THE EFFECT OF AN INQUIRY-BASED SCIENCE CURRICULUM ON STUDENT ATTITUDES AND PARTICIPATION

by

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ABSTRACT

This study was designed as a collaborative action research study and focused on the use of an inquiry-based unit in an eighth grade honors science class at a middle school with a diverse population in the southeastern portion of the United States in the Spring of 2005. The inquiry-based unit was taught through the use of the electronics unit in Full Option Science System (FOSS). The purpose of the study was to investigate the effects of an inquiry based curriculum on the level of participation in, attitudes of, and academic performance of students towards science. This collaborative action research study used both qualitative and quantitative methods. The qualitative forms consisted of written notes taken by the classroom teacher and I that included observations of the whole class as well as observations of students in smaller inquiry groups and conversation and interview notations of student comments while they were doing inquiry work, both individual and group, as well as my notations of interviews and conversations with the classroom teacher. Although used to a lesser degree, quantitative data was collected from pre and post attitude surveys as well as from students' scores on inquiry-based investigations, paper activities and formal assessments. All data was triangulated across a variety of data sources so that any resulting patterns or themes would be supported. My access to this middle school was based on my role as the science coach assigned to the school. As the science coach, I worked with teachers and students to integrate the FOSS middle school curriculum unit into the school's science curriculum. The FOSS kits, workbooks and related reading books were designed to increase the use of inquiry and hands-on activities within middle and elementary school science classrooms.

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WE DID IT!

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CHAPTER 1
INTRODUCTION

The importance of inquiry in science education has been the focus of conversation and debate among groups that run the gamut from local and state education agencies to national agencies such as the National Science Foundation (NSF) and the National Research Council (NRC). The National Science Education Standards, published by the NRC, addressed the issue of inquiry as follows, "Science as inquiry is basic to science education and a controlling principle in the ultimate organization and selection of students' activities" (National Research Council, 1996, p. 103). The idea of inquiry-based teaching is not new. As far back as 1910, John Dewey said, "Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject-matter of fact and law, rather than as the effective method of inquiry into any subject-matter" (p. 124).

I have observed during my years in science education that students appeared to have increased involvement, enjoyment, and academic performance when they were actively involved in the learning process. This appeared to be across the educational spectrum from middle school through high school. During the years I taught high school and as a middle school science coach I had the opportunity to observe multiple teachers using multiple styles of teaching. I discovered that my personal experiences teaching high school seemed to be supported by my observations of other teachers in middle school—that the students appeared to have more involvement and ownership of the learning when they were actively involved.

Purpose of the Study

This study was designed with the purpose of investigating the effects of the introduction of an inquiry-based science unit on the attitudes and participation of eighth grade students towards science. Keeping this in mind, I developed three specific questions. These questions were:

1. How did inquiry-based learning affect the attitude of middle school students toward science?
2. How did the introduction of an inquiry-based unit affect the participation of middle school students in science classes?
3. How did the introduction of an inquiry-based unit affect the academic performance of middle school students in science classes?

Significance of the Study

Many students went through science in school and experienced it as a series of facts and seemingly disjointed information thrown their way and they were never presented with the opportunity to experience the actual science for themselves. Using this as a basis for their experiences, students may never development a sense of ownership of the subject or their learning. Without opportunity or ownership, student attitudes decline and participation wanes. The few times an “opportunity” arose it did so in the form of a lab where students were handed a step-by-step list of instructions that led to a pre-determined outcome. While this may be hands-on learning, it is far from inquiry. In fact, the NSF concluded that classroom inquiry takes many forms and not everything that can be defined as active learning is true inquiry (Foundations Vol. 2, pgs 41-46).

The nature of science is to investigate the unknown and to solve problems using what you already know and the materials at your disposal. This is what people do naturally throughout their lives. Students love to explore and use their hands. In fact at the Science and Mathematics Achievement Reaching the Top (SMART) Summer Institute in Orlando, FL (2006), Dr. Allyson Morrison Shetlar of the University of Central Florida said, “Inquiry based learning is based on questions. When you ask questions students tend to use the resources around them, including each other, to answer those questions. With discussion, lots of ideas come out and the students start looking at the ideas and see how they are connected.”

Educators today need to look no further than Socrates to support the belief that inquiry is based on questions. The Socratic method has been utilized for centuries with the express purpose of teaching students to challenge themselves in order to think, discuss and learn (Dow, 2000). While it has been utilized regularly as a tool in International Baccalaureate and Advanced Placement classes, education does not view this as a day in/day out method of instruction.

In learning through inquiry, students were able to explore ideas and ways to solve problems and then discuss their findings with each other. Throughout their discussions they were required to support their conclusions while constructively questioning others. In this way they experience, teach and learn the science. There may be no better way to learn than through inquiry.

Unfortunately, many teachers do not see the importance or the scope of the effects of inquiry. They may not feel that the rewards and benefits were worth the time and effort that must be put forth on their part to create an inquiry based environment. They just do not see how switching to and teaching through inquiry can so greatly affect the participation in, attitudes of, and consequentially, the performance levels of their students.

The format for inquiry starts with a problem, which requires an investigation to be created or designed and then carried out by the students themselves, essentially allowing them to explore. They then discuss the findings among their group and then eventually share them with the class as a whole. The students then reflect upon the conclusions they have ascertained and apply them to the world around them. These conclusions and applications eventually lead to more questions. This format can be summed up as follows: Questions→Problem→Investigation→Discussion→Reflection→Questions. When inquiry was looked at this way, it was evident that it was cyclical and would therefore facilitate continuous learning through inquiry.

It has long been known by teachers that when students like what they are doing, see the importance of what they are learning, and can work with other students in the process they connect to the subject. The connection creates a sense of ownership. It is through this sense of ownership that students are inspired to participate as a member of society; they connect with the world (Gibson, 1998). All of these connections create an atmosphere that not only connects them to the world, but that increases participation, which in turn may increase their academic performance.

When students learn through inquiry they have a stake in the learning process. Inquiry fosters a more positive learning environment where students are allowed to explore, interact, learn and teach. This helps them to see the importance and relevance of the material and encourages them to participate by allowing them to explore and learn for themselves rather then to simply follow directions. In 2002, Standard A of the National Science Education Standards stated that teachers had to plan an inquiry-based program. Apparently, it has been decided that for now inquiry is to be an integral part of science education.

Rationale of the Study

Throughout history much learning has taken place within the context of social interactions which goes as far back as recorded history and especially well-documented through the ancient Romans and Greeks where philosophers debated in market squares learning through debate and discussion. Quite often people would prepare experiments to support their theories and refute others to get their points across, hence, inquiry. Inquiry has been around and in use throughout history, be it by a variety of different names. In the 20th century, Dewey, Piaget and Vygotsky have discussed the importance of inquiry learning in different formats.

Dewey believed that rather than simply memorizing facts, students would develop a greater understanding of the material if they constructed their own understanding and advocated schools that allowed students numerous opportunities to do so. Dewey also felt that students should be responsible for their own learning and should be placed at the center of education.

Piaget, much like those early Greek and Roman philosophers, believed in the very essence of inquiry, that we should not just accept information as true but should question it and confirm it through the gathering of information and data, conducting experiments and then drawing a conclusion. Piaget (1952) said “learning is provoked by situations—provoked by a psychological experimenter; or by a teacher…or by an external situation”(p. 176). By nature people, especially students, attempt to make sense of the world in which they live. Quite often they do this through their interactions with other people. We see this every day with our students as they converse, discuss and debate on a wide variety of topics—dating, television, movies, music, grades. Although some of these topics may seem trivial, we should take the time to notice that in defending their beliefs in these matters they were drawing on their own observations and data, as well as on the observations of others, to make conclusions. This is the exact same process that we would like them to use and that inquiry requires them to use in science.

Vygotsky, through his Social Development Theory, tells us that people learn from each other through social interactions, which lead to knowledge acquisition. A relative point that Vygotsky makes is that “the most significant moment in the course of intellectual development, which gives birth to the purely human forms of practical and abstract intelligence, occurs when speech and practical activity, two previously independent lines of development, converge” (p. 24). Without this moment, it is hard to imagine that social interactions, which he deemed necessary for knowledge acquisition, would ever occur.

Chang and Mao (1999) found that student attitudes, participation and academic performance rates were tied in a positive correlation with the use of inquiry-based learning. They went further and said that the positive attitudes of the students seemed to be tied to a sense of ownership of something that was real and not just contrived by a teacher for a classroom exercise. In addition, Zuckerman, Chudinova, & Khavkin (1998) found that students involved in inquiry-based learning must solve problems in cooperative groups.

The research that Zukerman, Chudinova, & Khavkin (1998) reported on went on to make other assumptions. They suggested that the use of cooperative learning stimulates a greater understanding of the subject matter and aids the students to have more positive attitudes regarding the concepts they are studying. It is far easier to be positive about something in which you are successful. In addition, they suggested that students who work in cooperative learning groups also feel more confident in taking risks than they would on their own.

Assumptions

I approached this study with several assumptions. The first assumption was that the implementation of an inquiry based science unit would lead to a more positive attitude among the students and a greater level of participation. Second, there was an assumption that the teacher and students I observed would be honest in their comments and interactions with each other and myself when I was in the classroom and that the teacher would be honest in reporting her observations. Third, the teacher and students would not feel that they would be penalized or looked down upon in any way for any negative comments that they might give. Finally, it was necessary to assume that my previous knowledge of, experience with or professional training in the use of inquiry would not interfere with my ability to report my findings in a truthful and unbiased manner.

Limitations

There were several limitations to this study. The first limitation was the limited time I spent conducting classroom observations. As my job requirements limited my time on campus, I had to rely on the observations of the classroom teacher on the days that I could not be there. The second limitation was the small class size (18 students) and level of the class involved—eighth grade honors. The third limitation was the short time span of the study, a 9-week period over which a single inquiry based unit was covered. Finally, my extensive training in and belief in the effectiveness of inquiry as an instructional philosophy could be viewed as a source of bias and therefore a limitation.

Descriptions

Attitude: Throughout this study student attitude relates to how the students felt about the investigations they were being asked to perform, the teacher, their classmates, the content they were studying and science in general.

Honors: Students placed in honors courses have a score at the 7th stanine or above on an approved standardized achievement test using national norms. Additionally, students at the 6th stanine with grade point averages of 3.7 and above as well as a written teacher recommendation were placed in honors classes.

Full Option Science System (FOSS): This is a research based science curriculum that was developed at the University of California, Berkeley. The FOSS middle school curriculum has nine courses, one of which is the electronics kit that was used in the course of the research presented in this paper.

Inquiry Based Instruction: The classroom activities of students where they were engaged in solving open-ended questions that lead them to knowledge and understanding of science through the use of multiple investigations and hands-on activities. (NRC, 1996)

Minority groups: According to the American Heritage Dictionary, Fourth Edition (2000): a. An ethnic, racial, religious, or other group having a distinctive presence within a society. b. A group having little power or representation relative to other groups within a society. c. A member of one of these groups.

Nature of Science: “The systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts” (http://www.nsta.org/positionstatement&psid=22).

Observation: I made observations several times a week. These observations consisted of me being in the classroom and taking written notes, on a notepad, on any actions or comments related to the use of inquiry and the goals of this study. These observations were used to help gauge two things→ 1. the level of participation of the students, and 2. the general attitude of the students to the inquiry instruction in the class.

Participation: For this study student participation was considered to be a students willingness to raise their hand to answer teacher or student proposed questions, to share their ideas or comment on other students ideas and to ask questions or provide comments during class discussions or note time or feedback during classroom investigations, their participation, by way of observation, in group investigations and activities and the percentage of work completed for those activities, investigations and assessments.

Science and Mathematics Achievement Reaching the Top (SMART): Title assigned to the grant intended to test the impact of using inquiry-based curriculum on learning science and mathematics in 3rd through 8th grade (Grant Proposal p. 4).

Stanine: This is a method of scaling test scores on a nine-point standard scale with a mean of five (5) and a standard deviation of two (2). It is from the nine (9) intervals (STAndard NINE) that the term takes its name.

Overview

In this chapter, I discussed the concept of inquiry, its history, and its role in education, specifically, though not exclusively, through science courses. I presented the purpose of the study as well as the significance and the rationale.

Chapter 2 was the review of literature that focuses on the changes that have occurred in science education, particularly in reference to the various forms of inquiry, over the past several decades as well as factors that may or may not affect the attitudes and participations of students in science class. Chapter 3 was a description of my research methodology and discusses how I organized my research, the selection of and the participants themselves, demographic information of the school and study population, data analysis and instruments used. Chapter 4 was the interpretation of the data collected on the students' attitudes and participation during inquiry based instruction. Chapter 5 discussed the conclusions drawn from the data analysis and recommendations for future research in regards to the effects of inquiry on the attitudes and participation of middle school science students.

CHAPTER 2
LITERATURE REVIEW

Introduction

Inquiry is the cornerstone of much of the curricular reform in science education today. In 1996, the National Research Council (NRC) published the *National Science Education Standards (NSES).* One of the things that the standards discussed was the importance of inquiry. Specifically, the standards state that inquiry immerses students in the "process of science" as opposed to "science as a process." Much of the research on inquiry finds that there is a positive correlation between the use of inquiry and student achievement (Schmidt, Gillen, Zollo, & Stone, 2002; Tamir, Stavy, & Ratner, 1998; Zuckerman, Chudinova, & Khavkin, 1998). In addition, there is much research that links the academic performance of students with active engagement and attitudes (Dowson & McInerney, 2001; Hancock & Betts, 2002; Lumsden,1994).

According to Lee and Songer (2003), inquiry in science is an understanding of science concepts and the application of scientific thinking processes thoroughly combined in order to promote student learning. Inquiry provides the participation and engagement that is needed for students to have the opportunity to achieve and to develop positive attitudes toward science and their role in the classroom.

The presence of extensive research on all facets of inquiry-based learning opens a wide range of possibilities for literature topics. However, the focus of this research was on inquiry and the impact it has on the attitudes, participation and academic performance of students. Therefore this review of available literature presented information on these areas. In addition, it is necessary to examine not just inquiry-based learning in a generic way but also the roots of inquiry as a constructivist approach to learning. Finally, no review of a topic related to curriculum should proceed without an examination of the role of inquiry in curriculum reform.

Constructivism

Constructivism is an educational theory on how people acquire knowledge. Regarding the acquisition of knowledge, Piaget (1952) said that "to know an object, to know an event, is not simply to look at it and make a mental copy or image of it. To know an object is to act on it" (p. 176). "Constructivists believe that determining truth requires a value judgment on the part of the individual. As such, it cannot be objective or removed from the self" (Zahorik, 1997, p. 17). Learning in constructivism is based on the implication "that the knowledge students construct on their own, for example, is more valuable than the knowledge modeled for them; told to them; or shown, demonstrated, or explained to them by a teacher" (Loveless, 1998, p. 285). It has been recognized that constructivist theory emphasizes the learner partaking in a role that consists of active participation and that this participation is necessary due to social nature of learning (Phillips, 1995).

This does not mean to say that teachers are not necessary. Lee and Songer (2003) pointed out that teachers utilize inquiry in science classes through questioning and investigations that are designed to assist the students in their quest to grasp and understand the scientific topics at hand and to demonstrate how the classroom learner "constructs" their knowledge of science (p. 937). "Knowledge is actively constructed by the learner, not passively from the environment; [and] coming know is a process of adaptation based on and constantly modified by a learner's experience of the world" (Jaworski, 1996, p. 1).

Inquiry-based Learning

"Inquiry learning and teaching is based on the constructivist approach, which perceives children as little scientists who experiment, solve problems, and discover how the world functions. Children become active classroom participants who connect with their own environments and formulate high-level questions" (Schmidt, Gillen, Zollo, & Stone, 2002, p. 534). In addition, "they acquire knowledge, skills, and habits of mind that will enable them to come to deep understanding of the big ideas in science and to become facile with the process of engaging in scientific reasoning" (Palinesar, Collins, Marano, & Magnusson, 2000, p. 241).

In 2000, Olson and Loucks-Horsley stated that inquiry in the context of learning "refers to the teaching and learning strategies that enable scientific concepts to be mastered through investigations" (p. xv). This statement placed inquiry into its role in science education and is further supported in the introduction to the National Science Education Standards (NSES) when it is said that "the standards in Chapters 3 and 4 present a broad and deep view of science teaching that is based on the conviction that scientific inquiry is at the heart of science and science learning" (p. 15). It is clear that from the standpoint of the *Standards* themselves that the role of inquiry-based learning needs to be front and center in the future of science education.

Short and Burke in 1996 said that inquiry from an instructional standpoint allows for the students to explore and research their own questions using the knowledge and skills they already possess as opposed to using theme, activities or textbooks to drive learning (p. 98). However, it must be remembered that the NRC (2000) pointed out that not only is the role of the teacher crucial to inquiry learning, but also the degree of engagement of the students in the learning process. The individual student does not learn through inquiry in a self-contained space. The learning process is a group effort.

"Inquiry-based and constructivist activities may invigorate teaching and motivate students to take charge of their own learning, understand multiple perspectives, and develop high level reasoning skills" (Yoder, 2005, p. 1). The process of acquiring knowledge is reiterated by Dewey: "Only by taking a hand in the making of knowledge, by transferring guess and opinion into belief authorized by inquiry, does one ever get a knowledge of the method of knowing" (1910, p. 124).

"Traditionally, science teachers taught science the way they were taught. They used cookbook laboratory approach, where specific steps and expected answers were predetermined and students followed the directions as set forth in the laboratory manuals to derive the desired conclusion" (Jeanpierre, 2003, p. 7). Haury (1993) points out that the use of inquiry-based teaching does not rule out the use of textbooks. In fact, there are many textbooks that appear to be designed to integrate into an inquiry-based learning environment (Hall & McCurdy, 1990; Sarther, 1991; Haury, 1992). "Science inquiry, unlike many other fields of study, is integrally bound to the use of materials and equipment" (Jones et al., 2000, p. 760). All of this research on inquiry suggests that there may be a strong link between inquiry and the method in which individuals learn.

The NRC Commission on Behavioral and Social Sciences and Education published their research findings in How People Learn. The six main general findings within the study implicate that inquiry plays a large role in explaining how people learn (Bransford, Brown, and Cocking, 1999). These six general findings are laid out by the NRC (2000) as a case to support inquiry-based education and are as follows:

- Research Finding 1: Understanding science is more than knowing facts.

- Research Finding 2: Students build new knowledge and understanding on what they already know and believe.
- Research Finding 3: Students formulate new knowledge by modifying and refining their current concepts and by adding new concepts to what they already know.
- Research Finding 4: Learning is mediated by the social environment in which learners interact with others.
- Research Finding 5: Effective learning requires that students take control of their own learning.
- Research Finding 6: The ability to apply knowledge to novel situations, that is, transfer of learning, is affected by the degree to which students learn with understanding.

These findings reflect increases in student participation and academic performance (2000). In addition, Kelly (1999) said that inquiry based classrooms build students' scientific knowledge by linking new science experiences with prior experiences. These prior experiences may be directly related to student participation as prior participation suggests that an individual is left with experiences. This would directly link to the aforementioned findings in How People Learn and may suggest that inquiry learning and participation are connected.

Inquiry Learning and Participation

The authors of the National Science Education Standards (NRC, 1996) maintain that inquiry engages students in the "process of science" rather than "science as a process" (p. 105). This engagement in the "process of science" suggests that students need to be actively participating in science and that this participation is a key to successful learning. In a study in 2006, Akey stated that:

> Student engagement can be defined as the level of participation and intrinsic interest that a student shows in school. Engagement in schoolwork involves both behaviors (such as persistence, effort, attention) and attitudes (such as motivation, positive learning values, enthusiasm, interest, pride in success). Thus, engaged students seek out activities, inside and outside the classroom, that lead to success or learning. They also display curiosity, a desire to know more, and positive emotional responses to learning and school (p. 3).

In 2004, Patrick and Yoon concluded that in order "For students to gain the most substance from investigations, they need to discuss expectations, observations, conclusions, theories and explanations before, during and after conducting the activity" (p. 320). Additionally, Phillips (1995) pointed out that there is recognition that it is necessary for the learner's role to be one of active participation due to the social nature of learning.

The link that Phillips (1995) makes between the social nature of learning and active participation might suggest that there is an additional link to the need for the learner to have real world experiences on which to build future learning. The 1996 report by the National Research Council observes, "student understanding is actively constructed through individual and social processes" (p. 28). Kelly described inquiry as an instrument to advance higher-order thinking skills through the connection of real world experiences to the student learners (1999). "Interactions with other persons provide individuals with information, in the form of attitudes, beliefs, and behaviors of relevant others, that becomes a guide for the development of their own attitudes" (Tocci & Engelhard, 1991, p. 280).

All of this research seems to suggest that there is at least one common thread and that is the importance of participation in order for the learner to succeed. There must be participation in both the learning experience and through life in order to give the learner real world experiences on which to build. Dewey (1916) does an excellent job of linking these ideas and science when he said, “Science represents the fruition of the cognitive factors in experience” (p. 229). In addition, Anderson (2001) specifically stated, “when we promote “science as inquiry” as a national goal, we aspire to influence the ways that our citizens go about making sense of the world around them” (p. 629).

Inquiry-based Learning and Attitude

Research shows that attitudes of students toward learning vary according to the type of learning in which students are engaged. Students exposed to inquiry-based learning in a laboratory environment ask more reflective question and exhibit a deeper understanding of the topic than students engaged in expository learning (Berg, Bergendahl, and Lundberg, 2003). “Students tend to make sense of experience by focusing on what they care about, embedding [academic] standards in…guided experiences naturally motivates students to ask questions that are personally important to them and that meet the standards at the same time” (Caine, Caine, & McClinitic, 2002, p. 70).

In their study, Gibson and Chase (2002) concluded that students exposed to inquiry-based science curriculum—in the form of a 2 week summer camp—developed and continued to exhibit a positive attitude towards science subjects and a higher degree of interest in pursuing a science related career. Gibson (1998) suggested her research showed that students who are sanctioned to make learning decisions independently take ownership of the learning and develop positive attitudes regarding their learning. Not only have positive attitudes increased in middle grade students who participate in inquiry-based programs, but the students scientific literacy has improved (Haury, 1993).

There is research that has shown that the attitudes of students toward school can be directly correlated to their success in academics (Mason, et. al. 1989, Chang & Mao 1999). However, it should be noted that this is not universally accepted. Wareing (1990) specifically states that while there has been some evidence found that suggests a connection between student attitude and achievement there is not conclusive data that proves the extent or the direction of this connection (p. 352).   These conflicting views may suggest that it is necessary to also seek out additional data on the correlation between inquiry-based instruction and academic performance.

Inquiry and Academic Performance

The increase in the academic performance of students is considered a key to the success of education in certain circles. This is a point driven home by the actions of our government in the last two decades.

In 1994, Congress passed and President Clinton signed into law Public Law 103-227 commonly known as Goals 2000: Educate America Act. Section 102 of this law stated that the academic performance of students in the United States would be first in the world in both science and mathematics by the year 2000. This was a bold claim by the United States Government and one that was reinforced in January of 2002 with the passage of No Child Left Behind (NCLB).

It must be noted that neither of these attempts by the government to legislate student academic performance were responsible for the focus on inquiry in the NSES. In 1991, the

National Science Teachers Association (NSTA) asked the NRC to act as the facilitator in an effort to create a national standard for science education. The NSES was the product of this request and inquiry was a central focus of the new educational standards in science. The field of science itself had recognized a need for change and prior to government suggestions had begun to move to increase the academic performance of students.

It is important to remember that academic performance in science is more than just a letter grade. It also includes the ability to carry out tasks, to solve problems effectively and to express ideas. Haury (1993) indicates that research shows that students participating in inquiry-based programs show improvement in a number of areas, such as data interpretation, laboratory skills, math skills including graphing and academic performance when testing procedural knowledge. In 1993, Roth and Roychoudhury conducted a study that showed that students in 8th and 11th grade science classes who were exposed to inquiry over time demonstrate the ability to select research problems as well as being able to plan and design investigations that will answer questions that they (the students) have raised through study and research.

Studies have shown that student academic performance, as well as their understanding of complex science concepts, drops between fourth and eighth grade in comparison to the same age group internationally (Linn et al, 2000). Ware, Richardson, and Kim (2000) identify the importance of relevance in improving academic success. They say that it is crucial for teachers to link science and mathematics learning to the everyday lives of students or they risk the students' academic performance. In addition, it is important to remember, "many students in science classrooms are members of marginalized or oppressed groups" (Atwater, 1996, p. 823).

These marginalized or oppressed groups are typically minority groups within a school setting and can be separated by economics, race, ethnicity or ability level. Von Secker (2002) suggests that the effect of inquiry is sensitive to social context differences; achievement gaps can grow if considerations are not taken to accommodate the needs of all students. For those students who are classified as economically disadvantaged or urban, the gap between U.S. and international learning groups is even wider (Songer et al., 2001) and this needs to be considered as the nation moves together to reform science curriculum.

Summary

The research relating to inquiry based instruction has led me to believe that to varying degrees it is possible to find support for the premise laid forth in this paper. It is obvious that inquiry-based instruction is viewed as key to the immediate future of science education. The process of integrating inquiry into schools has begun in school districts nationally and the integration of inquiry into the national standards has supported this process.

The National Science Education Standards state, “Teaching must involve students in inquiry-oriented investigations in which they interact with their teachers and peers. Students…engage in problem solving, planning, decision making, and group discussions” (NRC, 1996, p. 20). In this very statement, there is a push for inquiry impacting student learning which encompasses participation, academic performance and even attitude. Within the literature there is support for the assumption that inquiry-based instruction has a positive impact on student attitudes, learning and academic performance, and it is this data that I believe supports my research topic.

Chapter 3 of this thesis was an examination of the methodology that was used to conduct this research. It explained the purpose, the design, the procedures and the methods used to carry out the study.

CHAPTER 3
METHODOLOGY

Introduction

The purpose of this study was to determine how an inquiry based science unit affected the participation, attitude and performance of a class of eighth grade inner city honors students. This collaborative action research study used both qualitative and quantitative methods. The data were collected from the following: a pre/post attitude survey, interviews with students, conversations with students, student work and observation notations made by both the classroom teacher and I. This chapter explained the design of the study and the methods used in the study.

Design of Study

This study was designed as a collaborative action research study and focused on the use of an inquiry-based unit in an eighth grade honors science class at a middle school with a diverse population. According to Hughes (2001), the intent of any action research study is two-fold; "Action research is action <u>and</u> research in the same process. It has twin, aims of action for change in an organisation or community, with research to increase our knowledge and understanding" (p. 281). This collaborative action research project was based on the following questions:

1. How did the inquiry-based unit affect the attitude of middle school students towards science?
2. How did the inquiry-based unit affect the participation of middle school students in science classes?

3. How did an inquiry-based unit affect the academic performance of middle school students in science classes?

Prior to the commencement of the study, I submitted a request to the University of Central Florida Institutional Review Board (IRB) for permission to carry out the study. I was granted permission and then preceded with the steps for securing permission from the school, the parents and the students. The principal of the middle school granted written permission for the study, the parents of the impacted students signed permission slips for their children to participate and the students themselves signed assent forms giving permission for their participation.

During this study several forms of qualitative and quantitative data were collected. The qualitative forms consisted of written notes taken by the classroom teacher and me that included observations of the whole class as well as observations of students in smaller inquiry groups and conversation and interview notations of student comments while they were doing individual and inquiry group work. The qualitative methods also included my notations of interviews and conversations with the classroom teacher. Although they were used to a lesser degree, quantitative data were collected from pre and post attitude surveys as well as from students' scores on inquiry-based investigations, paper activities and formal assessments.

Student and teacher comments and observations were analyzed in chronological order (from the earliest to the most recent date) for any patterns or themes and then compared with the student surveys, participation charts and inquiry assessments. All data sources were triangulated across a variety of sources to identify emergent themes and patterns.

Setting

This study took place in a large urban middle school in the southeastern United States. With 772 students during the study, the school was overpopulated and contained 22 portable classrooms in addition to the 11 separate buildings that made up the central part of the campus. The school was 82.12% African-American, 10.62% Hispanic, 5.31% White, and 1.95% other. Eighty percent of the students were on free or reduced lunch. The students participating in this study were enrolled in a fifth period eighth grade honors science class. The class was 50% male and 50% female, while the racial demographics were slightly different from those of the school as a whole. The class was 77.8% African-American, 11.1% While, 5.55% Hispanic and 5.55% other. My access to this middle school was based on my role as the science coach assigned to the school through the SMART Grant. As the science coach, I worked with teachers and students to integrate the FOSS middle school curriculum into the school's science curriculum.

This class was selected as the research group for four basic reasons. First of all, I had visited this class many times during the course of the academic year and the class roster had remained constant. Therefore, the students were accustomed to my presence in their classroom. This would likely increase their comfort level with my presence. This comfort with my presence created an atmosphere where my questions would be unobtrusive and their comments would be natural. Second, there was a comfort level between the students and the teacher as twelve of the eighteen students in the class had this particular teacher in their seventh grade honors science class and had moved up with her. Third, I had worked with this particular teacher more than others in this school over the course of the year and the previous summer and I believed that we had developed a working relationship as well as a high level of trust and comfort. Finally, this particular teacher had her planning period during sixth hour, which meant that I could talk with her immediately following each observation.

The arrangement of the classroom was six rows of five individual desks that could be placed together into groups of four to form a larger table for lab activities and investigations. One side and the back of the room were lined with lab benches and sinks. Empty bookcases mounted above the lab areas lined the classroom and allowed each class to keep their materials (in large zip-lock bags by group) separated from the other classes. A white board and Elmo projector were located at the front of the room and were used for bell work as well as preliminary discussions and notes in addition to class discussions following the inquiry paper activities, activities and investigations. In addition, the media center was equipped with computers that were used for any group activities that required them.

Procedures

Data were collected in the Spring of 2006 over a nine week period during the 5th period class of a six period school day. The inquiry-based unit was taught through the use of the electronics unit in Full Option Science System (FOSS). Beginning in the Summer of 2005, teachers were trained in the use and implementation of the FOSS units with the intent to begin classroom implementation in the late winter or early spring of the 2005-2006 academic year. All FOSS units included an instructional binder with a script for the instructor if they were uncomfortable with the science content in the unit to be taught.

The class was identified based on aforementioned criteria. All students and parents had signed assent and permission forms respectively and the pre-attitude survey was administered. The survey was designed to collect data on student attitudes towards science class as well as their attitudes regarding science instruction in school. By administering the survey in a pre/post fashion, there would be data available regarding the students' attitudes before and after their experience with the FOSS electronics unit and inquiry based learning.

There were a number of variations in how a typical day unfolded. However, they all began in the same manner. Students entered class and completed a 5-minute bell work assignment associated with the days' inquiry based lesson. The information from this assignment would be integrated into the days' lesson and the assignment itself would be placed into the individual students' work folder to be graded at a later date. The bell work would be followed by a brief general introduction to the day's activity and at this point there is a truncation in what occurred.

Next, the students would either divide into groups if the activity was group based or complete the individual assignment on their own. In the case of group activities the students would end their work approximately 10 minutes prior to the end of class in order to regroup as a class and share/discuss their work for the day. When the activity was intended to be completed by the individual student, the students would work for approximately 15 minutes before getting into small groups and discussing their individual findings. In both of these cases the teacher and myself would circulate through the room answering questions and making observations.

During the course of the study, I conducted formal observations one to two times a week for nine weeks. The students spent the nine weeks of the unit working on inquiry based activities, investigations and problem-based activities, follow-up class discussions and formal written assessments. During the inquiry-based activities, investigations and problem-based activities, I conducted informal interviews by walking around to the different groups and recording my observations. In addition to my observations, I also recorded student comments regarding their work and responses to specific questions I asked regarding what they were doing and how they liked what they were doing. The students in the group openly discussed their thoughts and shared their opinions. The students were not observed during their formal written assessments.

During preliminary and post discussions I observed the students and notations were made on the Participation Tick Chart (Appendix A) in order to keep track of how often each student participated. Participation in this case meant the asking of questions, answering of questions or the offering of comments to the discussion of the investigation group or of the class as a whole. Additionally, I recorded general observations of noticeable trends and formal meetings (scheduled meetings during sixth period to discuss observations opposed to passing comments made during class or in the hallway) that were held with the classroom teacher at least twice a week in order to get her attitudes and observations of what was happening in the class to compare to the observations and notes I had taken. Moreover, at these formal meetings we would review any student comments that she had recorded on days that I was not in the class and they would be added to the data base of information. These qualitative forms of data were used to help gauge the students' attitude in the class, their level of participation in the class and their enthusiasm or lack of enthusiasm of the inquiry classroom.

Quantitative data were collected using the pre/post survey choices, assessments, paper activity and investigation write-up scores and percentages representing what portion of the aforementioned tools were attempted by the students. These pieces of quantitative data were used to help measure their level of interest, participation and academic success in the class. At the end of the nine weeks, the post attitude survey was administered which would be compared to the pre attitude survey to assist in measuring any increases or decreases in their attitudes towards science in general, science class and or science instruction.

Role of the Science Coach

The research for this study was carried out in a class that was part of the district's SMART Grant and my involvement with the class was as a science coach and this position was funded by the grant. The class that was used as the study group was in fact at one of the two schools that were part of the grant, and it was the first year that the school containing the study group was involved in the grant.

As the SMART Grant Middle School Science Coach, I had a full schedule. A normal week included three days at the study school and 2 days at the other participating middle school. Every other week, one of the two days at the other school was given up in order to attend a grant specific coaches meeting. In two schools, I was responsible for 22 teachers. The study school had 12 science teachers, three of whom taught ESE science and one who taught ESOL science.

My responsibilities included classroom observations, planning with teachers for co-teaching/team teaching, pre and post-conferences for the aforementioned planned lessons, post-conferences for all observations, planning for demonstration teaching and the development of inquiry lessons. The inquiry lessons were tailored to the science curriculum for each grade level at each school. In addition to these tasks, I was also required to develop and conduct workshops for the teachers to familiarize themselves with the six inquiry unit kits that were being introduced at each grant school.

Classroom centered instructional tasks, though a major focus of the science coach's position, were only part of the job. In addition to the instructional tasks, I was also responsible for the grant required record keeping at each of the grant schools. This record keeping included detailed anecdotal notes on all instructional tasks as well as keeping records related to student academic performance. These records included the recording of the raw data from unit pre/posts tests as well as the calculating and measuring of learning gains based on these unit tests.

In addition to everything listed above, it was also the responsibility of the science coach to be available to the grant administrators for grant activities at all levels (elementary and middle), such as chaperoning field trips, as well as being available at the school level to assist with things such as testing and the cataloguing of science supplies and equipment.

The myriad of tasks left little room for maneuvering and in the early spring of 2006 when I was conducted my research for this study, we were notified that the grant had been cancelled effective July 1, 2006, and this created a situation where previous schedules were no longer valid. The coaches were now meeting at least once a week, instead of only once every other week, and in addition to those meetings we had to implement new plans to end the grant one year early. This disrupted the classroom visitation schedule and left the coaches with considerably less time to spend in the classrooms.

Full Option Science System (FOSS)

The Full Option Science System (FOSS) kits, workbooks and related reading books were supplied by a grant within the school district designed to increase the use of inquiry and hands-on activities within middle and elementary school science classrooms.

The FOSS program was developed at the Lawrence Hall of Science, University of California at Berkeley. It is an inquiry based program that was designed to develop students' abilities to do and understand scientific inquiry, to develop students' ability in technological design and understanding of science and technology, and to develop an understanding of science and technology in society. In addition, students learned to identify questions, design, develop and conduct scientific investigations to solve those problems, use tools to gather, analyze and interpret data, make predictions, explanations and models using data and evidence, communicate scientific procedures, explanations and findings and to understand that scientific explanations emphasize evidence.

The FOSS program utilized inquiry through student based investigations and analysis that used laboratory equipment, student readings and technology to guide students through critical thinking and decision processes that allow for the full integration of reading, writing and math. Besides laboratory investigations, the students used journals and projects to demonstrate their mastery of the subject. The FOSS kit included all materials that are required to conduct all kit activities, including videos and CD-ROMs.

The stated goals of the FOSS electronics unit were to make sure that 1. Students' learned about basic electronics, and 2. That inquiry would be used as the basis for the instructional delivery. In addition, it must be noted that some traditional methods were used in the instruction due to curricular mandates from the school-based administration. During the nine-week period, the teacher taught some of the lessons from the electronics unit and some lessons were team taught by the teacher and I. Inquiry based instructional methods and lessons were taught in the style and method presented by the FOSS teacher's manual.

The inquiry based FOSS Electronics unit was divided into the following nine investigations, each of which contained a variety of inquiry-based group activities (hands-on and computer generated), paper activities, readings, videos and assessments:

1. Circuits: In this investigation students discovered how to create complete circuits and how to identify series, parallel, and short circuits.
2. Resistors 1: In this investigation the students discovered how resistors influenced the performance of lamps in electric circuits, and develop a model that explained what resistance is and how it might affect the flow of current in a circuit.
3. Voltage: In this investigation students explored, measured, and manipulated one of the two main attributes of electricity, voltage, and discovered how voltage can be influenced by components in a circuit.
4. Electronic Dissection: In this investigation students explored electronic consumer products to discover the kinds and numbers of electronic components used in their design, and consider the impact of technology on American life.
5. Resistors 2: In this investigation students discovered the rules for predicting the total resistance imposed by multiple resistors placed in series and or parallel circuits.
6. Diodes: In this investigation the students discover the characteristics of diodes and compare their behavior in circuits to the behavior of other components with which they are familiar.
7. Capacitors: In this investigation the students discovered the characteristics of capacitors, compared them to components with which they were familiar, and used them in circuits to perform new functions.
8. Current: This investigation lead students to understand the concept of electronic current, and to use their understanding to solve circuit problems.

9. Transistors: This investigation allowed the students to investigate the functions of a transistor and used their knowledge to make comparisons between transistors and switches.

The Full Option Science System (FOSS) electronics kit was the unit used in the collaborative action research study. The middle school implemented the system as part of the SMART grant whose purpose was to utilize inquiry-based curriculum in middle school science classes (6^{th}, 7^{th}, and 8^{th} grade).

Instruments

In order to complete the research necessary for the study, the following instruments were utilized to gather data regarding student attitude and participation during the use of the FOSS unit:

Participation Tick Charts

On the participation tick charts there were boxes and each box represented each student desk used to record their participation during inquiry lessons. Each time a student would raise their hand and contribute to the discussion, a hash mark would be placed in the box corresponding to that students' seat (Appendix A).

Student Interviews/Conversations

Student interviews/conversations were used whenever they worked in groups or on their own to ask clarifying questions about the activities. The classroom teacher and I circulated the room to answer questions asked by the students or asked questions to guide the students. The time spent circulating the room presented the opportunity to conduct informal interviews (specific questions that were asked to each student or each group of students) or "conversations" (an exchange of information that varied from group to group and individual to individual). These two questioning techniques were used to discover how students felt about their work and whether they had a preference for learning methods—inquiry-based or traditional. Information was documented on a legal pad and then transcribed into a word document on a computer.

Student Survey

At the beginning and conclusion of the study, I administered a student attitude survey that was developed by the SMART committee of a large urban school district in central Florida (2004) (Appendix C). The county science coordinator granted the permission for the use of this survey in this study. The survey was developed to help determine middle school students' attitudes towards science in real world and in school science as well as their feelings regarding instruction of science in the classroom and the relevance of science in the world around them.

The student survey was developed by several science coaches and science specialists at the county level in the county of the study. Face validity for the survey was obtained by having a panel of science specialists, independent of those who developed the survey, examine the survey. The specialists were three county level science coordinators and two national science grant and survey specialists all of who had extensive experience in working with science surveys.

Student Assessments

A series of eight inquiry based assessments that were a component of the module. The purpose was to show progress in the students' understanding and application of inquiry as a method of learning. I utilized all of the assessments as data sources for the study.

Student Work Samples

The teacher collected student work upon completion of assignments. The assignments were completed either daily or every other day depending on the assignment. Of the collected work, I utilized all of the investigations and activities that occurred during my days of observation as data sources for the study. They were collected to help gauge student understanding of the concepts as well as their participation and enthusiasm in the class. As with all the other materials provided, the student work samples were part of the FOSS electronics kit.

Methods of Data Analysis

Throughout this study, data, both qualitative and quantitative, were collected and analyzed to determine any patterns in student attitude, participation and performance in the classroom. All of the data were organized in a way that would allow conclusions to be drawn and then any patterns that would help to provide explanations for these conclusions would be noted. Member check with the classroom teacher and triangulation across data sources helped to reduce bias in any conclusions and added to the trustworthiness of the research.

Student and teacher comments and observations were analyzed across data sources for any patterns or themes and then compared with the student surveys, participation charts and inquiry assessments. All other sources of data, including the surveys and student work, were carefully evaluated to determine if they supported or refuted these patterns. Recurring patterns and the data that supported them were then placed in easy to read charts along with any discrepancies, questions and concerns. This facilitated my triangulation of the data for the identification of emergent themes.

Participation Tick Charts

A chart was used to record tallies (ticks) of how often a student raised their hand to participate in the discussion, whether it was to ask a question, offer an answer to a question or simply to offer any input to the discussion. A chart was kept for each day I was in class and a discussion occurred. Each chart was tallied and then the charts became tools that illustrated any increase or decrease in individual students' participation in class discussions over time.

Student Interviews/Conversations

Questions were asked of individual student during each inquiry lesson. These questions and their answers helped us (teacher and I) to gather data on student attitudes regarding inquiry learning based on the activities and the written work they were required to complete. The questions were asked as the teacher and I circulated through the room to facilitate learning through questions. Student answers to questions were documented on a legal pad and then transcribed into a word document on a computer.

Student Survey

The SMART Grant science coaches constructed this survey and it was given at the beginning and conclusion of the study to assist in better understanding the students' attitudes towards science and science class as well as to help gauge any changes in those attitudes. The three major topics or themes within the survey were how students viewed the relevance of science in the world around them, their feelings about science class and the delivery of the material in that class and their feelings of how science might affect their career path in the future. Students responded to the questions either true or false. True responses were given a score of 1 and false responses a score of zero. Ratings were: “strongly agree” a point value of five, “agree” a value of four, “no opinion” a value of three, “disagree” a value of two and “strongly disagree” a value of one. In this scoring system, central tendencies were determined for each question. A table displayed the tally of each response for each question as well as changes in those scores.

Student Work Samples

Raw scores on the individual assignments and assessments were used to measure student understanding of the subject matter and were used to assist in charting any increase in understanding as they became more familiar and comfortable with inquiry. The percentage of work attempted on the investigation reports, paper activities and assessments, regardless of whether the responses were correct or incorrect, was used to help gauge the students levels of participation and enthusiasm or attitude in the class and to help chart any changes in these levels. The teacher collected the student work on the completion of the assignments.

Teacher Interviews

The teacher interviews were used to collect data on the attitudes of the students. She would often add to or re-enforce my observations with one’s of her own. She would also share with me her thoughts and feelings about inquiry based teaching from a teacher’s point of view as well. These interviews helped to strengthen my observations and conclusions and to help lessen any bias on my part.

Summary

The purpose of this chapter was to present the methods used in the study. It outlined the process taken prior to the commencement of the study as well as the processes used in the study. The various instruments used in the collection of data were presented and then explained how each instrument was used to collect data and how that data was analyzed.

The triangulation of the data resulted in the research findings linked with this study. Chapter four contained, in both descriptive and narrative forms, the findings that were associated with the study. In addition to the descriptive and narrative forms, the Chapter also included visuals in the form of charts.

CHAPTER 4
RESULTS

Introduction

A collaborative action research study was conducted on an eighth grade honors science class in an inner-city school in the southeastern portion of the United States in the Spring of 2005 to investigate the effects of an inquiry based curriculum on the level of participation in and attitudes of students towards science.

Data, in the forms of written pre/post surveys, samples of student work in the forms of investigations, worksheets and assessments, observations of student behavior and comments as logged by the classroom teacher and I were collected and analyzed for themes and patterns. All data were then triangulated across data sources so that any resulting patterns or themes would be supported.

Student Attitude Towards Science

Research Question #1: How did inquiry-based learning affect the attitude of middle school students toward science?

The first pattern to develop through the triangulation of the data was that inquiry demonstrated a positive affect in the attitudes of students towards science class and science in general.

The data that supported this theme came primarily from the pre and post attitude surveys, observations, and comments students made to both myself and the classroom teacher during the activities, investigations and discussions.

To investigate the students' interest in and attitudes towards science both in and out of the classroom an attitude survey was administered at the onset and at the conclusion of the study. The attitude survey was developed by the county science specialist and the science coaches of the SMART (Science and Mathematics Achievement Reaching the Top) grant under which the study was conducted. The survey consisted of 19 questions, 3 of which were designed to record the demographics of the students and 16 of which were designed to assess the attitude of the students towards science. Of the 16 questions designed to assess the attitude of the students towards science, 8 of them were yes/no response questions and 8 were supplied with the choices of never, few times, many times and always. Student replies for each answer were tallied and percent and individual increases and decreases were determined (Table 1).

When the pre/post responses of the survey were compared, the evidence that suggested a positive change in attitude on the part of the students were seen in the following statements:

Table 1: Yes Responses to the Pre and Post Attitude Survey

Statement	"Yes" Pre-Survey	"Yes" Post-Survey	Individual Increase	Percent Increase
Do you look forward to science time at school?	13	15	2	11.11
In science does your teacher like for you to ask questions?	14	18	4	22.22
Do you want to have a job in science someday?	3	12	9	50
At home, do you talk about science activities that you have learned at school?	10	13	3	16.66

The questions, "Do you want to have a job in science someday?", "Do you look forward to science time at school?", and "At home do you talk about science activities that you have learned at school?" showed a 50%, a 11.11%, and a 16.66% increase respectively from students replying yes in the pre-survey to those replying yes in the post survey. were designed to assess the attitudes of at interest of students towards science in general. The increase in students replying yes to these questions after the study suggests that there may be a connection between the use of inquiry and the increase of student interest in science. The potential increase in student interest in science could contribute to student's showing both an increased inclination to talk about science outside of school as well as an increased recognition of the importance of science.

Two of these questions, "Do you look forward to science time at school?" and "In science does your teacher like for you to ask questions?" were used to directly assess students attitude and interest towards science class. Results for both of these questions showed a slight increase in positive responses from the pre to the post-survey with an increase from 13 to 15 students looking forward to science class and an increase from 14 to 18 students recognizing that their teacher likes for them to ask questions.

Reflected in the survey, student interest and enjoyment of science during the inquiry unit was also reflected in their comments during the investigations and discussions of the FOSS unit.

- "Yes! I love this!"
- "We want to show you what we did."
- "This is tight!"
- "This is a lot of fun…I like doing these activities."
- "I don't want to go to English class, I want to stay here and work some more."
- "I like coming to this class, it is the only one where we get to do anything."
- "Using this stuff is more fun then just looking at it."

During these investigations the students used a variety of materials including resistors, bulbs, circuit boards, and batteries and worked in pairs in groups of four. The comments that were logged and recorded above I crosschecked with the teacher whenever possible. Students' comments supported their excitement with and enjoyment of the investigations.

In addition to comments recorded during investigations, there were student comments made during the discussions of daily problems. Some of the comments that were made during these activities while I was in the classroom were:

- "Can I do this one?"
- "Can I show you how I got my answer on the board?"
- "Can we do more examples?"
- "Can I come after school and try more?"
- "My cousin is doing this in another class and I was able to explain it to him."
- "I told my mom last night that I know why all the lights went out when my sister stepped on one Christmas light."
- "I told my friends what we do in here and they want to come to our science class."
- "That's cool, we did not think of that."

These comments, along with the observations, which accompanied them, suggested that the students were excited about science and eager to show what they had learned. "Can I do this one?" and "Can I show you how I got my answer on the board?" help to illustrate how students wanted to share what they had learned rather then just check it against the right answer or procedure displayed by the teacher. The young lady who was all excited to share how she was able to explain the Christmas light situation to her mom and the young man who shared how he was teaching his cousin the material were examples of how students were not only excited about science but were using it outside of the classroom. When viewed with the comments made during the investigations and results of the pre and post attitude survey, these comments suggested that students were more excited about science when they were able to not only explore science but are able to share it as well.

The students were excited with and enjoying the investigations at least in part because they were allowed to actually use the materials to explore and investigate rather then simply following directions. This can be deduced from the comments: “This is fun ‘cause you get to play with the electric stuff” “Can we come in before school and try o find another way to light the bulbs” and “This is a lot of fun, I like playing with the [circuit] boards and wires…”

The observations made by both the classroom teacher and I documented students’ behaviors and actions. Some of the comments made to me by the classroom teacher during our formal and informal conversations suggested that students were more excited to come to class and that they wanted to “do” science. I observed that students smiled more as they came to class and that they came to class on time and settled down more consistently as the unit progressed. This was a big change as compared to earlier in the year when students were usually talking when and even after the bell rang and had to be reminded that they had bell work to do.

Even when students did problems for homework, they wanted to share how they had solved the problems with the rest of the class; a sharp contrast to having to make students get up and share their work or put it on the board. This desire to share reinforced the results of the attitude survey. The growth in positive student attitude was reflected in their desire to share observations and continue their work. When investigation time was over it was difficult at times to get the students to put away the materials because they wanted to continue to investigate, not play but conductively investigate and work on finding other ways to solve the problem or "discover new things".

Along with this need and desire to investigate I found that students were more willing to ask questions. They seemed to lose the fear they had earlier in the year of asking a "stupid" question or of giving a wrong answer. These observations were supported by the following comments that were made to me by the classroom teacher during our conversations:

- "They are more willing to take chances, they are not afraid to be wrong…this took some time."
- "A lot of quiet students have come out of their shells"
- "These activities have really boosted the self confidence of those students who did not want to work with others or who felt they were low achievers."

Again, this may be attributed to the high level of interaction among the students and the focus of inquiry to let the students solve problems on their own rather then telling them how to do it.

This positive change in attitude towards science and science class, as noted by my observations and the observations of the classroom teacher, was most likely due to two factors. One is that students were more involved in class and two they were carrying out activities designed to solve problems that they might encounter in their lives and therefore allow them to see the importance of science in their lives. The student comments, especially during the activities and investigations, suggest that the high level of involvement in those activities and investigations also helped to make science class "more fun" and exciting for students and when you are having fun with or like something then you are apt to have a more positive attitude about it.

Student Participation in Science

Research Question #2: How did the implementation of an inquiry-based curriculum affect the participation of middle school students in science classes?

The data that directly supported an increase in student participation came from three sources. First, the tracking of actions taken by the students—how often students raised their hands to ask questions, answer questions and offer comments or respond to comments during investigations, activities and discussions. Second, observations made by the classroom teacher and myself that include comments made by the students during these activities. Third, information provided by the student responses to questions in the attitude survey.

The tracking of student participation in class was accomplished through monitoring and recording the students' raising of hand. For each day I observed the class, I kept a clipboard with paper on it representing a form of seating chart (Appendix A) where each student desk was represented by a box. Each time a student raised their hand to participate in class—ask questions or offer discussion input, I wrote in a tick mark. The tick marks were then placed into a table (Appendix B) to show the progression of how often each student raised their hand over the nine-week period as well as the average number of times the students raised their hands on each day.

Using the per student data, the greatest increase of participation through hand raising being nine times per class period and the least being two per period and the average increase being six times per period. This data suggests that the students had more to offer in the way of input and questions as the study progressed. Although many students showed some fluctuation in the number of times they raised their hands over the nine-week period, most students showed an overall increase in the number of times they raised their hand over time with only one student showing no increase and remaining constant. While there is no differentiation between raising a hand to ask a question or add a comment to a discussion, the increase in hand raising suggested that with the use of inquiry students appeared to increase their participation over time.

The classroom teacher and myself documented students' comments during inquiry investigations. Student comments were in the form of constructive input and investigative questions rather then the "What are we supposed to do?" and "How do we do this?" type questions which were primarily asked earlier in the year as shown by records kept by the classroom teacher and I from earlier in the year. The comments that were made by students, which support a higher level of participation fell into three categories.

The first category of comments were those that were made during activities and investigations that showed the students were actively investigating and wanted to solve the problems on their own rather then be shown how to do it. Some of these comments were:

- "This is fun 'cause you get to play with the electric stuff."
- "Don't tell us...we want to try it ourselves."
- "This is a lot of fun, I like playing with the [circuit] boards and wires..."
- "Can we try it?"
- "I did it a different way and got the same answer…is that okay?"
- "Can we come in before school and try o find another way to light the bulbs?"

The following comments were made during the FOSS electronics activities and investigations during the study and showed that students and students groups were not only actively engaged in the investigations but were often seeking ways to go beyond the actual investigation and to explore further.

- "Can we try adding more light bulbs and more wires?"
- "What would happen if we used two batteries or a bigger battery?"

- "Let's try splitting the battery to three different bulbs and then putting all three bulbs in a line and see if there is a difference."
- Let's try the same color resistors in a different order to see if it changes the light."

These comments suggest that students were just using the materials to solve the problems presented to them by the investigation. In addition, they were looking to use additional materials (more or bigger batteries, additional light bulbs and switches and more and different resistors) to explore further and make their own additional discoveries. They were actually asking permission to increase their participation—to do and learn more.

The second category of comments were those made during activities and investigations or following them during class discussions which showed that students had not only actively investigated the problems but were proud of what they did and eager to share their methods with the rest of the class. The following comments were documented during follow-up discussions to the activities and investigations where the students were encouraged to share the discoveries they made during their investigations, the methods they used to get them and even the rationale behind those methods. These comments were logged during the follow-up discussions to the activities and investigations and show how students were willing to share their findings with the class.

- "We found that different color resistors caused the light bulb to light up different amounts."
- "We found that more resistors in a circuit caused the light to be dimmer."
- "We found that the potentiometer controls how light the light gets."
- "We found another way for that one!"

Although students were not called upon to share their discoveries, methods or rationales, many students were eager to share them and were excited to show any additional methods they used to solve the problems. As some of their comments showed, “We found another way for that one!” and “Can we come before school to find another way to light the bulbs?” for many students it actually became a personal challenge to find new and additional ways to solve the problems so that they could report them back to the class. This involved additional work and learning that then needed to be reported back to the class during the discussions—participation.

The third and final category of comments were those that were made as they entered or were leaving the classroom that expressed that they enjoyed and were participating in the activities and investigations. These were comments that expressed that they enjoyed and were participating in the activities and investigations. Some of these comments were:

- “I like coming to this class, it is the only one where we get to do anything.”
- “What I like best about this class is our freedom. You let us explore.”
- “This [the wonderboard] was fun…it was like a mystery game where we had to keep guessing and using what we already knew to figure out the answer.”
- “Oooo…are we going to get to do an experiment today?”

These comments helped to show how the students were actively participating in the activities and investigations that they were doing in the class “…the only class where we get to do anything” and “You let us explore”, that the investigations were the reason they now liked coming to science class “I like coming to this class…” and “What I like best about this class is our freedom…” and that they were eager and excited to explore and do more investigations “…are we going to do an experiment today?” and “…we had to use what we already knew to figure out the answer.”

These three categories of comments show that they wanted to investigate and discover for themselves rather then be shown how to do it: “Don’t tell us…we want to try it for ourselves.” “Can we try it?” and “I did it a different way and got the same answer…is that okay?” As with the data showing how often students raised their hands to offer input, these comments suggested that the students were actively participating and investigating in the class and that they were excited about doing so.

Based on the classroom teacher’s records and observations of the students over the course of the study, she pointed out that the students were initially frustrated and confused and asking the teacher, myself and even each other what they were supposed to do. After the first few activities and investigations, where the both the teacher and I assisted the students by providing some guiding questions to the groups as we went around to address their questions (which usually led to the responses of “Ohhh…I get it now!” and “So I can do that?” and “So what if I did ….?”) students began to understand that they could explore under their own volition and began to do so. I soon observed the students using many more materials then the lab called for and even asking questions such as “Can I do this?” and “What would happen if we…?” and Can we have more [or extra}…{light bulbs, resistors, switches, batteries, etc.].

Soon after the students stopped asking these types of questions of the teacher and I, and began asking them of the other students in their groups. This showed that not only did students now understand that they were allowed to and should explore but that they no longer had to ask us (the teacher and I) if they could and what would happen if they did and instead discussed it among their partners and classmates. This suggested a much higher level of investigation and participation through inquiry.

I clearly observed that the students were spending substantial time on constructive exploration and less time trying to figure out what to do by way of the few directions that were given in the activity or investigation (which was usually nothing more then a guiding list of materials and a goal to reach or problem to solve). This was supported by the logged comments of the students which progressed from comments such as “Are you going to tell us what to do?” and “What are we supposed to do again?” and “Which things are we supposed to use?” which are questions that were asked at the beginning of the introduction and use of the FOSS kit.

In comparison, the comments logged as the FOSS investigations continued included such things as, “Don’t tell us….we want to do it ourselves” and “”Let’s try splitting the battery to three different bulbs and then putting all three bulbs in a line and see if there is a difference.” These student comments suggest that the students were becoming familiar with the procedure of inquiry and investigating on their own after just a couple of investigations.

The classroom teacher agreed with my observations and supported them with the following comments during our meetings:

- “I am finding that the students are paying a lot more attention during this unit, they really seem to be listening to me and each other.”
- “…they also get in and get their bell work done more quickly…they want to get to the activities and investigations.”
- “They don’t even seem to mind taking notes, they just seem happier in general with whatever we are doing, especially when they know we are going to be doing an activity.”

Not only did the observations of the classroom teacher support my observations but the following comments added how the different levels of student in the class were being affected by the use of inquiry:

- "The higher level students usually enjoyed science anyway but now they are really excited and are easily encouraged to carry the activities to a higher level, in fact they usually do it anyway with out me encouraging them."
- "Lower level students are a lot more positive and interested in science. They definitely have a better attitude and ask me all sorts of questions about all aspects of science…not just electricity. It is like they just woke up to science…they are very excited."

Even though I was conducting this study in an honors class, like most honors classes in this particular school the class contained several students of a lower level who were placed in the class out of convenience or lack of another science class to place them in. However, as the classroom teacher mentioned, I too observed that these students became more engaged with the activities and were willing to explore and ask questions. Our observations, when corroborated, showed that all of the students were engaged and asking questions.

The third source of data to support increased student participation was provided by the student responses to questions in the attitude survey. The questions shown in Table 2 were designed to assess the participation of students in science in school. This type of question helps to determine what may or may not be responsible for students' involvement in science class. These questions were essential to assessing the amount of student involvement and exploration in their science class prior to and after the survey.

Table 2: Multiple Choice Responses to the Pre and Post Attitude Survey

Statement	"Always" and "Many Times" Pre-Survey	"Always" and "Many Times" Post-Survey	Individual Increase	Percent difference
In science, how often do you follow written directions to do an activity?	13	5	-8	-44.44
In science, how often do you use manipulatives such as blocks, rulers, cubes or a magnifying glass to solve a problem?	5	13	+8	+44.44
In science, how often do you take tests where you have to explain your answers?	9	14	+5	+27.77
How often do you discuss how science is used in everyday life?	6	10	+4	+22.22

The initial question, "In science, how often do you follow written directions to do an activity?," saw a decrease in the answers "always" and "many times" from pre-test to post-test. A decrease in students from 13 prior to the study to 5 after the study may suggest that students recognize that they are thinking and exploring on their own in science activities and investigations. This situation suggested that inquiry may lead to a higher level of involvement, innovation and deductive reasoning on the part of the student.

The second question, "In science, how often do you use manipulatives such as blocks, rulers, cubes or a magnifying glass to solve a problem?," saw an increase from 5 prior to the study to 13 after the study of students who replied that they were using manipulative "always" or "many times" in science. When combined with conducting activities without written directions, using manipulatives may suggest an inquiry-based classroom where students are engaged in "doing" science rather then just memorizing.

The data that supported an increase in participation in science class by students came from the comments that students made to both the classroom teacher and myself, the charting of how often students raised their hands to offer input in science and the increased success on inquiry based assessments. These observations were made during the activities and investigations and when this data were triangulated it suggested a firm link between the use of inquiry and student participation. By encouraging students to investigate problems using their own creativity and knowledge, to share their findings with the rest of the class, and to be receptive to the ideas and discovery of others increased the participation of students in science class.

Student Academic Performance and Science Inquiry

Research Question #3: How did the implementation of an inquiry-based curriculum affect the academic performance of middle school students in science classes?

The final pattern or theme which emerged from the analysis of the data was that inquiry helped students to gain a better understanding of the nature of science and to become more comfortable in using the nature of science to approach and solve problems. Evidence collected during this study that suggests that inquiry not only helped students to better understand the content material better then traditional methods but that it helped them to better understand the nature of science itself, could be found in the inquiry based students assessments, student and classroom teacher comments and through observations made by both the classroom teacher and myself.

The pattern, which supports these views, first emerged during the analysis of the inquiry assessment scores. The graph in Figure 1 shows the scores of each student on the seven inquiry based assessments that were taken over the duration of the study as well as the average class score for each assessment.

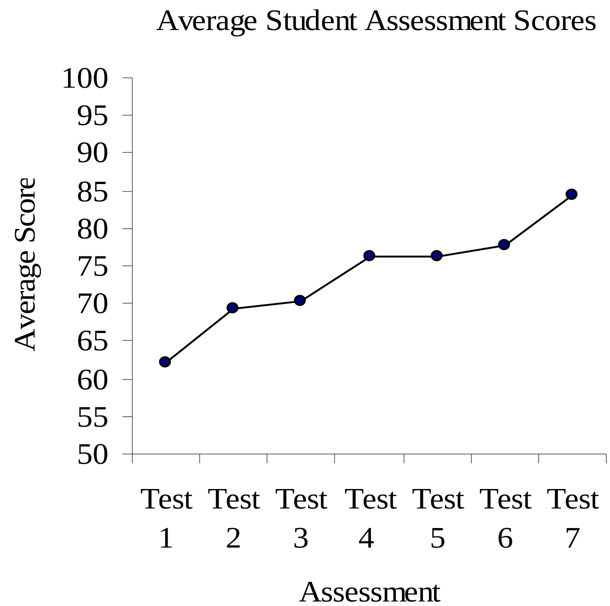

Figure 1: Average Scores on Inquiry-based Assessments

These inquiry style assessments consisted of approximately six questions which all required the students to create ways to solve problems to situations or to explain the results of an investigation based upon what they knew and to then support those conclusions based on the situation. Some examples of these questions were:

- Look at the schematic to the right. Explain what will happen in this circuit, and why, when the switch is closed.
- How could you calculate the resistance of a component, like a light bulb or a motor, using a meter and a resistor?
- An electrician has a multimeter, a 9-volt battery, a lamp, and a 200-ohm resistor. She made a series circuit using these components. She determined that there was a

voltage drop of 4.0V across the resistor. How much current was flowing in the circuit?

- Ms. Waters had two aquariums with beautiful tropical fish. She wanted to install in each tank some lights that she could turn on in the evening and off in the morning. Her small aquarium needed on light, and her large aquarium needed two lights. She had one battery, two switches, three light bulbs, and eight pieces of wire. How should she wire her aquarium to have one bright light in the small aquarium and two dim lights in the large aquarium?

The data in the graph (Figure 1) showed that the class average for the inquiry-based assessments administered at the onset of the study were almost 20 points lower then the assessments administered at the end of the study. The classroom teachers' records indicate that the primary reason for the low scores on the first few assessments were due to students not attempting the more challenging inquiry-style questions on the assessment. Initially, many of the students either skipped these questions to address the questions or parts of questions that asked a more straightforward question such as definitions or the differences between two terms or pieces of equipment.

The classroom teacher reported that as the study progressed and students appeared to become more comfortable with the inquiry style questions, they were choosing to attempt them. In addition, the classroom teacher logged in her records that not only were more of the students attempting more of the questions on the assessment but also that they were getting them correct. It was also noted that if they were not getting the questions correct, they were at least providing a more involved answer that demonstrated a level of innovation and understanding. These assessments, along with the classroom teachers' observations of their performance, suggested that inquiry was helping to raise the level of investigation and innovation on the part of the students.

As mentioned earlier, the inquiry assessments required students to solve problems by combining data provided to them in the problem with knowledge they already have about a topic and then using that information to solve the problem in the best way that they see fit, making sure to describe the method they used. This is same procedure as ascribed to the nature of science by the NSTA. Because of this, inquiry based science questions test students ability to use the nature of science to solve problems just as much as it does the content material.

When students are required to explain their answers on an assessment rather then answer "true" or "false" or chose a, b, c or d, not only requires them to demonstrate their understanding of a topic but also allows them to express their understanding in their own way using examples that they recognize as important to their lives or as best illustrating the content of the question rather then choosing a memorized definition or situations discussed in class. By being asked to explain their answers, students are asked to think about a topic and how it relates to a situation rather then to recall memorized information. The number of students who felt that they were asked to explain their answers "always" or "many times" on science tests increased from 9 prior to the study to 14 after the study (Table 2).

Therefore inquiry based questions such as "Ms. Waters had two aquariums with beautiful tropical fish. She wanted to install in each tank some lights that she could turn on in the evening and off in the morning. Her small aquarium needed on light, and her large aquarium needed two lights. She had one battery, two switches, three light bulbs, and eight pieces of wire. How should she wire her aquarium to have one bright light in the small aquarium and two dim lights in the large aquarium?" and "Look at the schematic to the right. Explain what will happen in this circuit, and why, when the switch is closed" provided the students with the opportunity to demonstrate their ability to apply their knowledge. In order for students to be successful on the inquiry-based assessments, they needed to have an understanding of the nature of science and how it worked (even if they did not know it by name) as well as an understanding of the content material.

The data provided in Figure 1 showed that the class average on the inquiry assessments did increase as the study progressed, suggesting that students not only became more familiar with the format of the inquiry based assessments but with the nature of science as well. Although student scores on inquiry assessments did exhibit some flux over the course of the study, there was a definite increase in the class average score from the first to the last assessment from 62.1 to 84.5. This showed a class average increase of 22.4%.

Student comments in class and during activities and investigations also supported their understanding of inquiry.

- "I like how we get to try our different ideas to see if they will work."
- "Each of us had a different idea of how to make it work and we each got to try our idea. We found that they all worked…we were all right."
- "Randi thought that we should use 2 purple resistors and I though that we should use two yellow ones. When we tried it we found that neither of them worked right. When we looked at it again though and added up the resistors we found that we had to use one of each to make it work…and then we could put them in any order."
- "We found that we could get the light bulb to light up more by doing different things to it…we found more then one answer to the question."

- “We found that if the resistors added up to the same amount that the amount [voltage] dropped the same amount, even if we used different ones [resistors].”

A comment such as “We found that if the resistors added up to the same amount that the amount [voltage] dropped the same amount, even if we used different ones [resistors]” showed that students were examining the situation, materials and the knowledge they had already gained. In the following comment, the students’ demonstrated that they were not only using prior knowledge, but that they were using it to further question the situation and search for further explanations such as other solutions:

> “Randi thought that we should use 2 purple resistors and I though that we should use two yellow ones. When we tried it we found that neither of them worked right. When we looked at it again and added up the resistors we found that we had to use one of each to make it work…and then we could put them in any order.”

These newly formulated questions led the students to search for answers and the evidence to support those answers; “We found that we could get the light bulb to light up more by doing different things to it…we found more then one answer to the question.” This, in turn led to new discoveries and a better understanding of the content; “Each of us had a different idea of how to make it work and we each got to try our idea. We found that they all worked…we were all right.” These comments definitely suggested that the students are using and learning the nature of science as it is defined by the NSTA, even if they do not actually know the term or have ever even heard it before. They are learning to explore and try different things.

Along with the classroom teacher, I completed student observations. Over the course of the study I found, through my observations, that students wanted to find out information for themselves; they no longer wanted to be given the answer or told how to do it. They would still ask for guidance from time to time, but did not want to be given a definite answer or procedure. They also wanted to look for patterns as they were increasingly less satisfied with finding "the answer." They wanted to search to find more than one way to achieve the desired result, or, in the case of a few groups, they wanted to try to find exceptions to the results or conflicting results.

Another trend that I observed was that the talk between the students became more and more productive over the course of the study. The conversations that took place during the activities and investigations revolved more around the task at hand and applying what they had learned to the situation and less about their personal lives.

A final trend that emerged over the course of the study became evident upon the classroom teachers reflection of her records and logged student comments as well as those I made, was that students became better at drawing conclusions from their data and at seeing trends within their data and investigation results. This also helped to demonstrate a better understanding of the material on the part of the students as was evident through the increasing average score on the inquiry based assessments over time (Figure 1).

Some of the comments and observations that the classroom teacher reported were as follows:

- "You can now ask most of the kids, especially the higher ones, a leading question and they are determined to figure it out."
- "They [the students] react better to inquiry labs; they seem to feel they have used their brains and accomplished something, they figured out something on their own. With traditional labs they felt like they were just following a recipe, a seemingly mindless activity."

- "Many of the students felt as if these activities helped them on the practice FCAT. The processes [on the FCAT] involved solving problems rather then just showing the right answer."
- "The students have become very excited about testing out their ideas in class. Now, when they ask questions they don't just want the answers, they want to do something to test the answer or test what they think is the answer. They are a lot more investigative then they ever were."

These comments suggested that the students were using and learning the nature of science as it is defined by the NSTA. They are learning to explore and try different things. They are making conclusions based on their discoveries and in many cases are even allowing their discoveries to lead them to new questions and new investigations…the true mark of the nature of science.

All of these sources of data, when triangulated, suggested that the implementation of the inquiry based unit helped the students to better understand the nature of science and so to use science to help solve questions, problems and observations in the natural world around them.

Summary of Results

Through the analysis of the various data, three themes were found. The first is the connection between inquiry and student attitudes. The second is how student participation is linked to inquiry and the third is the relationship between inquiry and academic performance. These themes were discussed at length in this chapter. However, even though there was a great deal of data to support these findings, there were some indications that inquiry did not have the same effect on all students. In the attitude survey, not all questions demonstrated the jump in results that may have been expected. On the inquiry based assessments, although half of the students showed consistent increases in their scores, others remained relatively consistent with their scores throughout the study, with some being low and some being high, while others varied too greatly to draw any definite conclusion. These same discrepancies can be applied to how often students raised their hands to offer input during class. Finally, the small size of the class and the fact that they were honors may also have affected the results in that these are students who would be expected to actively participate and challenge the material and the teacher in any instance.

The meanings of these patterns and discrepancies as well as recommendations and implications were discussed in Chapter Five.

CHAPTER 5
CONCLUSION

Introduction

Inquiry as a form of education has a long history. Yoder (2005) observed, "Socrates encouraged the youth of Athens to ask questions" and that the "Socratic Method includes several components that are evident in today's efforts to promote inquiry." While the Socratic Method has been utilized in education since the time of Socrates, it is not always the first choice of teachers. Over time many teachers began to rely on textbooks and they became information dispensers while students were the receptacles of knowledge.

One focus of the *National Science Education Standards* is the importance of inquiry-based learning in science classrooms. They base this on the importance of the "process of science" as opposed to "science as a process" in order for successful learning to occur. This belief has been supported by research done by Phillips (1995), the NRC (1996), Patrick and Yoon (2004), and Akey (2006).

The objective of this study was to examine the effect of the introduction of an inquiry-based unit on the attitudes, the participation, and the academic performance of eighth grade students towards science and science class. My interest in the focus of this study was due to my involvement as a science coach with a federal grant to increase the level of inquiry based instruction in our schools. I have always utilized inquiry-based instruction in my classes and was eager to observe the changes in science students as they moved from a traditional form of instruction to one of inquiry.

In order to achieve my research goals, I focused on three questions that tied inquiry learning to student attitudes, participation, and academic performance.

- How did inquiry-based learning affect the attitude of middle school students toward science?
- How did the introduction of an inquiry-based unit affect the participation of middle school students in science classes?
- How did the introduction of an inquiry-based unit affect the academic performance of middle school students in science classes?

Student comments over the course of the study showed that not only did their interest increase with the use of inquiry but that they were eager to do more and that they were looking forward to science class. Comments such as “I love this class!” and “Can I stay and work on this some more?” and “Look at what we found out!” became commonplace in the classroom. These comments imply that the students are having a good time in the class and that they enjoy doing all of the activities. This in turn shows how they have a very positive attitude towards the class.

The patterns that emerged from the data suggested positive answers to the research questions. While these patterns helped to show that student’ attitudes become more positive through the use of inquiry to teach science, it additionally showed that while students are being taught through inquiry they exhibit an increased level of participation during activities and during class discussions. In addition, Haury (1993) supported my findings by observing that positive attitudes increased in middle school students who participated in inquiry-based programs.

This quote helps to describe my findings concerning student attitudes and participation. Although data was collected from a variety of sources, including student assessments and a pre and post attitude survey, the greatest amount and most useful and telling sources of data were the observations and comments from the students and the classroom teacher.

My classroom experience over the years has lead me to believe that the more participatory the coursework the more likely students are to maintain a positive attitude, a desire to participate, and a passing academic performance. I also believe that a positive attitude is tied to increased participation, and through this students take ownership of their learning. Research conducted by Lumsden (1994), Dowson and McInerney (2001), and Hancock and Betts (2002) illustrates this link between the academic performance of students with their attitudes toward and engagement in learning.

My findings on the inquiry method suggest that inquiry may have an impact on student attitudes, participation, and academic performance. This study has helped to reinforce my belief that inquiry, both guided and open, is the most productive way of teaching science for both the students and the teachers.

Limitations

The first limitation was the school year itself. Due to the time-frame of the school year, review for state tests and the framework of the SMART grant, my time was limited to less then two class periods per week over a nine week period at the end of the school year. More time would be needed to ascertain the extent of the influence of inquiry on student attitudes, participation, and academic performance. The additional time would allow for more than one inquiry unit to be introduced and taught allowing for a comparison between different units. This way I would have data to confirm that it was inquiry and not the “electronics unit” that caused the response from the students.

The second limitation was in the group involved in the study. The study was done with a single eighth grade honors class rather then several classes of varying academic abilities and grade levels. In addition, the study was carried out in a relatively small class of only eighteen students of a widely uniform demographic range. To help broaden the scope of the study, several classes of varying levels and demographic make-ups could be used.

The third limitation was the potential bias of the researcher and classroom teacher towards the use of inquiry. My role at the middle school was to provide my assistance as a middle school science coach whose purpose was to help increase the amount of inquiry-based hands-on experiences in middle school science classrooms. Both the teacher of the classroom and I had attended and continued to attend workshops on inquiry, including instructional methods and the proposed benefits of inquiry teaching. Although this bias would have been completely unintentional, our eagerness could have been contagious to the students and helped to increase their own enthusiasm for the class.

A fourth limitation would be the validity and reliability levels of the student attitude survey. Although it was created through the collaborative efforts of three experienced science coaches and was provided with face validity by several national and county level science experts, the survey may still have had a questionable level of validity and reliability due to wording, response choices or lack of pre-testing.

Recommendations

The research that I conducted has lead me to acknowledge that a number of patterns exist as well as suggesting the presence of potential conclusions. I believe that future research is needed to provide additional data and extend the scope of the study.

First, I would carry out the study in a minimum of three middle schools in the same school district. The increase in the number of schools involved in the study broadens the availability of data to support the findings. The increase in the number of schools involved in the study creates data that may be more reliable and valid to support the purpose of the study. For each class that participates in the study, I would have a control class against which to compare it.

A potential problem with the increase in the number of classes and schools involved is that the researcher will have less time available to spend in each of the study schools. One suggestion was to involve multiple researchers and assign one to each school participating in the study. This, while an effective solution, also raises the issue of additional chances for the bias of individual researchers to impact the results.

The schools selection process was done in such a manner as to ensure the availability of a diverse socioeconomic and demographic make-up. These changes would create a research database that potentially would carry much more weight, as it was possible to compare the data on a variety of levels. By including diversifying the make-up of the study schools, it is possible to get a clearer picture of the impact of demographics and socioeconomics on the reaction of students to inquiry-based learning. Through the inclusion of these two variables, it would be easier to show whether or not inquiry is equally effective with all students or if it is more effective with specific groups of students.

Second, I would like to have carried out the study for a much longer period of time. I believe that a minimum of an entire academic year is truly necessary. The added time would allow the students to adjust to and accept the inquiry as an everyday occurrence in their school day. This adjustment would allow the researcher to discover if the students grew bored with it or if they continue to increase or increase and then sustain an increased level of attitude and participation.

Third, I would have a researcher present in each class as often as possible and consistent with each study and control class. Optimally, this would have a researcher present in each class each day of the study but more realistically this number would be closer to three days to allow time for the researcher to document and compare their results throughout the study. It would also best to have each researcher observing an equal number of study and control classes to give each researcher a basis for comparison.

Fourth, in order to decrease the possibility of bias as much as possible, I would like to have a more definite, reliable and valid form of recording observations. This would likely be in the way of surveys and snapshots with a proven high level of reliability and that have been developed by more experienced researchers.

As a final recommendation, I would like to add a facet to the study to cover a pattern that emerged during the study that was unexpected and surprising to the degree that it was observed. This pattern was the level of cooperation that was reached by the students. Therefore, it would behoove the study to add the issue of cooperation to the initial questions to be addressed in the study. Observations made during the introduction of the inquiry-based FOSS program suggested that inquiry was impacting the students' willingness to work cooperatively with others.

Students who normally did not associate with each other except when they had to work together and then the association lasted only as long as the assignment were now interacting on a regular basis on many levels. Most surprising was that this was a change that extended beyond the science classroom. A comment made by the classroom teacher reflects this observation: "I bumped into the math teacher today and he said that the students were actually working together and REALLY helping each other on the math problems and he had never seen them do that before. He asked them why they were doing that and they said that they were just use to it from science class...I felt really proud."

Summary

At the onset of this study, the traditional curriculum of an eighth grade honors science class in an inner-city school in the Southeastern United States was replaced with the FOSS electronics inquiry based curriculum. Throughout this study I have charted and documented changes in student attitude and participation through their comments, classroom teacher comments, classroom and teacher and researcher observations and student assessment scores. I then triangulated all data to determine the emergence of any patterns over the nine-week course of the study. Patterns suggested that student attitude and participation levels increased during the study. Although there were limitations to the study, the findings do warrant further investigation through a more controlled study with a longer investigation time and broader base of sample size.

In conclusion, I must say that this limited study has simply bolstered my belief in inquiry-based curriculum. The reactions of the students with whom I interacted combined with the depth of research illustrated a need to use inquiry as the basis of instruction. This does not mean that there are not times when a more traditional—book and paper—method is needed. However, it is important that current teachers are trained to utilize inquiry in their classrooms and that future teachers are taught inquiry as a basic method of curriculum delivery. In the end, inquiry is not just crucial for science education. Anderson (2001) sums up the importance of inquiry in saying that through inquiry our citizens make sense of the world they inhabit and is this not the goal of every teacher for every student.

APPENDIX A
PARTICIPATION TICK CHART

Participation Tick Chart Date:

Observations/Notes:

APPENDIX B
STUDENT PARTICIPATION TABLE

Student	**3/10**	**3/23**	**3/28**	**4/5**	**4/10**	**4/12**	**4/20**	**4/24**	**4/28**	**5/1**	**5/3**	**5/10**	**5/15**
Reuben	0	2	1	3	4	4	3	7	4	A	6	6	5
Florence	2	1	3	2	2	3	4	2	1	3	4	5	4
Peter	6	1	2	5	4	1	5	4	3	6	8	8	9
Randi	4	1	4	5	4	4	6	6	7	6	6	7	6
Bobby	0	2	2	4	0	5	5	7	8	7	7	8	8
Keith	2	3	5	4	7	6	3	5	A	6	A	6	7
Greg	0	A	A	2	0	1	A	3	A	2	A	A	2
Chris	2	A	3	3	4	4	3	4	4	A	4	5	7
Shirley	5	1	5	6	3	6	5	7	7	7	9	A	7
Jan	3	3	4	3	2	5	3	5	4	6	2	4	4
Danny	1	1	1	3	5	4	6	8	8	9	9	11	9
Mike	1	1	1	3	A	3	2	5	5	4	3	4	5
Carol	4	0	A	4	4	A	4	4	5	4	A	5	A
Sam	5	2	5	6	6	8	8	A	9	9	7	13	10
Marsha	3	1	1	2	1	3	3	4	3	5	4	3	5
Laurie	A	1	0	2	0	0	1	1	3	3	2	3	1
Alice	0	A	1	1	3	3	4	A	2	1	A	0	A
Cindy	5	A	3	A	4	7	6	A	6	5	A	5	7
Average	**2.5**	**1.4**	**2.6**	**3.4**	**3.1**	**3.9**	**4.2**	**4.8**	**4.9**	**5,2**	**5.5**	**5.8**	**6.0**

A=Absent

APPENDIX C
STUDENT SCIENCE SURVEY

Science Survey

Thank you for participating in the SMART science questionnaire. This questionnaire is being conducted with students to find out how they feel about science. Your answers are very important. We will use your input to improve science programs at the school.

To complete these questions, please follow the directions circle your confidential responses.

The first part asks you to describe yourself.

1) What is your grade level?

grade 6 grade 7 grade 8

2) What is your race or ethnicity?

Asian Black Hispanic White Other

3) What is your gender?

Female Male

The next part asks you "yes-no" questions. First read the question and then circle your answer.

4) Do you look forward to science time at school?

yes no

5) Do the things you learn in science help you understand things that happen in the world around you?

yes no

6) Do you think science more useful for boys then girls?

yes no

7) Does learning new things in science help you answer questions?

yes no

8) In science, does your teacher like for you to ask questions?

yes no

9) Do you want to have a job in science someday?

yes no

I0) Is it important to know science to get a good job?

yes no

11) At home, do you talk about science activities that you have learned at school?

yes no

For each of the following questions, indicate how often you participate in the task described in your science class. You will need to choose from: never, a few times, many times, or always.

12) In science, how often do you follow written directions to do an activity?

never few times many times always

13) In science, how often do you use manipulatives such as blocks, rulers, cubes or a magnifying glass to solve a problem?

never few times many times always

14) In science, how often do you work in groups to learn an idea or solve a problem?

never few times many times always

15) In science, how often do you read from a book or printed material?

never few times many times always

16) In science, how often do you take tests where you have to explain your answers?

never few times many times always

17) How often do you discuss how science is used in everyday life?

never few times many times always

18) How often do you learn about people who are scientists or mathematicians?

never few times many times always

19) How often do you use the internet to find information for science?

never few times many times always

Thank you for participating in the science questionnaire. Your answers are very important.

APPENDIX D
STUDENT ASSENT FORM

Student Assent Form

My name is Mr. James Perlmutter, and I am a graduate student at the University of Central Florida. I would like to ask you to participate in my study, "The Effect of an Inquiry-Based Science Curriculum on Student Attitudes and Achievement." Your participation is strictly voluntary and whether or not you participate in the study will not affect your grade. During the study, you will take assessment tests and I will ask you questions about the lessons we are studying. When I ask you questions, I will be making notes regarding your answers. You may stop at any time and do not have to answer any questions you do not want to answer. Would you like to participate in my study?

YES or NO (Circle one)

________________________________ ______________________

Print First and Last Name Date

____

Student Signature

APPENDIX E
PARENTAL ASSENT FORM

Dear Parent or Guardian,

My name is James Perlmutter and I am the xxxxxx County Science Coach at xxxxxx Middle School. During this academic year, as part of a District program currently being implemented at xxxxxx, your son/daughter will be asked to take a number of assessments to measure the effect of Inquiry-based Science Curriculum in the classroom. In addition to this program, I am currently engaged in my Master's Program at the University of Central Florida. My thesis is based on the research in which your xxxxxx student will be participating.

Your son/daughter will be asked to take attitude surveys before the implementation of the science curriculum and after the curriculum has been taught. The information obtained through these assessments will be kept anonymous and confidential. There will be no identification of the students. In addition to the surveys, your son/daughter will also participate in informal interviews with myself during class. These interviews will be held as both group and individual discussions and will occur inside the confines of the class period. The notes taken during these discussions will be kept confidential as well. There will be no penalties for choosing not to participate in the research and there will be no rewards for students who do participate. Students may choose to stop participating in the study at any time. Data will be collected during regular science classes. Students who choose not participate will be engaged in the same classroom activities but no data will be gathered about them.

In order for your son/daughter to participate, I need a written release from the parents. Please fill out the form below and indicate whether you are giving permission for your xxxxxx student to participate or if you are denying permission.

I would like to thank-you for your help with this matter. If you have any questions, please feel free to contact xxxxxx Middle School and leave a message for me with the school secretary.

Sincerely,

James Perlmutter

Contact Information—UCF Faculty Advisor
Bobby Jeanpierre, Ph.D.
Assistant Professor, Teaching and Learning Principles
University of Central Florida
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Orlando, FL 32816-1250
407-823-4930
E-mail: bjeanpie@mail.ucf.edu

I have read the procedure described above. I voluntarily agree to participate in the procedure, and I have received a copy of this description.

I, ______________________________ have read and understand the letter for participation in “The Impact of Inquiry-based Science Curriculum on Student Attitudes and Participation” research study.

_____ Yes, I give permission to my child to participate.

_____ No, I do not want my child to participate.

____________________________ ______________

Parent Signature Date

Information regarding your rights as a research participant may be obtained from:

Barbara Ward, CIM
Institutional Review Board (IRB)
University of Central Florida (UCF)
12443 Research Parkway, Suite 207
Orlando, Florida 32826-3252
Telephone: (407) 823-2901

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