea of creating new whiteout fluid, she and her friends Lesley and Arianna began to experiment with adding color to the whiteout. A few days after the initial experiment, they excitedly showcased their new invention.

> At the back table before the beginning of science class, Gabriella, Lesley, and Arianna demonstrate their new invention to a group of classmates. Gabriella opens the whiteout container. Lesley hands her a marker with the felt tip removed so the ink can be poured into the whiteout jar. Gabriella shakes the jar and then brushes some of the whiteout on a piece of paper. The added ink has not affected the color of the whiteout. Gabriella then adds two additional colors – red and brown – from different markers. Each time she shakes the jar and spreads some of the whiteout on the paper. Finally, the whiteout appears to be tinged with a red or pink color. The demonstration/experiment is finished as the teacher calls them to their seats (March 3, 2010).

On the surface, this demonstration appeared to be little more than students fooling around with available materials for their enjoyment. A discussion with Gabriella and Lesley revealed the scientific process that they followed. After learning about osmosis and diffusion, they wanted to discover how much and which color ink would "spread" through the whiteout causing the color to change. They described what they had done from the numerous attempts to "color" the whiteout. They recited procedures, measurements, experiments, observations, retests, and the ratio of whiteout to marker ink that produced the final result. Although not related to any sanctioned classroom activity, the girls followed their curiosity and did science in the process.

Gabriella struggled with math during the year. She later admitted that if math could be more creative, she would like it more. She added that if she could be asked problems that allowed her to work with whiteout experiments, she would like it *a lot* more.

Girls also expanded the science activity to include other interests, such as creative writing. While maintaining the science topic discussed, they expressed themselves in a medium they enjoyed. Tyrah liked to write and could be observed typing poems on the computer during free time. During a discussion of the environment, Julie emphasized the importance of Earth's resources. After learning about the water cycle, students researched how wastewater is treated and created posters to be presented in class. As the students prepared to begin their work on their posters, Tyrah could be seen writing in her science notebook. At first, it appeared she was preparing her notes for the project. However, Tyrah was writing and illustrating the pages with reflections on an apple tree. Later she tore the pages out of her notebook and stapled them together to create “The Book (poem) about the Apple Tree.” Here it is verbatim:

> This is a tree, an apple tree,
> It’s just simply . . .
> an apple tree. You
> see it as a tree with leaves,
> but no, no, no
> it’s an apple tree.
> We eat from this
> tree, whe shade near
> this tree, Climb in
> this tree, Hide behind
> this tree, but to
> others you see . . .
> It’s just a plain ol’
> apple tree.

On another page, she wrote

> Heres an apple
> from the apple tree
> but that’s another
> poem you see. This
> apple is nice, red

and sweet.
Apple gone all
ate up, all
thats is the
core and seeds,
thats the part that
you cant eat. I'll
plant the seeds to
make another apple
tree. (Field notes, November 19, 2009)

Although this event differed from the previous examples, it stood out because of the connections Tyrah made between her writing and the science material being discussed. "The Apple Tree" book emphasized the renewal of nature ("plant[ing] the seeds to make another apple tree"), the obliviousness of the public to the beauty and importance of nature ("you see it as a tree with leaves"), and personal responsibility ("I'll plant the seeds to make another apple tree"). Julie mentioned all of these themes as part of her unit plan. Although Tyrah completed the required poster and subsequent presentation to the class with Renee, she revealed a deeper understanding of the core content through her own writings and was able to add an activity she enjoyed (writing) to the science project. In this way, she expanded the science activity to incorporate her own interest in creative expression.

In each of the examples, the girls increased their engagement in the science activity by extending the activity beyond it assigned parameters. Their participation did not follow a proscribed path but rather digressed from the activities. Their digression served to solve a problem, to make things easier, or to use a cherished skill in the process of doing science. By expanding the science activity, they promoted engagement and maintained interest throughout the group work.

Modifying Science Activity

Sometimes the assigned science activity was modified rather than expanded. In these instances the girls would incorporate aspects of themselves in the actual tasks that had to be completed. Rather than expanding the science activity, the girls personally connected with the science activity. The phrase *modifying science activity* refers to the practice of changing components to individualize the science activity. In this way, the girls engaged with the activity on two levels. First, they responded in the expected classroom manner. Second, they made their activity their own by assimilating aspects of themselves into the task. One way girls modified the activity was through role-playing, where the girls would adopt different personas as they engaged in assigned science activities.

Role-playing in this context refers to the creation of a role that is superfluous to the assigned activity. It may be short-lived, or it may be woven into the activity for an extended period of time. Most of the role-playing involved personifying some of the science materials. During the unit of plants, Gabriella and Lesley named and talked to their plants as if they were children. They took great pride in the growth of their plants. The following excerpt reveals how they incorporated their role-playing into the activity.

> At the beginning of class, Gabriella collects her plant from the back table. She speaks to her plant as if talking to a child. 'Oh, you look so good. You've grown so tall.' Without looking at any of the other students, she adds, 'See what happens when you talk to a plant.' Later Gabriella and Lesley are sitting at their table recording the measurements of the height of their plants. Lesley is measuring while Gabriella records. Gabriella has also drawn numbers on small pieces of paper. She points to her plant, 'This is Susan. She gets $20 for her allowance.' She points to Lesley's plant, 'This is – what's her name?' Without looking up from her measuring, Lesley responds, 'Julia.' Gabriella continues, 'This is Julia. She gets an allowance of $1.' Gabriella begins to sing to her plant while gently touching it. She continues to record measurements (Field notes, October 13, 2010).

When asked later about talking to her plant, Gabriella said, "That fits in with my way of science. If I have plants, if I'm planting plants and I want it to grow more, I talk to it, . . . comfort it, pretend it can hear me . . . In a way, I was helping it grow." Gabriella did not consider this action as off-task or not related to science. She modified the activity to help her plant grow (Interview, June 10, 2010).

Similarly, during an activity exploring the effects of different solutions on eggs, Tyrah and Nicole held, caressed, and talked to their eggs before putting them in the solutions. Tyrah even joked, "I'm not going to be the only one taking care of these kids!" Later, when discussing her personification of the egg, Tyrah said,

> I think it's part of the science work because to me, if like when I'm talking at it and treat it like my little egg, it's just like me caring for my project but in a more sensitive way . . . so instead of just like building a plant and just leaving it or taking the egg and just putting it away, it's just more . . . it feels like to me you're learning the project more and like . . . having fun that way (Interview, June 8, 2010).

These role-playing practices became part of the activity and were considered by the girls to be integral to learning. In Gabriella's instance, she was helping her plant to grow, while Tyrah viewed her actions as injecting fun into the project and consequently learning more. Modifying the assigned science activity with role-playing allowed the girls freedom to express their individual personalities. Those who participated in this activity incorporated their actions so they were not distracted from the assigned task. In most cases the role-playing seemed to deepen the engagement with the project.

Girls also modified science activities by personalizing aspects of the assignment. Personalizing here refers to the way girls projected themselves into the activities by informally connecting to the content. This connection could take the form of social interactions or incorporating personal objects into the project.

Social interactions occurred throughout the science activities. The girls playfully teased one another as they continued with their activities. Teasing gave them an opportunity to continue their social networking while participating in science. During an extended activity on adaptation of animals, students were asked to design a dog whose characteristics would help it do a job of the students' choosing. Before drawing their new breeds, they had to research the characteristics of actual breeds of dogs. The following excerpt took place several days into the activity, after students had researched facts about dog breeds.

> Gabriella, Lesley, and Arianna have completed a poster with six columns. At the top of each column are images of six breeds of dogs – two for each girl. The poster shows a Doberman Pinscher, Shiatsu, Prazky Krasurik, Boston Terrier, Min Pin, and Dachshund. The girls playfully banter back and forth about how they are each similar to the dogs depicted on the poster. Arianna describes how she is mostly like a Doberman – 'loyal, kind, good guard dog.' Gabriella adds, 'Yeah, you're a Doberman . . . Like if I ever touch her pen . . . Last time I touched her pen and she smacked me down, threw me on the ground.' Lesley then says she is like a Prazsky Krysarik. Gabriella lists the characteristics of the dog while simultaneously describing Lesley – skinny, scrawny, listens a lot. Earlier Gabriella had described Lesley as a Chihuahua, tiny but with a strong bark. Finally, Gabriella describes herself. 'I am mostly Min Pin [Miniature Pinscher], loyal, cute . . . I am more of a dog who doesn't know what is happening.' She goes on to talk about her dog, Buddy, who never knew what was going on around him (Field notes, February 25, 2010).

The back and forth banter of the conversation occurs easily and reveals good-natured teasing among the girls. The teasing gives the girls an opportunity to socialize and reveal feelings about each other within the topic of the science lesson. They modified the activity to allow them to discuss dogs in the way in which they were familiar while they completed the assignment. The girls valued this interaction. Lesley, a small, slight girl described in the above passage as “skinny and scrawny” later revealed that talking during group work helped her. “I’m also like building up some social skills. . . . I think it helped me so that I’m not always bored like if I had no friends, then I’d be really bored all the time and I wouldn’t really get along with other students as well” (Interview, June 10, 2010).

Personalization of science activities also included incorporating personal interests in the project. Choosing a theme that interested the girls allowed them to connect to the science material in a more personal way. Unlike the design a dog assignment, the personalization became part of the science project, not just a topic of discussion.

While teaching about the concept of stratification as a historical and geological process, Julie directed the students to create a model showing the layers of the earth found at a geological or archeological site. She instructed them to bury objects to illustrate what would be found at the different layers of the Earth.

Melanie and Nicole worked together on this project. Unlike the other groups, they decided to construct an undersea model of the Earth’s layers. Melanie explained that they wanted their project to be different from the other students in the class who were constructing land-based models with dinosaurs (Interview, June 8, 2010). Both Melanie and Nicole loved the feature film “Titanic” and wanted to incorporate elements of a sunken ocean liner. Melanie also liked boats. Melanie had a blue napkin that they crumpled and used as the water on the top. They understood that the oldest layer was on the bottom, with each later time period added chronologically on top. They put the older fossils on the bottom and labeled each layer according to the geologic timeline. They incorporated their Titanic storyline near the top. Nicole and Melanie placed a broken boat in the model and used metal game pieces (shoe, top hat) from Monopoly® to represent different artifacts from the ship. They also included a toy ring with a "blue diamond" to represent the necklace from the fictionalized story featured in the movie Titanic (Interview, February 11, 2010).

Melanie and Nicole's interest in the geological time model was minimal. Dinosaurs did not excite them, and they wanted to do something that was "different" from the other students. By incorporating the Titanic theme into the project, they modified the activity without losing the goal of the assignment. They constructed the model, which reflected their understanding of geological time zones in the Earth's layers. At the same time, they were able to engage in discussions about the movie Titanic while receiving praise from Julie for their creativity and unique interpretation of the assignment.

In each of these examples, the girls engaged in the science activities by changing aspects of the lesson or activity that allowed them to relate to the activities in more personal ways. This modification included individualizing the activity so the girls could participate in the expected classroom manner while socially interacting with each other.

Merging Science and Non-science Talk

The girls in the study also engaged in conversations during group activities that combined science and non-science talk. Girls would begin the assigned science activity by concentrating on the task at hand. As the activity proceeded, girls would break into other strands of conversation sometimes tangentially related to the science topic and sometimes totally related to their own lives. *Merging science and non-science talk* refers to the way the girls switched between school talk and personal talk in a fluid way, without allowing the social talk to overshadow the school work. The merging of science and non-science talk allowed the girls to incorporate their personal lives into the science activity. As with expanding and modifying science activity, merging talk gave the girls an opportunity to project their personal selves into the activity.

During a Life Science unit on habitats, the students created individual terrariums to examine the interactive nature of living ecosystems. The students placed mosquito fish, snails, rocks, and parrot feather in the bottom half of a plastic soda bottle filled with water. The top half was inverted and placed over the top and filled with dirt, "roly-polys (isopods)," carrots, and wet paper towels. To observe the roly polys more closely, students were allowed to remove the isopods from the soil and hold them in their hands. The following is an excerpt from one of those encounters.

> Erika, Lesley, Melanie, and Arianna are looking closely at the roly polys that are crawling on their hands. Erika has done some research at home, so she shares facts about them with the others. 'They don't sting; they use

their antennae to help them get around.' As she points to a 'boy' (her word), Melanie asks her how she can tell the difference. She responds that the dark ones are the boys and the lighter ones are the girls. One of the roly-polys starts to curl up into a ball and Erika explains that they roll up into balls when they do not feel safe. Lesley, noticing that one of the roly polys is not moving, exclaims that it has died of fright. The girls look closely, but it starts to move its legs. As they continue to monitor the roly polys, Erika announces that she will not be in class on Friday because she is going camping this weekend. She tells the other girls that it is going to be freezing but she will be sleeping 'in a cabin on an air mattress, not bunk beds.' Lesley adds that she and her sister have two sets of bunk beds. Each girl sleeps on the top bed and uses the space below for other activities. She then remarks that the roly polys 'stink.' The girls continue to examine the roly polys. Without lifting her eyes from her observation, Erika tells the others she 'hopes she doesn't see any crickets or frogs' when she goes camping. Without missing a beat, Lesley says she had two frogs. Arianna jumps in, 'One froze to death.' Suddenly, Erika notices that one of the roly polys is shedding and the girls' attention is focused solely on the roly polys (Field notes, May 11, 2010).

In this description, the girls engaged in several conversations during this activity. Although they never stopped examining the roly polys, Erika used the activity time to share her weekend camping plans with her classmates. Although her interest in the science activity was high, as evidenced by her supplemental research at home, she nevertheless continued her description of her upcoming trip during the activity. Although Erika dominated much of the conversation, the other girls rather than being bored or distracted by her talk, continued to observe the roly polys and added to the conversation not with descriptions of their weekend plans but with information that was only tangentially related to the discussed topic.

Of particular interest is their fluid intercutting of science and non-science talk that occurred naturally. To the casual observer they may not have seemed to be on task but for the girls their social interactions added to their enjoyment of group work in science class. The students enjoyed being able to discuss other things during the less-structured group work in this class. When asked to compare the group work in another class where the teacher has a different management approach, Erika responded, “I don’t like that because we’re just talking about one topic, and then we try to talk to each other at the same time, but then she just says, oh put your name on the board, blah, blah, blah and then we go OK and we put our name on the board” (Interview, June 8, 2010). The girls did not view their conversations as interfering with their classroom work.

Merging science and non-science talk did not just take place during observation activities. Even when girls were actively engaged in physical activity, they continued their practice of switching between the personal and the assigned activity. They engaged in non-science talk even when the science task at hand was challenging and unfamiliar.

As a special activity, Julie bought a robot kit from a specialty store. The owner of the store came to the class over the course of several weeks to conduct a workshop with the students so they could construct a robot. Julie divided the students into three groups, with each group being responsible for one component of the robot such as treads, base, and arm. Although the assigned groups consisted of boys and girls, there was little to no crossing of gender lines as the students began their activities. Both the oral and written directions were confusing at times for the students, but they persisted in the building of their component.

During the second visit by the storeowner, one of the teams was charged with getting the treads on the robot. The girls on the team – Erika, Lesley, and Renee – disassembled the frame from the previous week and redid it because of a change in directions. This setback did not deter the girls and they diligently followed the directions that were provided as they constructed the robot. Jenna joined the group because her team had finished their assignment and was waiting for the first team to finish so the two components could be connected. Renee and Jenna secured wheels with collars. Erika and Lesley turned screws and added supports. When they encountered a problem, they consulted the written directions, or called the storeowner to the table where they were working. As noted in the field notes, conversation continued throughout their work.

> The girls work carefully to assemble the robot. They follow the written directions. When the screws for one part do not fit, they try other hardware. Everyone is working on a different part of the robot. The conversation jumps from robot-based to personal and back to robot-based without any awkwardness or break in the activity. As they were turning screws or adding supports, they spoke of upcoming Spring recess. Renee discussed

> her upcoming travels to New York City to visit relatives. They all discussed people they knew in the area, recounted incidents from the neighborhoods, and described how they would be traveling. Abruptly, that strand of conversation would stop, and they would be engaged in discussions of the robot (Field notes, April 16, 2010).

Future plans were not the only non-science talk that occurred during science activities. Conversations could be triggered by something mundane happening in the surrounding environment. One very hot day late in May, the students were attending their Science Literacy class, which they attended twice a week. The teacher, Ms. Beverly Mason, decided to hold the class session outside, since the air conditioning was not working. Some girls sat on the low concrete ledge surrounding the school, while others sat on the grass. Beverly distributed worksheets, which included word searches, number games, and logic puzzles. Clarissa, Tyrah, and Nicole sat together on the concrete wall. Although Beverly usually did not allow talking among students during class, outside the atmosphere was more relaxed due to the heat in this outdoor environment, and the students collaborated more than usual. During this time, flying bugs continually bothered the students, who swatted at them. Soon the conversation turned from the worksheets to the bugs, as the following excerpt illustrates.

> Nicole excitedly jumps off the wall and announces to everyone within earshot that she hates bees. She sits down again but nervously looks around. Clarissa mentions that she was once stung by a bee but they couldn't find the stinger. Nicole reacts to the story with disbelief. Tyrah

glances and nods at Clarissa as she tells her story but continues to do her work. As Clarissa is telling the story, Tyrah asks, 'Have you found *electron* [referring to the word search]?' Clarissa and Nicole check their worksheet and answer they have not. As that exchange ends, Clarissa and Nicole are looking down at their worksheets but Clarissa continues her story about the bee sting. When she is finished, she, Nicole, and Tyrah turn their full attention to their worksheets.

Each girl contributed in a unique way to the merging of the science and non-science talk. Nicole initiated the merge (prompted by the bee in the environment) by announcing that she hated bees. Clarissa then became the main focus of the interaction by telling her bee story. Nicole then retreated into the listener position. Although Tyrah was not directly involved in the interaction and did not concentrate solely on Clarissa's bee story, her head (nods) and eye (glances) movements indicated her attention to the story. She acted as a secondary listener, thereby encouraging Clarissa to continue. Since she was still involved with her work, she interjected a question about the assignment. This action brought Nicole and Clarissa back to their work, although Clarissa did finish her story. As with the earlier examples, the girls combined their science work and non-science talk in a fluid, inclusionary way, allowing them to socialize while completing their work.

The merging of science and non-science talk occurred during all aspects of group work. The girls were able to switch between project and personal conversations without disrupting the science activity. The girls conducted multiple strands of conversation during group work which served to keep them engaged in the science task rather then serving as a distraction to them.

Discussion

This study sought to address two research questions – "How do girls engage in school science?" and "What do girls reveal about themselves when engaged in school science?" The answers to these questions are explored through a discussion of the ways girls merged social interaction and science activities and the ways girls adopted multiple roles during group work.

Merging of Social Interaction and Science Activities

Social interaction, especially during group work, plays an important role in engaging students in school science. Early adolescents who are coping with the onset of puberty come to school with social and emotional needs that influence and impact their classroom experiences. As students work to establish new relationships, develop interpersonal skills, experiment with social identities, and enter new communities of peers, they are simultaneously entering a school environment that demands academic development (Wentzel, 1996).

As the girls in this study engaged in assigned science activities within small groups, they merge their social and academic worlds in ways that are sometimes subtle and sometimes obvious. They expanded science activities by digressing from the science activity and following strands of scientific thought that served a practical but not essential purpose. They modified science activities by adding or changing aspects of the activities to incorporate part of their individual or collective personalities. They easily switched between talking about the science activity and talking about other more personal subjects as a way to maintain social connections while building momentum for the science work.

At first glance, it might appear that the girls were engaging in off-task activities. Hofer (2007) describes off-task behavior as "all activities not directed toward learning" (p. 28). He writes, "When teachers begin a teaching session pupils usually display on-task behaviour – they pay attention to the teacher's instructions and concentrate on the task. When pupils cease to follow the teacher's instructions, alternative actions are no longer inhibited and pupils disengage from activities related to learning" (p. 28).

One of the triggers of off-task behavior Hofer (2007) describes is competing goals. The student chooses one goal when that goal is more attractive or more important at that specific point in time than the other competing goals. Wentzel (1996) identifies three sets of goals – prosocial, socially responsible, and academic – that students strive to reach. Each of these goals can motivate behavior, however the students may pursue multiple goals. Wentzel suggests that socialization is part of the schooling process and social competence represents a positive aspect of school adjustment. She writes, "[P]ursuit of goals to behave in prosocial and responsible ways appear to be an underlying variable that links social adjustment with positive academic outcomes" (p. 240).

The girls in this study were able to coordinate their social and academic goals by pursuing both goals at the same time so the perceived "off-task" behavior became part of the science activity. Certain conditions may lead to goal conflict, as identified by Hofer (2007). The first, *interest of the main task*, refers to the level of interest (for the students) in the learning activity. Students turn to off-task behavior if the activity does not hold their interest. The girls in this study used their "off-task behavior" to increase their interest level. Melanie and Nicole incorporated aspects of the Titanic in their undersea model of the Earth's layers. Gabriella, Lesley, and Arianna chose to design a dog using breeds that represented aspects of their personalities. All the girls were able to increase their interest level in the science activity by simultaneously pursuing socialization and academic goals. Melanie and Nicole legitimized talking about the Titanic, while Gabriella, Lesley, and Arianna good-naturedly teased one another about their personalities.

The second condition that leads to goal conflict according to Hofer (2007) is *attractiveness of the alternative*, which refers to the appeal of the conflicting goal. The girls in this study solved this dilemma by incorporating the alternative (socialization) into the academic activity. The girls continued to discuss weekend or vacation plans (socialization goal) while observing isopods or constructing robots (academic goal). Attention to scientific details was not sacrificed to personal discussion. The data revealed patterns during this socialization process showing that the girls managed the off-topic discussion by switching seamlessly from the personal to the science-related task without interrupting the flow of either.

Hofer's (2007) third condition, *value orientations*, refers to the emphasis students place on different academic and social goals. The girls revealed in interviews that they place value on doing science. They also believe that socializing during science work added energy and new ideas to the process.

The last two conditions, according to Hofer (2007) that lead to goal conflict are *self-determination* and *self-regulatory strength*. Since the girls experienced a great deal of autonomy in their groups, they were able to self-regulate and determine if, when, and how much socialization occurs. By synthesizing their social and academic goals, the girls in this study kept their attention focused on the academic tasks by using "off-task" behavior to increase interest in the science activities. Hidi and Harackiewicz (2000) describe situational interest as being "generated by certain conditions and/or stimuli in the environment that focus attention . . . and centers on responses to environmental factors that promote interest in a particular context" (p. 152-153). Enhancing situational interest may increase student involvement and academic motivation, especially in areas when individual student interest in a topic may not exist. According to Hidi and Harackiewicz, in addition to modifications to learning tasks, situational interest may be increased by working in groups where students work together to develop and use strategies that help them engage in uninteresting tasks. These efforts help them to maintain interest and to persist in required activities.

The girls in the study continually engaged in strategies that made the science activity more enjoyable and interesting to them. When the dead bee odor became overwhelming, the task of pollinating their plants became unappealing to Tyrah, Clarissa, and Renee. Their interest in the activity waned. Rather than complaining or not participating in the task, they engaged in something they enjoy (coloring with markers) and solved the problem at the same time. They then continued with the pollination of the plants.

Since situational interest depends on certain conditions of the learning environment, it is important for students to have several different strategies to promote engagement. When creating a device to pour highlighter ink into the soil, Lesley and Gabriella did not just rely on something they enjoyed doing. When the messiness of the ink on their hands threatened to sidetrack their interest, they created a device from available materials that could solve the problem and keep their hands clean.

In some instances, the girls created or triggered situational interest in an activity that didn't excite them as evidenced by Melanie's remark, "just plain dinosaurs." Melanie and Nicole used their interest in the Titanic to get enthusiastically involved in their layers of the Earth project. Other times, students such as Tyrah, Clarissa, and Renee used their strategies (coloring) to hold their attention in the activity.

Identifying the girls' strategies for engagement allows us to look at what is happening in the classroom in new ways. Morgan-Fleming et al. (2003) write that "the on-task/off-task dichotomy is an overly simplistic . . . model with which to capture the habits of mind that lead to learning" (p. 1). They question the connection between on-task behavior, learner attention, and activity to persistence and motivation. They believe that at some level, people are always engaged and learning. Certain parallels may be made with girls' activities in science class. Morgan-Fleming et al. view play as an opportunity to invent and adapt and note the connection between play and scientific research. Lorenz, as cited by Morgan-Fleming et al., writes,

> All purely material research conducted by a human scientist is pure inquisitive behavior – appetitive behavior in free operation. All scientific knowledge – to which man owes his role as master of the world – arose from playful activities conducted in a free field entirely for their own sake. . . . Anybody who has seen in his own activities the smooth transition from inquisitive childhood play to the life-work of a scientist could never doubt the fundamental identity of play and research (p. 4).

The merging of social interaction and science activities takes on a new perspective when viewed from this perspective. Girls' inventions such as ink pouring device, color-tinged whiteout fluid and their sidebars, for example coloring of plant tray to mask odor become examples of non-sanctioned activities which are scientific explorations in their own right.

The girls engaged in science in ways that served their needs and reflected a style of learning that combined social interaction and science activities. The girls' ways of knowing can be connected to Belenky et al.'s (1997) "epistemological perspectives from which women know and view the world" (p. 15). According to Belenky et al, the fourth perspective, *procedural knowledge*, includes two distinct forms *separate* and *connected knowing*. The girls in this study were connected knowers when they worked in small groups. Belenky et al, write,

> Connected knowing builds on the subjectivists' conviction that the most trustworthy knowledge comes from personal experience rather than the pronouncements of authorities. . . . Since knowledge comes from experience, the only way they can hope to understand another person's

> ideas is to try to share the experience that has led the person to form the idea (p. 113).

The girls demonstrated connected knowing through their intimate, informal, and unstructured conversations during science activities. Their conversations developed from trust and continued to build trust. Belenky et al. (1997) write, “Conversations grow out of connection, and they cement connections” (p. 116). Gabriella, Lesley, and Arianna teased one another as they worked on their poster showing the different breeds of dog. They revealed their familiarity and knowledge of the characteristics of different dogs by comparing each other to the dogs depicted on the poster. They completed the assignment on the adaptation of animals while strengthening their relationship at the same time.

Connected knowing is also revealed when Erika, Lesley, Melanie, and Arianna examined the roly polys crawling on their hands. Multiple strands of conversation including science and non-science talk flowed through the activity. There was no competition for attention. No one tried to monopolize the conversation. Belenky et al. (1997) describe learning by connected knowers as looking through the lens of another person by developing “procedures for gaining access to other people’s knowledge” (p. 113). The girls demonstrated what Belenky et al. call procedural knowledge in their small group work, even though they might exhibit other epistemological perspectives at other times in the classroom.

Girls engaged in science activities in small groups created a unique combination of the school and social spheres. When doing group work, these 6^{th}

grade girls created a way of doing school science that merged their ways of social interacting with assigned activities that allowed them to increase engagement with science without losing their own social ways of interacting that serve them throughout their lives.

Adopting Multiple Roles

The girls in the study easily adopt multiple roles while engaged in science activities in the classroom. They occupy the role of science students by hypothesizing, testing, measuring, recording, discovering, and concluding while simultaneously taking on their social roles of friends and classmates. This merging of roles suggests a complex interrelationship between the social and academic tasks. Instead of conflict of roles, the girls in this study maintain their social roles as friends and classmates while engaging in class science activities. The girls were able to continue their socialization process as they embarked on their academic work. Instead of detracting from their science activities, they were able to enrich their in-class projects through their way of activity, interaction, and connection. This dynamic suggests that what is happening is more complex than a simple division of social and academic activities of science.

Similarities to managerial women may be found in Ruderman et al.'s (2002) study on multiple roles for women. Ruderman et al. found that combining employment and personal roles provided benefits which included the sharing, integration, and expansion of resources across home and work domains. Specifically, benefits could be grouped into *psychological resources* and *social support*. Psychological benefits included the increase of one's self-worth.

According to Ruderman et al. multiple roles offer numerous opportunities for positive self-experiences. They write, “[W]omen who have more roles have more opportunities to feel good about themselves, their activities, and their accomplishments” (p. 371).

Similarly, multiple roles for pre-adolescent girls offer positive opportunities. Self-worth as a benefit is very relevant for 6^{th} grade girls. As girls enter puberty, they are simultaneously experiencing physical, social, and psychological changes in their lives. Their bodies begin to exhibit physical transformations as they begin to mature. Unlike the attributes of size and strength that are usually associated with puberty in boys, a developing and bigger body type does not always signal a positive change for girls. Additionally, girls face different social norms, new rules, and changing relationships (Sadker & Sadker, 1994).

In 1990 the American Association of University Women (AAUW) conducted a nationwide survey that examined male and female students at different stages in their education. Sixty-nine percent of elementary age boys and sixty percent of elementary school girls agreed with the statement “I am happy the way I am.” By the time of high school the percentages had dropped to 46 and 29 respectively, revealing a much greater decrease in self-image among girls (American Association of University Women [AAUW], 1992).

Although the percentages varied across different racial and ethnic groups, girls nevertheless showed a drop in self-esteem from elementary to high school. White girls exhibited the greatest drop in being happy from 55% (elementary school) to 22% (high school). The self-esteem of Hispanic girls decreased from 68 to 30 percent while African-American girls showed the least change from 65 to 58 percent. African American girls, however, did not exhibit high levels of confidence in academic areas (AAUW, 1992). Sixth grade represents one of the transitional years between elementary and high school.

Additionally, a connection between self-esteem and academic achievement exists. Sadker and Sadker write,

> When girls lose confidence in their ability to learn math and science, they avoid these subjects. When they believe they can't succeed, they become less willing to attempt new science and math tasks. As they have fewer and fewer experiences with math and science, they become less capable. As their competence withers, so does their self-esteem, and the vicious, connected cycle continues: attenuation of self-confidence that leads to loss of mental ability and results in the diminishment of self-confidence (p. 97).

The girls in this study showed confidence in their science abilities. Several of the girls mentioned science-related fields as career occupations. When doing science, they were not solely focused on science activities. They talked about weekend and vacation plans; they played the role of a caregiver when talking to their plants or eggs. The girls acted as science investigators as well as storytellers and conversationalists. The confidence they displayed during their socialization was carried over into the science activities, even though much of the school science was new to them.

Ruderman et al. (2002) also identify social support as a benefit of multiple roles for managerial women. They write, “Higher levels of social support were associated with lower level of strain symptoms” (p. 371). Julie’s support of a collaborative, student-centered classroom corresponded with her inclusion of difficult science topics. The students used the social support of their classmates to help them interpret and examine science issues.

The idea of personal relationships influencing science involvement is also explored by Lee (2002) in his study of high-achieving high school students enrolled in a summer science enrichment program. Although the focus of Lee’s study on the retention of students in science and technology fields did not include a representative sample of the general high school population but only successful and interested students, certain aspects may be considered when examining the girls in this study. Lee found that new social relationships gave girls a stronger science identity.

The classroom represents a place where school, community, and personal lives coexist, so there are opportunities for the emergence of multiple roles and the possibility of conflicts when those roles have different goals. Varelas et al. (2002) explored the meeting of youth, classroom, and science genres in a sixth-grade urban science classroom to examine student experience. Genres, as described by Varelas et al., are “both the tools by which we make sense and perform in the world, . . . and a product of this activity. . . . [G]enres inherently incorporate social aspects of our ways of doing and knowing” (p. 581).

According to Varelas et al. (2002), the youth genre is not a fixed entity but one that is specific to a particular culture and generation. Students bring their own values, practices, and interpretations to the classroom, which influences their interaction in both social and academic tasks. The resources they bring to the classroom impact their academic exploration. The classroom genre, according to Varelas et al. (2002), includes the “relations, expectations, norms, habits, and interactions between the teacher and the students, among the students themselves, and among the students, the teacher, and the subject matter” (p. 582). The teacher and students bring different classroom genres.

Julie’s classroom atmosphere supported the girls’ practices. The girls’ incorporation of multiple roles was allowed to emerge. Julie’s classroom genre included independent group work with a strong emphasis on student initiative, collaboration among classmates, and sharing of work. The student-paced activities that were supported by Julie created an atmosphere that encouraged and allowed socialization as students participated in science activities because of the teacher’s acceptance of the merging of the youth and classroom genres.

The science genre in Julie’s classroom was based on inquiry, another aspect that allowed the girls to incorporate multiple roles easily and seamlessly. Inquiry classrooms expand the role of students and create a social and participatory environment where students need to work collaboratively with other classmates to learn. Although Julie also used traditional methods of teaching, group work demanded inquiry that required both the teacher and the students to participate in social interactions within a learning community.

Students also took implicit cues from the ways that Julie positioned herself and the explicit directives from what she said. These cues determined the character of student participation and allowed the multiple roles of the girls to thrive within the science genre (Enyedy, 2004). In Julie's classroom, the environment also allowed the girls to define their own terms of participation, which took the form of taking on several seemingly incompatible social and academic roles.

The 6th grade girls acquired the ability to multitask or occupy many roles when engaged in group science work. Their commitment to multiple roles allowed them to expand and modify the science activities.

Gilligan (1991) wrote that adolescence marks the time in a girl's life when she initially faces the dilemma of being labeled *selfless* (responsive to the needs of others) or *selfish* (responsive to her own individual needs), a choice that is viewed as mutually exclusive. She viewed eleven and twelve-year old girls as "astute and outspoken and clear-eyed resister[s] . . . in danger of drowning or disappearing" (p. 37). Through her interviews with adolescent girls she noted that girls constructed an intricate knowledge of the social world by relying on their power to see and listen, to understand responses and reactions, and to value thoughts and feelings. They viewed relationships as a way to gain knowledge about others and themselves but as Gilligan writes, "[T]hey will speak only when they feel that someone will listen and will not leave in the face of conflict or disagreement. Thus, the fate of girls' knowledge and girls' education becomes tied to the fate of their relationships" (p. 47).

Gilligan's (1991) work relates to the literature on adolescence discussed earlier which emphasizes social changes taking place, including the ways adolescents are viewing and relating to others while becoming aware of deeper feelings on an emotional level (Walker and Lirgg, 1995). The interactions of the girls in this study further illustrate the significance Hurd (2000) puts on interaction with peer groups and friends on identity formation.

The girls in this study related to others in a social manner even while participating in group activities. The importance of interaction can be seen in the way they continued their social connections while maintaining interest in science work. The trust they felt toward the other members of their group allowed them to feel safe in sharing both personal as well as classroom science information.

In a way, the girls in this study did not feel what Gilligan (1991) identified as "the dilemma of inclusion" where women and young girls struggle to "include both oneself and others in one's life" (p. 33). The girls' participation in science activities in single-gender groups allowed them to merge their socialization with their science activities and to adopt multiple roles that did not require them to choose between being selfless or selfish.

Until this point, the issue of race and ethnicity has not been identified as a factor in the findings. The girls in this study belonged to non-mainstream populations. As discussed earlier, girls from non-mainstream groups may have cultural habits and beliefs that differ from the accepted school-endorsed mainstream white traditions. According to Brickhouse et al. (2000) African-American women are not always silent participants in their communities. To counteract challenges of belonging to two marginalized groups, emphasis is placed on self-determination, strength, and assertiveness in girls (Thomas & Rodgers, 2009).

In the face of oppression and discrimination girls from non-mainstream groups may depend on their resilience and their ability to, as Aikenhead and Jegede (1999) write, “travel from their everyday life-world to the world of science found in their science classroom” (p. 274). The girls in this study used their socialization as a bridge to connect their everyday life to the world of classroom science. Aikenhead and Jegede (1999) further wrote that to be successful, students must be able to switch “from being one person in one context to being another person in a different context, without losing [their] self-identity (p. 273). The adoption of multiple roles by the girls in this study allowed them to maintain their identity, along with the confidence and familiarity it brought, within their new roles in science. In this way, the retaining of their identities may have helped them to successfully maintain engagement with school science.

In this study, group work in the science classroom represents a complex activity that involves the merging of academic content and social relationships that allows girls to maintain their identities and play different roles while engaging in the science activity. The ease with which girls manage these identities and roles reveals that a simple division between academic and social worlds is not appropriate. The complicated merging of social interaction and science work and the adoption of multiple roles enrich classroom science activities and allow the girls to actively engage in science. The girls engaged in interaction that demonstrated understanding through application of the concepts, ideas, and content of the lessons in their own ways.

CHAPTER 5

CONCLUSION

The most recent reform in science teaching and education began in 1989 with the publication of *Science for All Americans* by the American Association for the Advancement of Science (AAAS). It called for scientific literacy for all students. In 1996, the National Research Council (NRC) and the National Science Teachers Association (NSTA) developed the *National Science Education Standards*. Attention is again focused on science education. Science has become the latest content discipline to be included in the No Child Left Behind (NCLB) performance measures (AAAS, 1990; NRC, 1996, Southerland et al, 2007).

As science education becomes part of reform efforts, it is important to examine the experiences of all students who have been marginalized. Although Science for All Americans, the National Science Education Standards, and NCLB stress the importance of equity for all students, they do not provide a blueprint for the multiple approaches needed to teach science to diverse students (Rodriguez, 1997). Examining the ways girls do science, especially those in urban areas, is crucial to understanding what is needed to help these students reach the goal of scientific literacy not through changing the "girl" but through accommodation of the way girls engage in science (Southerland et al., 2007).

Understanding what girls, especially urban girls of color, do when they participate in school science activities can lead to science classes where girls feel they can undertake science exploration on their own terms using practices with which they feel comfortable. This understanding is especially important for 6th grade girls who are undergoing the strong physical, emotional, and social changes brought on by puberty.

This study presents ways in which one class of 6th grade girls maintained engagement, which better ensured their continued participation in classroom science activities. The study also revealed ways the girls increased their own interest and involvement as necessary precursors to learning.

The girls created their own unique engagement in two ways. First, they merged their social and science interaction which allowed them to claim ownership of the science activities while legitimizing their social ways of participation in science. They were allowed to socialize within the context of the science activities. They did not have to choose one role over another. The second way they created their own unique practices was through the adoption of multiple roles. They could continue their social roles as they took on the roles of science students. Their multiple roles allowed them to transfer the confidence associated with the roles of being a friend to the unfamiliar roles of science investigator and team member.

There are five implications of this study for urban girls and science. First, the ways girl "do science," that is, the practices they engage in when participating in school science activities, are complex and need to be examined further for what they are to the girls. Rather than examining girls through a traditional lens that identifies "correct" academic procedures for doing science, such as staying "on-task," girls' ways of doing science must be investigated as avenues for building involvement and excitement in science in the classroom. By looking at science education from different perspectives, a broader, more inclusive pedagogy is reached. The acceptance of the different ways that girls do science offers alternatives to the ways science education is currently practiced in schools. It does not seek to replace traditional science pedagogy but adds a different perspective to the teaching of science for girls. Gilligan (1993) writes,

> [T]here is a tendency to construct a single scale of measurement, and since that scale has generally been derived from and standardized on the basis of men's interpretations of research data driven predominantly or exclusively from studies of males, psychologists has have tended to regard male behaviors as the 'norm" and female behavior as some kind of 'deviation' from that norm (p. 14).

By accepting girls' ways of doing, females' experiences are acknowledged and valued. The validation of other ways of doing science in the classroom acknowledges the personal experiences, knowledge, and accomplishments of all students. This validation gives girls a way to connect to each other as well as other students in the class, the teacher, and the content of science (Middlecamp & Subramanium, 2006, Schacht, 2000, Shackelford, 1992). The multiple "ways" used to describe how girls engage in science, reveals girls are not a homogeneous group and the approaches that each takes when doing science will differ.

Accepting girls' ways of doing science means reviewing the dichotomy of on/off-task behavior that is traditionally applied in school settings. The merging of social and science practices requires a skillful navigation of social and academic participation and interaction. Each needs to be understood in the context of girls' involvement in the activity.

The second implication for this study highlights the complex socialization patterns used by urban girls when engaged in school science. This socialization needs to be valued and not regarded as "girl talk." At this stage of development 6^{th} grade girls try on new identities as they explore the development of their social selves. This exploration does not stop when they enter the classroom but continues when they explore the formation of their academic identities. Merging these explorations requires a delicate balancing act that plays out in many places, including the science classroom.

The socialization that is illustrated in this study requires they be allowed to socialize during science activities without being overwhelmed by the personal aspects of their lives. These unspoken rules require group monitoring that allows one or more of the girls to serve as coordinators to bring the group back to the science activity if the need arises. This delicate balancing act of continuing the socialization when shifting the focus back to the science activities without discouraging any of the group members demonstrates subtle rules of engagement that reflect understanding of the complex socialization patterns.

The third implication considers the multiple roles of girls during science activities. The holding of many roles simultaneously needs to be viewed as an asset not a deficit to learning. Rather than considering one role as taking away from another, the multiple roles girls experience need to be accepted as enriching each other. As girls enter puberty, there will be some roles that fit more comfortably than others, especially those roles that are carryovers from their social environment. Caregiver, friend, sister, “talker,” and social organizer all represent roles that many of the 6th grade girls will have experienced with success. By accepting the validity of these roles in the classroom, the confidence and self-worth associated with these social positions may be transferred to the new roles of science student, team member, researcher, investigator, and public presenter, roles that may be new, unfamiliar, uncomfortable, unappealing, and frightening to 6th grade girls at the outset. Validating the multiple roles of girls doing science allows girls to find support and encouragement and the drive to pursue new goals.

The fourth implication extends the research of Barton et al. (2008), that examines how urban middle school girls create hybrid spaces for engaging with science, based on the understanding that the science classroom comprises a culture that may be different from the one girls bring to school. Barton et al. support the view that students should be encouraged to adopt the culture of school science without giving up their unique worldviews and cultural ways of knowing, talking, and doing. They use the concept of hybrid space that they describe as:

> new forms of participation that merge the first space of school science with the second space of the home to create a third space that has elements of both. This third space is described as a hybrid space because it brings together the different knowledges, discourses, and relationships one encounter in ways that collapse oppositional binaries, allowing them to work together to generate new knowledge, discourses, and identities (p 73).

In their studies, Barton et al. (2008) noted the ways in which middle school girls use their knowledge and resources that allowed them to participate in the science classroom on their own terms. The girls create hybrid spaces where they merge their sociocultural worlds with the world of school science by creating signature science artifacts, playing with identities, and negotiating new roles for participation.

Although Baron et al.'s (2008) research reveals a strong connection between specific science content and girls' practices, this study shows that 6th grade girls are not discarding their sociocultural practices when engaged in science. For example, using scented markers to mask the odor of the bees demonstrated their strong take-charge attitude and the problem-solving skills that they likely exhibit in their home environments. Melanie, although not one of the initial participants in this situation, revealed a mature, practical side of her personality when she described how she uses science at home by mixing vinegar and baking soda to clean the bathroom of soap scum (Interview, February 11, 2010).

Taking charge and finding a solution to the unpleasant odor of the bees allowed the girls to incorporate their identity into a science activity that was new, unfamiliar, and potentially uninviting. By using skills from their personal lives, they were able to transfer some of the confidence to the science task while negotiating the task in the classroom.

The hybrid space they occupy when doing science extends beyond just exhibiting strong personality traits that they carry over from their personal lives. The hybrid space also allows the girls opportunities to merge school science with outside interests. They were able to blend their out-of school and in-school worlds, incorporating seemingly out-of-context elements into their science work. By including elements of the movie *Titanic* into their geological layering project, Melanie and Nicole were able to increase their interest level and their engagement. Their "off-topic" discussion of the movie during science class was legitimate.

Creating hybrid spaces where socialization takes place defined 6^{th} grade girls' science practices. The girls were aware of the differences between on- and off-task behaviors and willingly acknowledged that their talking about non-science topics was "off-task." They were equally aware and confident that they could manage their "distractions" with ease as demonstrated by the ways they switched back and forth between science and non-science talk. They also realized that one person in the group would act as coordinator to bring the group back to science work if the non-science conversation became too distracting.

The fifth implication of this study highlights the important role teachers play in the engagement of 6^{th} grade girls doing science. Although many science teachers represent traditional mainstream groups who differ from the urban girls of color in their classrooms; awareness that girls bring both gender and ethnic or racial perspectives to their engagement must be acknowledged. Dismissing behavior that is off-task or not considered "scientific" could lead girls to disengage with the science activity. An awareness and acknowledgement does not mean acceptance of all manner of distractions in the science classroom. What is required is understanding that not all students, especially those from different gender and ethnic or racial populations, have ways of doing activities that do not fit narrow constraints of classroom rules and procedures. The role of the teacher becomes one of guidance where he/she accommodates the strengths of the girls' ways of being, doing, and learning by valuing and using these ways to engage girls while providing direction when necessary.

Engagement in science is not a single endeavor where only those students who fit the traditional way of doing science are successful. Many paths to involvement should exist, so girls do not have to choose between whom they are and what school science requires. By allowing girls to engage in practices with which they are comfortable with school science practices that may be unfamiliar schools can create learning places that accommodate the sociocultural practices of all students.

This study presents directions for future research with two possibilities noted here. First, further research is needed to examine socialization patterns that occur during group work among 6^{th} grade girls in science classes in other urban schools. Research could also examine what girls from mainstream populations in more affluent, suburban schools do when engaged in science activities. Second, further research could examine the achievement and future interest in science by girls in classes where this socialization takes place.

Limitations of Study

There are several limitations to this study. First, by making generalizations about how 6^{th} grade girls from non-mainstream urban populations engage in science it is not the intention of this researcher to stereotype girls by including all girls of particular populations into one heading. Gender is complex. There is no one homogeneous group of science learners. Diversity exists between and among broad categories of girls, and school science practices are enacted in different ways at different times.

Although the purpose of this study was to examine gender and science practices, the findings are not uniquely limited to girls. Perhaps these practices are common to youth culture. In this study, however, the participants were girls. Since gender is an integral part of identity, the findings can only be applied to girls.

Second, the patterns attributed to these ten girls are not in and of themselves characteristic of the larger population. The data in the practices of doing science is only of girls in one class in one school. The school was a Charter school specializing in science, technology, engineering, and mathematics (STEM) content. Students and their families chose to be part of the lottery system that granted admission. Students could be dropped from the school roster if they didn't meet certain expectations.

Third, the 6th grade girls in the study remained in elementary school, unlike their counterparts in other parts of the district, state, and country. Although the students still faced pre-adolescents issues, they did not face the different social norms, new rules, changing relationships, and different content specialist teachers of middle school. Moreover, the girls at City Charter had known one another for many years.

The fourth limitation concerned the scope of this research. The focus of this research centered on the ways 6th grade girls engaged with science in the classroom. This engagement was viewed independently of academic achievement with the understanding that academic engagement represents a critical component of school science. However, future research should examine whether the practices discussed in this study lead to greater academic achievement.

APPENDICES

APPENDIX A: ASSENT AND PERMISSION FORMS

Student Assent Form for Research

My name is Ms. Carol Giuriceo and I am a student at the University of Rhode Island and Rhode Island College. I am doing a study to try to find out how students do science in middle school. The purpose of this study is to examine how 6^{th} grade students participate and interact when doing group activities in a science classroom.

If you (and your parents) agree to be in this study, you will be observed two to three times a week during the academic school year as you do your science activities during class. You may be interviewed by me about your group activities. One-on-one and/or group interviews will last approximately fifteen minutes and will take place during lunch in a private area. Risks will be minimal. You do not have to be interviewed if you do not want and you may skip any question if you agree to be interviewed.

Your participation is completely voluntary. Your participation will not affect your grades. All information will be kept confidential. The school, your teacher, the other students, and your name will not be identified. I will be the only person to keep the specific information. The data will be kept securely in a locked file cabinet at the University of Rhode Island for three years and may be destroyed after that time.

The decision to be part of this research is up to you. You do not have to participate even if your parents say "yes." If you do decide to participate, you can always drop out of the study at any time without needing to provide an explanation. No one will be affected or disappointed. If you want to quit the study, just contact me, Carol Giuriceo, cgiuriceo@mail.uri.edu or have one of your parents contact me. Your parents may also contact Dr. David Byrd, (401) 874-5484, dbyrd@uri.edu or the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

Signing your name at the bottom of this form means that you have read and understand the information about this research project. Signing this form also means that you agree to participate in this study and your questions have been answered. You and your parents will be given a copy of this form after you have signed it.

______________________	______________________	__________
Student's Name (Please Print)	Student's Signature	Date
Carol M. Giuriceo	______________________	__________
Researcher's Name	Researcher's Signature	Date

Parent/Guardian Permission Form for Research

My name is Ms. Carol Giuriceo and I am a doctoral student in the University of Rhode Island and Rhode Island College Doctoral Program in Education (Ph.D.). I am conducting a research project to study how students do science in middle school. The purpose of this study is to examine how 6th grade students participate and interact when doing group activities in a science classroom. Times^2 Academy has given me permission to conduct research in this class. The research will not interfere with your child's studies.

I would like your child along with others from his/her class to be part of the research. If you (and your child) agree to be in this study, he/she will be observed by me two to three times a week during the academic school year as he/she does science activities during class. He/she may be interviewed by me about his/her group activities. One-on-one and/or group interviews will last approximately fifteen minutes and will take place during lunch in a private area. Risks will be minimal. Your child does not have to be interviewed and may skip any question during the interview. Interviews will be conducted periodically during the entire study.

Participation is completely voluntary and will not affect your child's grades in any way. All information will be kept confidential. The school, the teacher, the other students, and your child's name will not be identified. I will be the only person to keep the specific information. Hard copies of the data will be kept securely in a locked file cabinet at the University of Rhode Island for three years and may be destroyed after that time. There will be no access and use of this data beyond the dissertation and any related work that develops from this dissertation.

The decision to be part of this research is up to you and your child. If you do decide to participate, your child can always drop out of the study at any time without needing to give an explanation. If your child no longer wants to participate in the study, just contact me, Carol Giuriceo, at cgiuriceo@mail.uri.edu.

If you are not satisfied with the way this study is performed or have any other questions, you may discuss your complaints with me, Carol Giuriceo or with Dr. David Byrd, (401) 874-5484, dbyrd@uri.edu, anonymously, if you choose. In addition, you may contact the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

Signing your name at the bottom of this form means that you have read and understand the information about this research project. Signing this form also means that you agree to let your child participate in this study and you have been given the opportunity to ask questions.

A separate informed consent form must be signed for permission to audiotape the classroom observations and the interviews and to videotape in the classroom.

______________________	______________________	
Parent's/Guardian's Name (Please Print)	Child's Name	
______________________		__________
Parent's/Guardian's Signature		Date
Carol M. Giuriceo	______________________	__________
Researcher's Name	Researcher's Signature	Date

Student Assent Form for Audiotaping

My name is Ms. Carol Giuriceo and I am a student at the University of Rhode Island and Rhode Island College. I am doing a study to try to find out how students do science in middle school. The purpose of this study is to examine how 6th grade students participate and interact when doing group activities in a science classroom.

If you (and your parents) agree to be in this study, you will be observed two to three times a week during the academic school year as you do your science activities during class. The observations will be audiotaped with a small digital recorder placed on the table. In addition the interviews about the observed science activities will be audiotaped. Risks will be minimal.

Your participation is completely voluntary. Your participation will not affect your grades. All information will be kept confidential. The school, your teacher, the other students, and your name will not be identified. I will be the only person to keep the specific information. The audiotapes will be kept securely in a locked file cabinet at the University of Rhode Island for three years and may be destroyed after that time. No activities will be audiotaped unless all students in the group (and their parents) agree.

The decision to be audiotaped is up to you. You do not have to be audiotaped even if your parents say "yes." You can still be part of the study. If you do decide to be audiotaped, you can always ask to stop being audiotaped without needing to provide an explanation. No one will be affected or disappointed. If you want to stop audiotaping or quit the study, just contact me, Carol Giuriceo, cgiuriceo@mail.uri.edu or have one of your parents contact me. Your parents may also contact Dr. David Byrd, (401) 874-5484, dbyrd@uri.edu or the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

Signing your name at the bottom of this form means that you have read and understand the information about this research project. Signing this form also means that you agree to be audiotaped as part of this study and your questions have been answered. You and your parents will be given a copy of this form after you have signed it.

______________________	______________________	__________
Student's Name (Please Print)	Student's Signature	Date
Carol M. Giuriceo	______________________	__________
Researcher's Name	Researcher's Signature	Date

Parent/Guardian Permission Form for Audiotaping

My name is Ms. Carol Giuriceo and I am a doctoral student in the University of Rhode Island and Rhode Island College Doctoral Program in Education (Ph.D.). I am conducting a research project to study how students do science in middle school. The purpose of this study is to examine how 6^{th} grade students participate and interact when doing group activities in a science classroom.

I would like your child along with others from his/her class to be part of the research. If you (and your child) agree to be in this study, he/she will be observed by me two to three times a week during the academic school year as he/she does science activities during class. The observations will be audiotaped with a small digital recorder placed on the table. In addition the interviews about the observed science activities will be audiotaped. Risks will be minimal.

Participation is completely voluntary and will not affect your child's grades in any way. All information will be kept confidential. The school, the teacher, the other students and your child's name will not be identified. I will be the only person to keep the specific information. The audiotapes will be kept securely in a locked file cabinet at the University of Rhode Island for three years and may be destroyed after that time. No activities will be audiotaped unless all students in the group and their parents agree. There will be no access and use of this data beyond the dissertation and any related work that develops from this dissertation.

The decision to be audiotaped is up to you and your child. Your child can still be part of the study even if he/she is not audiotaped. If you do decide to allow your child to be audiotaped, your child can always ask to stop being audiotaped without needing to give an explanation. If your child no longer wants to be audiotaped, just contact me, Carol Giuriceo, at cgiuriceo@mail.uri.edu.

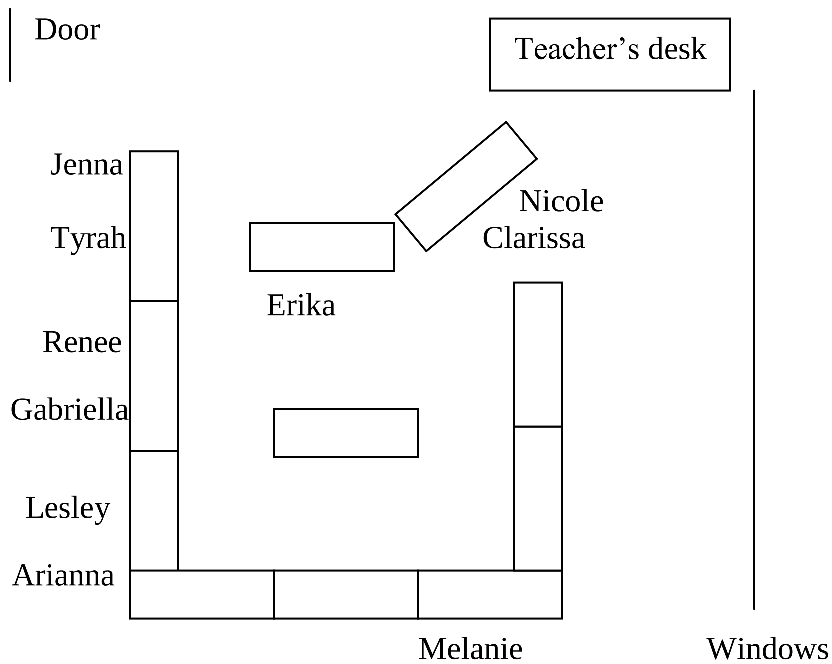
If you are not satisfied with the way this study is performed or have any other questions, you may discuss your complaints with me, Carol Giuriceo or with Dr. David Byrd, (401) 874-5484, dbyrd@uri.edu, anonymously, if you choose. In addition, you may contact the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

Signing your name at the bottom of this form means that you have read and understand the information about audiotaping and this research project. Signing this form also means that you agree to let your child be audiotaped as part of this study and you have been given the opportunity to ask questions.

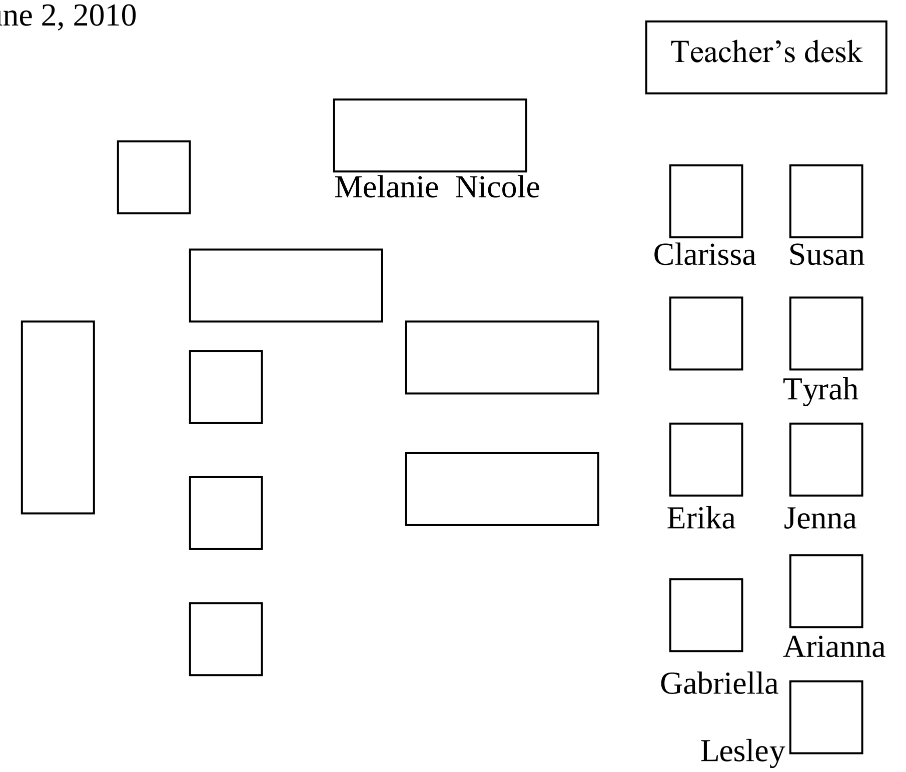
Parent's/Guardian's Name (Please Print)	Child's Name	
Parent's/Guardian's Signature		Date
Carol M. Giuriceo Researcher's Name	Researcher's Signature	Date

APPENDIX B: SAMPLE OF SEATING ARRANGEMENTS

January 7, 2010



June 2, 2010



APPENDIX C: STUDENT INTERVIEW QUESTIONS

I. Descriptive Questions
   A. Describe science class.
   B. Describe group work in science class.
   C. What are some of the things you do during group work?
      1. When I listen to the tapes of the group work, what kinds of things will I hear?
      2. When you are working in a group, what do you talk about?
         a. Are there different things you talk about?
         b. Can you tell me what some of those things are?
         c. Can you think of any others?
   D. Could you describe what happened during group work today from the moment you started working together?
   E. Can you give an example of a single event that happened today during group work?
   F. How is group work different from the rest of science class?

II. Structural Questions
   A. Do students talk about other things besides science during group work?
      1. What other things do they talk about?
      2. Do you ever get distracted from your science activity?
   B. Is talking about other things besides science part of group work?

APPENDIX D: PRELIMINARY STUDENT INTERVIEW ANALYSIS

Group Work	Action	Project/Science Related	• Project Activities
			• Naming components
			• Trying different ideas
		Other	• Talking to plants
			• Personifying eggs (little babies)
			• Singing
	Interaction	Science Talk	• Discussing background information
			• Sharing ideas
			• Listening to different perspectives
			• Project ideas
		Non-science Talk	• Home life
			• Friends
			• School
			• Movies, clothes, etc.

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