

THE EFFECT OF INQUIRY-BASED, HANDS-ON LABS ON ACHIEVEMENT IN
MIDDLE SCHOOL SCIENCE

by

Donna Kaye Green Miller

A Dissertation Presented in Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education

Liberty University

June 20, 2014

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ABSTRACT

The purpose of this quasi-experimental study was to measure the difference in science achievement between students who had been taught with an inquiry-based, hands-on pedagogical approach and those who had not. Improving student academic achievement and standardized test scores is the major objective of teachers, parents, school administrators, government entities, and students themselves. One major barrier to this academic success in Georgia, and the entire United States, has been the paucity of success in middle level science classes. Many studies have been conducted to determine the learning approaches that will best enable students to not only acquire a deeper understanding of science concepts, but to equip them to apply that new knowledge in their daily activities. Inquiry-based, hands-on learning involves students participating in activities that reflect methods of scientific investigation. The effective utilization of the inquiry-based learning approach demands inclusion of learners in a self-directed learning environment, the ability to think critically, and an understanding of how to reflect and reason scientifically. The treatment group using an inquiry-based, hands-on program did score slightly higher on the CRCT. However, the results revealed that there was not a significant difference in student achievement. This study showed that the traditionally instructed control group had slightly higher interest in science than the inquiry-based treatment group. The findings of this research study indicated that the NCLB mandates might need to be altered if there are no significant academic gains that result from the use of inquiry-based strategies.

Dedication

First of all, I want to thank God for giving me perseverance to fulfil this dream that I had set for myself since I was very young. “Blessed is the man who perseveres under trial, because when he has stood the test, he will receive the crown of life that God has promised to those who love him” (James 1:12, NIV). I do feel like there were lots of trials through this process, which makes me even more thankful to have had God walking with me and even pushing at times.

The biggest trial that I faced was losing my mother, Janice Green. I want to dedicate this dissertation to her because she was there for me. She was always encouraging me to do my best and keep moving forward. The school districts that I used for this study were at least three hours away so my mother travelled with me so that I did not have to go by myself. She was my editor and enjoyed supporting me. I know she is proud of me and I will forever miss her and her support. I love you, MOM.

I do also want to dedicate this study to my husband, Donnie Miller, who kept telling me that I could finish this and to my son, Austin Blake Miller, who had to be willing to do without my attention and help on his homework. I hope that one day I will be attending your doctorate graduation because you know that if your mother could do this, then you can definitely finish and graduate from dental school. I love both of you very much and am proud to have you in my life.

I have to praise my father, David Green, who has been there to help with my son and never tells me ‘no’. I appreciate all the support and it really means a lot when you are bragging on how proud you are that I am continuing my education and moving up within my career. Thank you for loving me. I love you very much, too.

I have to include my dear sweet sister, Debra Hallford, and my caring brother, Richard Green. I appreciate the prayers and encouraging words. It means a lot to know that both of

you would drop everything to be there to help me if I needed you. Thank you and please always remember that I love each of you dearly.

I am also very thankful that I had some help from the Rats. Craig this is another one that you successfully pushed through because I know that there were a few times you would have liked just to tell me to go jump in a lake, but instead you forgave me and just kept pushing. I will forever owe you and I hope one day I can repay the help to all of the Rats. I am glad to have such prayer warriors and supporters.

I would also like to thank my family at SHMS. The support and encouragement whether through prayers or spoken words really meant a lot. I am so lucky to have a family at work instead of just colleagues.

Acknowledgements

The dissertation focuses on ways of improving students' academic achievement in the science related fields of study, using an inquiry-based, hands-on learning approach to raise test scores in middle level classes. This is a topic that has not been fully addressed by research, so I required guidance from various individuals in order to bring this study to completion. I received significant support from professors, interviewees, participating schools, and family members. Therefore, I recognize and sincerely thank the following individuals for their unwavering support throughout the research period:

1. I would like to thank Scott Watson, PhD for serving as my dissertation committee chair and research consultant. I appreciate all your help and support. I also appreciate all your prayers as I worked through this journey in my life.

2. I would also like to thank Linda Woolard, PhD for serving as my second committee member. I appreciate all the time that you spent helping me through this process.

3. To all the administrators, teachers, and students that helped me out by completing surveys and allowing me to observe their classrooms. I hate that I have to keep these individuals anonymous because you truly are the only reason that I could do have completed this dissertation. You all accepted a stranger into your schools and classrooms and I will be forever grateful. However, you all know who you are and I really appreciate you allowing a strange to come in and make them feel like they were part of your school.

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List of Abbreviations

AYP – Adequate Yearly Progress

CIS – Course Interest Survey

CRCT – Criterion-Referenced Competency Test

GPS – Georgia Performance Standards

NCLB – No Child Left Behind Act

SBC – Standards Based Classroom

CHAPTER ONE

This chapter provides an introduction to the study. This quasi-experimental research study examined the effects on student achievement when inquiry-based, hands-on labs were implemented into a standards-based life science classroom. It compared the grades and test scores of students in inquiry-based, hands-on science labs with the grades and test scores of students enrolled in classes with more traditional methods of teaching, such as lecture and demonstration. Hands-on labs included all hands-on activities carried out by students during their science classes. Inquiry-based instruction required that the students had analyzed the results gathered during the hands-on labs and drew conclusions supported by the data. This research study will utilize a quantitative approach to address the controversy between the effectiveness of using inquiry-based, hands-on labs and the effectiveness of using traditional methods of lectures and demonstrations to improve science test scores. It begins by giving background information on the research topic. Next, the research problem is stated and the purpose of the research is explained, followed by the significance of the study. The research questions that guide this study come next. The operational definitions of the variables of interest are supplied. Key terms that are used throughout the research study are defined so that the researcher's communication is received as intended.

Background Information

Teaching middle school science is often unsuccessful in terms of knowledge transfer and instilling recognition of the function and significance of science in society. In order to change these trends, several learning approaches have been designed to ensure that students appreciate and understand the importance of raising their test scores. Inquiry-based learning is one approach that has been undertaken to improve the teaching of science by involving learners in authentic and practical investigations, as well as offering a more motivating and learner-centred environment (Lane, 2007). This active learning approach can also be

employed to teach and enhance the nature of science by encouraging students to develop a deeper learning of the material (Biggs 2003; Lemke 2001, Brew and Boud 1995; Prosser and Trigwell 1999). Since 2000, there has been an abundance of research published that discusses the need to enact reform in science education, and there has also been an abundance of research published regarding the benefits of inquiry-based practices in science education; however, there is a scarcity of literature available on the use of inquiry-based learning to improve student achievement in science (Florian, 2000; Larkin, Seyforth, & Laskey, 2009). The inquiry based learning approach is still not predominant in classrooms and is reported as misused especially by primary teachers who lack confidence in teaching science (Goodrum & Rennie, 2007). The misuse of inquiry-based science instruction occurs for multiple reasons, such as the insufficient amount of time allocated to classroom lessons, inadequate means for learners to conduct autonomous investigations, the challenges involving the incorporation of practical concepts with inquiry, and lack of educator expertise to effectively handle inquiry topics in middle school science classes (Lane, 2007).

Computer technology has evolved and currently has the potential to greatly facilitate the use of inquiry-based learning at different school levels and to deliver new tools for presenting science concepts in the classroom. Teachers can use video imagery that has been described as a “tool of the mind” (Forman 1999, 1) because it allows the students to go back and examine the data collected. This provides the students with the information need for them to process and obtain a deeper understanding. The utilization of technology to supplement teaching methodologies and objectives carries great potential to improve science education in the classroom, especially when the essential limitations of technology are identified and technology is employed as a tool rather than as the ultimate goal of the learning endeavor.

The idea of using hands-on labs to teach science in the United States (U.S.) has been

debated for more than a century. In 1861, Herbert Spencer proposed the object-centered instruction strategy so that students would directly contact with nature by observing natural objects and then form their own conclusions. Another inquiry-like approach was introduced in 1898 by English educator Herbert Armstrong, it has been called the heuristic (step-by-step) method; this method requires neither books nor directions from the teacher. The students are using a trial and error method to explore solutions to proposed problems. Then came John Dewey (1929), who supported project learning and said that science learning must include the process aspect of science, not just the information aspect. Dewey believed that students should use inductive thinking and be free to interpret their own learning without the pressure of others. After the launch of Sputnik by the Soviet Union in the late 1950s, inquiry instruction received renewed attention in curriculum design. As the new curricula extending into the 1960s were developed in the U.S., there was an inquiry focus introduced that had a positive effect on learners. Joseph Schwab (1962) said that science instruction is just a “rhetoric (talk) of conclusions” or “final form” science so learners never get to see the processes of science, just the end products. The U.S. beats the Soviet Union to the moon and John F. Kennedy is assassinated and even though there was a positive effect on student learning, education seemed to change again. Now, we see the push again to compete with the other countries in the 1980s so research begins again and inquiry approaches are mentioned so studies begin. Shymansky et al. (1983) found “when the cumulative results of the research were considered, students in the new programs outperformed those in traditional, textbook-based classrooms on every criterion measured” (p. 398). There are big gaps in using these methods of teaching. It appears that about every 20 years there is a push to reform education because the U.S. is functioning below the other countries. Even though we see the results and conclusions are formed, the U.S. continues to switch back to the more traditional methods.

Mary Burgan's article "In Defense of Lecturing" points to the controversy that still surrounds the question of whether or not to lecture (Burgan, 2006; Rehm, 2007; Bland *et al.*, 2007). Some educators claim that lectures are passive and ineffective (Mazur, 1996; Powell & Kalina, 2009), but research reveals that they are still used widely in many classrooms across the U.S. (Barr & Tagg, 1995; Kroll, 1997; Bain, 2004; Scholes, 2004; Feynman, 2005). Lectures can require less time and effort for the instructor and can be an efficient way to deliver the content (Marilla & McKeachie, 2011). Wilson and Korn report that "good lectures can be compelling, and the suggestion that lectures are inherently ineffective because students stop learning after 15 minutes has recently been called into question" (2007, p. 86). This suggests that expecting teachers to change the instructional approach may present a problem. This research proposal will attempt to answer the question through a quantitative analysis of the relationship between using hands-on methods of teaching science and the more traditional methods of lecture and demonstration to determine if student outcomes are affected.

The inquiry-based learning approach reflects a mixture of developing strategies and practices for long-term teaching and how it might be applied in an actual classroom setting. In education, there is need to understand, carefully select, and employ combinations of inquiry and hands-on teaching practices that collectively increase the prospect of helping students learn because not all approaches work effectively in all classroom situations at all times.

The strongest likelihood of improving student achievement in science usually occurs when schools implement multiple techniques in the teaching and learning activities that influence the daily life of students. For example, if the objective is to improve the students' scientific problem solving skills, then the school may consider developing teacher training programs that can equip them in (1) use of the learning cycle approach; (2) systemic

approaches to problem solving; and (3) use of computer simulations. It is noted, however, that planning to train teachers and providing the necessary supplies to implement and sustain these changes may be challenging, though they hold great potential for improving the understanding and quality of students' problem solving skills.

Even though the research indicates that there are numerous benefits of inquiry-based curricula, science teachers in the U.S. continue to use traditional methods of teaching in their classrooms (Larkin, Seyforth, & Laskey, 2009; Lotter, Harwood, & Bonner, 2007; Martin, et al., 2008; Wells, 1995). Therefore, it is important that schools and district administration institute a culture in which educators exercise their professional proficiency, explore effective practices, and share academic information in order to remain focused on the ultimate objective of improving student achievement and test scores in science.

Problem Statement

All students pursuing a Georgia high school diploma must successfully pass the Georgia High School Graduation Test (GHS GT) that covers four content specifications, as well as pass the Georgia High School Writing Assessment (Cox, 2010). These assessments help to confirm mastery of critical fundamental academic content. Data from the GHS GT indicates that the GHS GT science test has the lowest passing rate for the initial test out of the four content areas. This requirement from the state and the need to meet Adequate Yearly Progress (AYP) presents the problem: Does the use of inquiry-based, hands-on labs improve the test scores of 7th grade middle school Life Science students? This study will also address an additional question: How do the 7th grade middle school Life Science students and their teachers perceive the use of hands-on, inquiry-based labs?

In an effort to improve the performance of students on these science examinations, Georgia has developed new performance standards, which are designed to promote a scaffolded approach to the curriculum so that students are presented with key concepts at

each level of education (Cox, 2010). Middle school teachers must help ensure successful mastery of the standards so that students leave their classrooms prepared for high school academics. All teachers are expected to use standards-based teaching strategies. In the U.S. National Science Education Standards (NSES) (1996), stated “students will learn science by actively engaging in inquiries that are interesting and important to them” (Standards, p. 13). “Students at all grade levels in every domain of science should have the opportunity to use science inquiry and develop the ability to think and act in ways associated with inquiry” (Standards, p. 105). Inquiry-based, hands-on labs follow the guidelines presented for a standards-based classroom. This decision by the state to adopt the standards-based instructional strategies, in addition to their need to meet Adequate Yearly Progress (AYP), fuels this research. The researcher sought to investigate two instructional science teaching methods: the use of an inquiry-based, hands-on lab approach versus the traditional lecture approach in an attempt to pinpoint the most effective method for teaching science at the middle school level in Georgia.

Purpose Statement

The purpose of this quasi-experimental study was to determine whether implementing an inquiry-based, hands-on lab instructional approach in seventh grade life science classes in Georgia schools resulted in improvement in students’ academic achievement, as measured by Criterion Referenced Competency Test (CRCT) scores. The No Child Left Behind Act (NCLB) (2001) supported standards-based training methods that utilize problem solving, inquiry, and asking questions that are open-ended to meliorate students’ achievement (Spring, 2008). It also mandated schools to enhance teachers’ content knowledge. This recommendation was supported by research that indicates improving teachers’ content knowledge positively affects teaching practices (Cohen & Hill, 2001; Kahle & Boone, 2000). For example, when teachers cover topics using inquiry-based, hands-on teaching techniques

and are themselves knowledgeable about the content, discussions can move in new directions based on students' interests. This becomes a more effective way for students to learn the difficult content outlined in the standards. (Kahle & Rennie, 1993; Lederman, 2004; Williams, 1998). When teachers address topics that they know less about, they mostly discourage active contribution by students, strictly control class discussion, concentrate on the presentation rather than on learners' discussions, and waste time on peripheral issues far from the main topic (Carlsen, 1991; Smith & Neale, 1991).

Significance of the Study

This study was meant to identify the most effective approach to teach life science in the state of Georgia. The study was conducted in order to fill the research gap regarding the effectiveness of the inquiry-based teaching using hands-on labs and activities daily when compared to the lecture teaching method that uses textbooks, demonstrations, and at least one lab per unit. According to Council of Ministers of Education (1997), the improvement of scientific knowledge is enhanced by favorable instructional environments that involve students in active inquiry learning activities. "Through such contexts the learners discover the significance of science to their daily lives and appreciate the interrelated nature of science, society, technology, and the environment" (Lemke, 2001, p. 85).

Additionally, the gains associated with an inquiry-based approach to learning can be enhanced when learning activities employed are learner-directed and open-ended. For this reason, it is imperative that learners are allowed to independently choose their specific research questions and be allowed to control the direction of their own inquiries. According to Hoffer and Moore (1996), "the demonstration of science is a procedure that follows step-by-step guidelines; filling in blank spaces on a worksheet only encourages inaccurate and impoverished impressions concerning the nature of science" (p. 98).

The researcher and other professionals should use this study results in order to justify the use of an inquiry-based, hands-on approach in their classrooms, since it proved to be an equally superior pedagogical approach for students when compared to traditional approaches to teaching science. The study provides information that can benefit other science educators in the target school, and also other schools within the target districts. For educators already using the inquiry approach, the researcher identifies an effective inquiry-based model that has the potential to make their implementation more effective in the classroom.

Therefore, this study assists administrators and educators in the target Georgia schools in determining the effects of employing an inquiry-based, hands-on teaching approach on the science achievement of seventh grade students. It did this by comparing inquiry-based learning approaches and traditional learning approaches on measures of student achievement. Schools within the targeted Georgia district or in the neighboring areas that presently employ this method, or anticipate adopting the inquiry-based approach, are likely to benefit from this study.

Research Questions and Hypotheses

This study examined the following research questions:

Research Question 1: Do seventh grade Life Science students who are taught using an inquiry-based, hands-on approach to science instruction score higher on the Criterion Referenced Competency Test (CRCT) than those who receive traditional, lecture-based instruction?

Research Question 2: Are seventh grade Life Science students who are taught using an inquiry-based, hands-on approach to science instruction more interested in science class than those who receive traditional, lecture-based instruction?

Null Hypotheses

The associated null hypotheses are as follows:

Null Hypothesis 1: Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not achieve statistically significantly different standardized CRCT science scores from students who received traditional science instruction.

Null Hypothesis 2: Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not rate their classroom experiences statistically differently than students who received traditional science instruction.

Operational Definition of Study Variables

There were two variables of interest in this study. Each is operationally defined below:

1. *Science Test Scores:* Science test scores were operationally defined as the results on the Georgia CRCT grade seven science assessment. The mean scaled score provided that number (Akhondi et. al., 2011; Brozo & Flynt, 2007; Bryce, 2011; Misulis, 2009).
2. *Course Interest:* Course interest was operationally defined as the score on the CIS. The mean score provided that number (Keller, 1984, 2010).

Definition of Important Terms

Adequate Yearly Progress (AYP): Adequate yearly progress or AYP was a part of the No-Child Left Behind Act (NCLB). The state of Georgia used the Criterion-Referenced Competency Test as one of the measures for the year-to-year student achievement. (Georgia Department of Education, 2012).

Constructivism: This is a learning theory that states humans can gain additional knowledge when allowed to complete real-life trial and error types of experiences (Esler W. & Esler M., 2001).

Course Interest Survey (CIS): This is a survey that is administered in order to define the level of motivation and interest the students have in a particular subject. This study

examined the level of interest that the student developed when the inquiry-based learning approach was adopted versus their level of interest when the traditional approaches were used (Keller, 1984).

Criterion Referenced Competency Test (CRCT): This is a standardized examination used in the state of Georgia to assess students' learning (Gadoe.org, 2012).

Didactic Method or Direct Instruction: "This is a method of instruction where the educator presents similar content material all at once to a class, either through graphic aids such as whiteboards or through PowerPoint slides accompanied by a demonstration to clarify a concept" (Estes & Dettloff, 2008, p. 19).

Georgia High School Graduation Tests (GHSGT): This is graduation tests used to evaluate whether Georgia high school students have mastered the vital concepts and skills from the covered curriculum adopted by the state; passing this test is a graduation requirement. Students graduating with Georgia diplomas are obligated to pass all the four sections of the GHSGT and the writing assessment, as well as meet the demands of other local and state graduation standards (Georgia Department of Education, 2012).

Hands-on Learning: Hands-on learning is a strategy used to provide instruction through tactile activities. It helps students to gain skills and knowledge beyond books and lectures by being an active learner that participates in experiments and carries out laboratory procedures in the classroom (Chang & Mao, 1998).

Inquiry-based Learning: This is a strategy used to promote active learning. Students are encouraged to develop experimental and analytical skills such as questioning, data analysis, and critical thinking. It is a learning methodology that engrosses learners in scientific investigation, where the delivered content is structured into an inquiry framework (National Research Council, 1996).

CHAPTER TWO: LITERATURE REVIEW

Introduction

This review of literature synthesizes past research from the fields of inquiry-based science instruction and hands-on learning in order to create an argument for the significance of this study. The information presented covers topics like improving student achievement by using an inquiry-based, hands-on labs approach of learning science, the relationship between hands-on science and student achievement, theoretical rationales for utilizing hands-on science to increase student achievement, and the interest level of students in regards to science courses. The chapter begins by presenting the theoretical frameworks upon which this study was built. Next is a discussion of literature related to the study. The chapter concludes with a summary of the literature review.

Theoretical Framework

There are three theoretical frameworks that guide this study. First is the Theory of Constructivism, first developed by John Dewey in the 1920s and 1930s, which proposed that learning occurs through experience. Second is the Theory of Ego Development, first proposed by Erik Erikson in the 1950s and 1960s, which stated among other things that a child's environment is crucial to his growth. Third is Vygotsky's Sociocultural Theory (1986), which stated that children are drawn into cognitive activities when active participation in the learning is required.

Constructivist Theory

The constant interaction between humans and the physical environment improves students' ability to construct knowledge. A major theme of the Theory of Constructivism is that learning is an active process in which learners construct new concepts and ideas that are based upon their past or current knowledge (Chi, 2009). One of the primary goals of using constructivist teaching is to make students own their own learning experiences by giving

them the freedom to make choices, like choosing between using inquiry-based, hands-on labs and learning by reading books. The learners choose information that allows them to construct hypotheses and make decisions, which gives the needed cognitive structure. Cognitive structure provides meaning and organization for their learning experiences and allows the individual to gain more than just the basic knowledge or vocabulary for the test. Furthermore, in the constructivist classroom, students work primarily in groups so that learning the required knowledge is interactive and dynamic (Bruner, 2012). This type of classroom emphasizes social and communication skills because the students are expected to collaborate with one another and exchange ideas. This is different from the traditional classroom, which involves the teacher using direct instruction to deliver the content and where students spend most of their time working primarily alone, which promotes routine learning through repetition. The use of textbook in the traditional classroom strictly guides the instruction. In the constructivist classroom, the teacher is a facilitator, using prompts to guide open discussions.

In 2007, Noddings examined Dewey's theory and found that an essential part of learning involves allowing students to use prior experiences and build on those experiences to gain true knowledge. Dewey (1929) stressed the importance of using scientific inquiry when he stated:

Science involves an intelligent and persistent endeavor to revise current beliefs so as to weed out what is erroneous, to add to their accuracy, and, above all, to give them such shape that the dependencies of the various facts upon one another may be as obvious as possible. (p. 210)

The constructivist theory supports inquiry-based learning because the students are encouraged to be actively involved in their learning by connecting prior experiences with new information (Ozmon & Craver, 2008). Montessori developed an educational approach

following the constructivist or “discovery” model in the 1920s (1967). This model allowed students to learn the content by working with materials, rather than through direct instruction (Lillard, 2011). Montessori’s teaching validated the need to implement inquiry learning by demonstrating that students learn in a different way, at their own pace, and by following the inner guidance of nature (Havis, 2006a). In the 1970s, David Kolb developed a learning model using the ideas from Dewey, Piaget, Lewin, and Williams that centered around experience, your own subjective experience. There are four elements: concrete experience, observation of and reflection on that experience, formation of abstract concepts based upon the reflection, and testing the new concepts (Kolb & Fry, 1975). It is a dynamic process that allows students to enter into the cycle at the level they are currently function (Figure 1). If the student is a concrete learner, then they can enter at that element and move into the other elements as they work through the content. Minner, Levy, and Century (2010) found that students who were involved in guided-inquiry lessons demonstrated greater science achievement than the students involved in traditional lecture classrooms. Minner et al. defined inquiry as a way to “motivate and engage students while concretizing science concepts through utilization of hands-on activities” (p. 475). The Lab-Aids program design was based on an acceptance of the constructivist approach and tended to favor a “guided inquiry” approach. Dr. Koker, director of the Lab-Aids Company, stated “this approach mixes activities that are very “open-ended”, with those featuring more direction for the student” (2007, p. 8). The *National Science Education Standards* states:

Guided inquiry can best focus learning on the development of particular science concepts. More open inquiry will afford the best opportunities for cognitive development and scientific reasonings. Students should have opportunities to participate in all types of inquiries (NRC, 2001, p. 30).

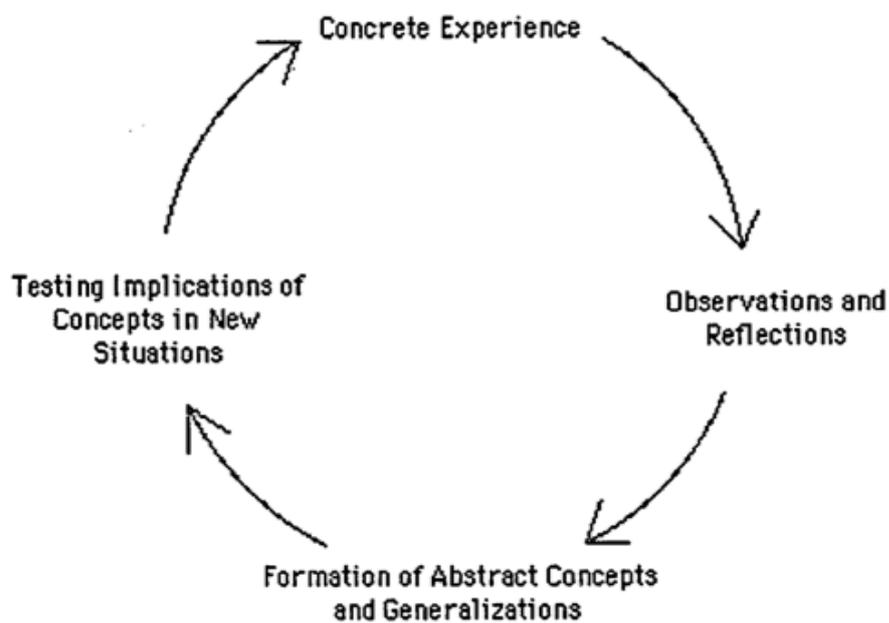


Figure 2.1. Experiential Learning Model
Kolb, 1985, p. 9.

Figure 1: *Experiential Learning Model* (Kolb, 1985, p. 9).

Theory of Ego Development

The Theory of Ego Development was proposed by Erik Erikson (1968). The Theory of Ego Development had eight stages, but Erikson's belief that drives the need for teachers to use inquiry-based, hands-on labs is that if the students are allowed to explore, they will conclude their own identity. Erikson would say, "Ego identity, then, in its subjective aspect, is the awareness of the fact that there is a self-sameness and continuity to the ego's synthesizing methods and a continuity of one's meaning for others" (1968). He indicated that middle school adolescent students usually demonstrate various attitudes that require a teacher's attention (Bonin, 2012). This prompts teachers to create favorable environments where students can explore dimensions of their identities. Erikson based his theory on eight strengths that a person goes through in their lifetime. Erikson (1988) explained "each strength has a "time-specific developmental confrontation," which must occur in a sequential

order, thus making it an epigenetic theory” (p. 74). Through Ego Development Theory, teachers better understand the need to view their students as more than scores on a standardized test.

Sociocultural Theory

Vygotsky’s Sociocultural Theory (1986) stated that learning should be a shared process rather than an individual one. The main emphasis of the theory is on the social and cultural context of children’s thinking. This theory also suggested that teachers need to take an active role in stimulating learning by creating those social and cultural experiences in the classroom. Vygotsky noted that students learn through participating and sharing another person’s frame of reference, so teachers who take a highly interactive role with students challenge them to exceed. The use of inquiry-based, hands-on labs allows a teacher to pair students in such a way that learning is promoted due to social interaction and active engagement and creates an environment where every student experiences deeper understanding of the concepts. As such, pedagogical knowledge used within the Lab-Aids program does require an understanding of cognitive, developmental, and social theories of learning and should be utilized within the classroom so that students can apply what they learn (Koehler & Mishra 2009).

Review of Literature

The Relationship Between Hands-on Science and Student Achievement

The relationship between hands-on learning and student achievement cannot be ignored. The hands-on lab approach has been suggested as a means to improve student achievement, especially in the science education (Guzman & Bartlett, 2012). Several principles, like think critically, analyze information, communicate scientific ideas, make logical arguments, work as part of a team, and acquire other desirable skills, have been developed that illuminate how the hands-on model of learning science benefits students more than the traditional approaches. Very few students have a good understanding of how to engage in scientific

inquiry because they do not get to experience the benefits of a hands-on, inquiry-based classroom (Adb-Hamid, Campbell, Der, & Wolf, 2012). Teachers can use inquiry to promote activity-oriented learning by allowing students to reflect after they complete scientific investigations (Adams & Chiappetta, 2004). “It has been found that students using an inquiry based approach score higher on standardized assessments, improve their science process skills, and have more positive attitudes toward science” (Gibson and Chase, 2002 p. 694).

Hands-on science is one method that can be employed in the inquiry-based approach. The verification approach is another method that sets up demonstrations of a lab and follows a predetermined procedure instead of actually allowing the students to perform the lab themselves, but it does allow the students to verify the information and discuss the outcomes. Contrary to the verification approach, inquiry-based, hands-on learning activities are not procedural in nature. The outcome of the study is not predetermined, but the student is expected to play an active role in designing, implementing, and interpreting the results. In practice, the inquiry-based approach is a demanding and time-consuming technique. It also requires abundant teacher skill and knowledge that may be challenging to package in a standardized curriculum.

There are diverse instructional approaches that can be classified as “hands-on science,” and educators can adopt and use them in any combination throughout the school year. Teachers, schools, and school districts vary in how vehement they are about the use of one particular hands-on approach to science. In this study, the inquiry-based approach is used to determine the relationship between the hands-on science and academic achievement.

The Council of Ministers of Education (1997) encouraged the adoption of an inquiry-based approach to teaching science. The framework states that

development of scientific literacy is supported by instructional environments that engage students in active inquiry, problem solving and decision making . . . set in

meaningful contexts. It is through these contexts that students discover the significance of science to their lives and come to appreciate the interrelated nature of science, technology, society and the environment. (p. 8)

This means that the level of acquisition of scientific knowledge and skills is dependent on the type of instructional approach adopted by the educator.

Most educators agree that students differ in their learning styles and these differences need to be addressed (Felder & Brent, 2005). Classrooms that promote active learners, decision makers, and problem solvers are more effective than those in which students are served exclusively through a lecture method, which simply presents information to a passive audience (Adb-Hamid, Campbell, Der, & Wolf, 2012; Crawford, 2000; Keys & Bryan, 2001). Guild (2011) found that when the standards being taught were matched with instructional quality, learning occurred. The majority of teachers interviewed in several studies revealed that teachers did present the content effectively and efficiently, while adding some true appeal with the assignment choices provided to the students, but sometimes the retention and transfer seemed to disappear quickly (Kyriacou, 1998; Gay & Kirkland, 2003; Marzano, 2007; Stronge, Ward, & Grant, 2011; Killen, 2013). Additional research showed that learning does not always occur just because a specific response is received when elicited (Tulving & Thompson, 1973). Students need to be able to apply knowledge learned so that they can retain the information for future use in their lives. Tulving & Thompson (1973) showed that learners' actions are strongly influenced by memory when they are forced to apply the information that they are learning (Aryes, Chandler & Sweller, 2003; Schwartz, 2009; Schwartz, Sadler, & Tai, 2008; Lamba, 2008). The No Child Left Behind Act of 2001 placed mandates on schools requiring the use of inquiry strategies to teach science (Spring, 2008).

Researchers have identified two expansive areas of scientific knowledge: content knowledge and process skills, which both contribute greatly to the mastery of science related subjects (Felder & Brent, 2005). Content knowledge involves facts, conceptual models, principles, theories and regulations that learners are expected to understand and memorize. Process skills, also known as procedural knowledge, are the techniques employed in learning science, such as measurement, observation, and formulation of hypotheses, which science students are required to master. Both domains are considered to be essential in order for learners to be able to completely comprehend science and apply the theories for solving problems (Eylon & Linn 1988). An inquiry-based, hands-on science learning approach is considered to be a means to intensify students' understanding of both forms of knowledge.

Science education also involves the application of process skills. These are the techniques of learning science, such as measurement and observation. It is noted that these process skills and how they are taught impacts the use of hands-on activities in learning science. The major concerns involving teaching process skills include the type of process skills being taught, the age they are supposed to be taught, whether the process skills are required to be taught in a definite order, and whether the skills can be taught in isolation from content knowledge. Gagné (1985) identified eleven process skills, which he placed into two categories: basic and integrated. According to his findings, basic skills need to be learned before the integrated skills. On the other hand, Lowry (1992) identified seven process skills and tried to determine the age in which learners are developmentally prepared to learn each of them. Higher order process skills are utilized together with basic skills mostly when young learners learn. It is also important to note that the correct application of the content skills is dependent on the content knowledge. This means that the hierarchical set of process skills cannot be taught without linking them to the content knowledge.

Another concern regarding process skills is supporting the ability of students to use a combination of all the specific process skills for proper problem solving and conducting independent scientific investigations (Foster, 2011). This should not be left only to the most scientifically adept students, but should be geared towards benefiting all students in their daily life applications. Therefore, all teachers of science must utilize the hands-on approach to learning science. An example of a process skill that is hands-on by nature is the measurement technique, which is best learned through hands-on activities. Other techniques, such as inferring, may be associated with hands-on learning activities, but is not actually hands-on by nature. This is because learners can practice and learn these skills using results collected from sources other than in-class activities. Therefore, the most important objective for inquiry-based, hands-on learning activities is collecting scientific information, either through measurement, experimentation, or observation.

Scientific content is typically abstract and complex. To improve understanding of scientific knowledge, there is need for students to examine and manipulate objects. This helps to make the increasingly abstract knowledge clearer and more concrete for learners (Guzman & Bartlett, 2012). Many students easily forget what they have learned and become unable to apply scientific knowledge when ordinary lecture methods are used (Friedlander & Tamir, 1990). Through hands-on approaches, learners are able to observe real life illustrations of the scientific knowledge they have learned and see the outcomes of experiments involving multiple variables. These illustrations, according to Shulman and Tamir (1973) and Friedlander and Tamir (1990), spur student discussion, since it is easier for students to remember illustrations than abstract content.

Students benefit from conducting experiments; it helps them to successfully move from a concrete way of thinking to a more abstract way of thinking, resulting in development of the brain. This improvement of the mind aids later retrieval of information from long-term

memory. This is because the real life illustrations helped to create greater relationships between fragments of knowledge, and helped in preventing or correcting disorganization of content knowledge. In terms of process knowledge, there are three primary benefits of hands-on science: most of the process skills are hands-on in nature, thus can simply be acquired through hands-on activities; some process skills connect abstract concepts to pragmatic reality, where students learn easily from concrete illustrations; and hands-on activities provide opportunities for comprehensive utilization of all the learned process skills while focusing on particular content knowledge.

The hands-on approach to learning science is consistent with the stages of human mental development (Bonin, 2012). The highest stage is the ability of the person to work with abstractions. Prior to the abstraction stage, human mental development first goes through a stage in which thinking is restricted to concrete issues. The most relevant aspect of these stages to this study is that constant interactions between humans and their physical environment facilitate the mind's transition through them (Piaget, 1973). An inquiry-based, hands-on approach to learning science assists learners as they pass through the stages of mental development by providing concrete illustrations of abstract concepts (Buxton & Provenzo, 2007).

Inquiry-based, hands-on learning is also in alignment with the Information-processing Model of Cognitive Theory. This model states that the mind has both a long-term memory used to store knowledge and a short-term memory that holds knowledge for immediate use (Emerson, Fretz, & Shaw 1995; Aryes, Chandler & Sweller, 2003; Schwartz, 2009; Schwartz, Sadler, & Tai, 2008; Lamba, 2008). The mind's ability to utilize information that is stored in the long-term memory depends on how the knowledge has been structured in the long-term memory, as well as the strength of links made between specific pieces of knowledge (Bruner, 2012). Hands-on activities help to create additional links between existing pieces of

knowledge so information can be referenced by both physical illustration and its abstract meaning, thus improving retrieval of information (Gage & Berliner, 1984; Buxton & Provenzo, 2007). Akus et al. indicated that using a program that promotes inquiry-based learning activities allows students to develop deeper understanding of the big ideas or concepts that must be taught in a science classroom (2007). This method of teaching helps to guide students through the phases required for them to solve problems, construct and test research questions, justify their claims with evidence, compare their ideas with those of others, and consider how their ideas have changed throughout this process. Learners are required to follow a continuous cycle of clarifying explanations with their peers and teachers.

Similarly, a hands-on approach can be employed to address errors in information processing. Cognitive Theory asserts that the discrete pieces of knowledge stored in the long-term memory are structured using schema. The schema is the unifying principle guiding understanding of the discrete bits of information, and is used to consolidate and assimilate new information (Harmon, 2002; Richey et. al., 2011). Occasionally, individuals can develop schema that do not conform to the real world. This may cause errors that inhibit learning because new information may be analyzed and assimilated in such a way that validates the error or overlooks contradictions to the error (Eylon & Linn, 1988). Conceptual change, which is one of the approaches for instruction, endeavors to identify student misconceptions. It helps the student to recognize that they do not correctly perceive an occurrence and support the student to adopt more accurate conceptions. Inquiry-based, hands-on science activities have been recommended as a technique to assist educators to identify these misconceptions and errors, and to provide favorable settings for learners to explore how their errors and misconceptions incorrectly forecast phenomena (Friedler & Tamir, 1990).

The influence of hands-on science on learners' academic and nonacademic achievement has been questioned. Critics such as Hodson (1996) argue that hands-on activities may either

reduce or improve learners' achievement. Some challengers argue that the approach has the ability to clarify as well as to confuse (Escalante, Montes, & Sucar, 2012; Javed, Babri, & Saeed, 2012). Proponents of hands-on learning reason that inquiry-based, hands-on science supports students in the visualization of abstract concepts (Ashton, 2007; Koc & Turan, 2012; Leung, 2011). Some research findings have also revealed that learners may not connect written activities with hands-on activities that concern the topic of study (Wellington, 1998).

Another practical criticism against the hands-on approach concerns the time taken and the cost. Hands-on learning substantially reduces the amount of knowledge content that can be handled in a course. A further criticism raises concern about equity between lower and higher ability students. Lower ability learners benefit both from the concrete illustrations and adequate time to conduct hands-on experiments, but may take longer to grasp a concept and actually get to the hands-on portion of the lesson (Leung, 2011; Mayer, 2004). Conversely, higher ability learners may be able to comprehend a topic within a shorter period, allowing for more inquiry-based, hands-on learning time.

Instructional Approaches for Hands-on Science

Different instructional methods can be adopted in order to implement hands-on science techniques. The approach that researchers have considered to be most suitable has varied over time, depending on the environments in which the studies were taking place and the subjects of studies. Even if one particular instructional approach dominates research, educators may still make use of other instructional methods in their classrooms. These different approaches and methods to hands-on learning make it necessary to consider the possible relationship between student achievement and the varying instructional approaches of hands-on science. The most frequently utilized teaching approaches for hands-on science include demonstration, exploration, discovery, inquiry, and the use of process skills (Buxton & Provenzo, 2007).

Traditionally, hands-on science has been predominantly applied to demonstrate or verify a phenomenon as a backup to direct teaching methods. Typically, the process is first described by the textbook or in a lecture; then the learners are engaged in carrying out a well-structured activity that permits them to identify and understand the phenomenon.

Another hands-on instructional method identifies the effectiveness of the verification approach in making an abstract model more concrete. However, verification learning technique is criticized on two fronts: its overuse can result in wasting time on repetitive activities, and its procedure only allows learners to merely follow directions and observe the outcomes without using their own capacities to comprehend what should transpire, how it is done, and what it means (AAAS, 1999).

The discovery method is another instructional technique used as a hands-on learning approach. It involves providing students with needed materials to work, but offers little guidance on what to do or what investigation is expected, as described by Mayer (2004). According to Seymour Papert, “The role of the teacher is to create the conditions for invention rather than provide ready-made knowledge” (1980, p. 8). The premise of using the discovery method is to provide students an opportunity to explore a problem and formulate an answer to the problem. The teacher guides the learning by helping the students develop skills to solve problems and encourages their creativity. The necessity for educator guidance of students has so resulted in the change to a *guided* discovery method (Hodson, 1996). The assumption that students will retain knowledge if they discover it on their own is the basis for the discovery method, which fosters curiosity and creativity.

Hands-on learning can also take place via the exploratory method. The exploratory method may seem similar to the discovery approach, but is actually more closely connected to the verification approach. With the explanatory method, students are given the required materials, and then issued instructions on the expectations, with little direct guidance. The

purpose is to make students confident and comfortable with the topic under study, arouse their interest, and inspire them to raise questions.

Process skills are another approach to hands-on learning that attempts to instill specific processes used in science without consideration for any particular science discipline or topic. Hands-on learning activities are the primary technique employed in teaching processes such as measurement. However, the process skills approach has been criticized based on reasoning that science content is inseparable from the process since content is vital to problem solving. Teachers that use process skills include the skills of prediction, observation, inference, and measurement (Bell, 2008). These skills could build a bridge connecting what is familiar and accessible to what is unfamiliar and abstract within the science curriculum (Bell, Mulvey, & Maeng, 2012). Based on Yockey (2001) study, educators understand the importance of teaching these instructional models that can directly and purposefully utilize process skills to build the knowledge base needed by the student to master the standards, as well as perform better on standardized tests. However, research has not clearly articulated this method (i.e., Akerson & Hanuscin, 2007; Donnelly & Argyle, 2011). It is difficult to transfer process skills from one framework to another because the learners appeared unable to bring together the taught skills into an overall ability to problem-solve (Hodson, 1996). Teaching process skills is still an objective of science education. Process skills continue to be taught both separately, and when amalgamated with other content matter.

Hands-On, Inquiry Based Learning

The inquiry approach, just like the discovery approach, carries with it two objectives of learning: to understand particular science concepts, and to develop the capacity needed to conduct one's own inquiries. Capacity in this case involves teaching students to combine thinking and performance skills with problem solving competence while addressing topics in

a student's area of interest. The educator's role is to provide guidance and support, particularly through questioning, but not by authoritarian means. An inquiry-based approach differs from the discovery method since it supports the use of both deductive and inductive teaching (Lane, 2007). It also differs from the process skill method because it utilizes a general approach that integrates process skills instead of addressing them separately. In addition, the objective for an inquiry-based learning approach is to allow students to gather observations and analyze data collected during experiments to form conclusions that answer research questions (Bell, Smetana, Binns, 2005).

Inquiry-based learning is currently gaining support in science education, with a surging number of teachers becoming attracted to, and interested in, teaching mechanisms involving projects or inquiry (Polman & Miller, 2010). The surge in popularity is because teachers realize that inquiry-based learning absorbs students in activities that reflect methods of scientific investigation and are interwoven with content that is addressed in inquiry context. For this method to be effective, students must master the basic skills of carrying out a scientific investigation and understanding how scientists perform their duties. The inquiry-based, hands-on learning approach should emphasize the significance of learning the process of science, such as developing empirically investigable queries and supporting the assertions with adequate evidence (Polman, 2000). The effective utilization of an inquiry-based learning approach engrosses learners in self-directed inquiry, in learning to ruminate and reason scientifically, and in helping students understand the relationship between proof and theory. The most important aspect of an inquiry-based approach is the process used, not the outcome; thus, it is imperative to provide adequate time for discussion and to urge students to make their ideas clear (Taylor & Watson, 2000). According to Byers and Fitzgerald (2001), an increased understanding of this approach has prompted research activities to empirically

support the effectiveness of inquiry-based learning as an instructional model, and has prompted the development and emergence of new curriculum guidelines.

This is the learning methodology that engrosses students in activities that encompass scientific investigation, where the delivered content is structured into an inquiry framework. To be able to meet the intended objectives outlined by the state of Georgia in the performance standards for 7th grade Life Science, inquiry-based learning needs to involve the basic skills of carrying out a scientific investigation and of instilling a deeper understanding in students regarding how scientists perform their duties (Lane, 2007). “This learning approach should stress the significance of learning the procedural framework of science, such as developing empirical questions that can be investigated, leading to claims that can be supported with evidence” (Polman & Pea, 2001, p.3). The effective utilization of an inquiry-based approach to learning engrosses learners in self-directed learning by ensuring that they think scientifically and allowing them to understand the connection between theory and evidence. What matters most is not the result of the investigation, but the learning process employed to gain the knowledge. Therefore, it is imperative to provide adequate time for discussion among the learners and to encourage students to reveal their ideas unequivocally (Buxton & Provenzo, 2007).

Research focused on inquiry-based learning prompted the development of new curriculum principles as seen in the presentation of the new Georgia Performance Standards and the new National Science Education Standards (NSES) (Palincsar et al., 2001; Cornelius & Herrenkohl, 2004; White & Frederiksen, 2005).

The American Association for the Advancement of Science (AAAS, 1999) and the National Research Council (NRC, 1996) recommended science curricula that keenly engaged learners in science activities using an inquiry-based learning approach. The adoption of this

learning approach has changed the direction of science education in the United States from the traditional style of memorization of the concepts and facts of different science disciplines, to the inquiry-based, hands-on learning style in which students search for answers to their own questions (Gibson & Chase, 2002).

A number of research studies involving middle level and high school students established that inquiry-based learning activities had a positive impact on student achievement in science courses, laboratory skills, cognitive development, science process skills, and general understanding of science facts when compared to students trained using a traditional instructional approach (Chang & Mao, 1998). According to Hodson (1996), the inquiry-based, hands-on learning approach is a more effective method for students to learn science. Similarly, studies have indicated that students employing an inquiry approach to learning science manifest improved positive attitudes towards science and schooling, while the traditional didactic approach results in the development of negative attitudes towards science and school. Selim and Shrigley (1983) found that learners engaged in the discovery approach (also known as the inquiry-based, hands-on approach) for a 21 day class treatment period had a more positive attitude toward science courses when compared to the control group, who were instructed using traditional lecture methods.

The research collected by Akkus, Gunel, and Hand (2007) established that the quality of the implementation technique does have great impact on students' posttest scores when they compared the effectiveness of inquiry-based science to traditional teaching practices. This means that using inquiry-based strategies can yield higher test scores that could aid in closing the achievement gap within science classrooms.

Inquiry-based learning focuses on the collaborative nature of scientific activities, that is, scientific argumentation. Scientific argumentation has three forms: analytical, dialectical, and rhetorical, which when used appropriately by teachers can effectively increase students'

understanding of science concepts (Osborne, Simon, & Erduran, 2002). Students can learn use the one-sided argumentative method to persuade others by presenting their point of view and convince them that the alternatives are not as good as their ideas by using *rhetorical* or *didactic arguments* (Driver, Newton, & Osborne, 2000; Yore et al., 2008). Debate and discussion can be used in the classroom to offer the students a way to examine differing perspectives in a more *dialectical argumentative* approach. For some students it seems to be better to offer an *analytical argumentative* method that follows the rules of logic (e.g., Toulmin, 1958) and may be inductive or deductive (Duschl & Osborne, 2002; Yore et al., 2008). Duschl stated “Inductive arguments include analogies and causal correlations, while deductive arguments include syllogisms and causal generalizations” (2008, p. 279). Scientific argumentation allows students to talk in terms of science concepts and ideas. Past science education reform have emphasized the use of dialectical and analytical arguments, which follow the guidelines for discussion in the Lab-Aids program (Driver et al., 2000).

Researchers have scrutinized middle and high school inquiry-based learning programs in relation to student achievement and the effectiveness of their process skills. In 2008, Duschl published statements that encouraged educators, policy makers, and any stakeholders to redesign learning constructs within the classroom and out-of-school learning environments so that there is a shift in educational research that examines the most effective learning strategies for future populations of students. Sawyer (2006) stated that the “goal of learning sciences is to better understand the cognitive and social processes that result in the most effective learning” (p. xi). Chang and Mao (1998) explored the long-term impact of the inquiry-based instructional method on students’ attitudes towards learning science. They found that learners taught by the inquiry-based teaching technique scored considerably higher on achievement tests than those taught using the traditional lecturing approach. Padilla,

Okey, and Garrand (1984) found that middle school students showed considerably higher scores in process skills than the control group when inquiry-based learning was employed.

The benefits of an inquiry-based, hands-on learning approach can be minimized when activities are not learner-directed and open-ended. It is imperative that learners choose their own problem or questions to investigate, and be encouraged to direct their inquiry programs in directions they choose (Laird, 2009). This not only increases their motivation and interest in the subject but also supports more genuine form of inquiry; hence, helps build improved and deeper understanding of science. When educators opt for traditional instructional methods, such as the textbook-based instruction, demonstration, worksheets with predetermined results, or a combination of the traditional approaches with inquiry, students fail to develop a clear understanding of the nature of science (Lemke, 2001). Hoffer and Moore (1996) observed that the presentation of science as a progression that follows step-by-step instructions and involves filling in the blank spaces on worksheets encourages erroneous and misleading concepts concerning the nature of science.

Inconclusiveness of Previous Research

Several research studies looking at the relationship between hands-on science learning and test scores have been conducted since the beginning of the century (Klahr & Li, 2005; Klahr, Triona, & Williams, 2007; Strand & Klahr, 2008; Supalo, 2010). According to the findings of Ruby (2001), these researchers have been focused on three research methodologies. The first involves small-scale experiments where very small clusters of educators are assigned a specific teaching technique, such as lecture, hands-on science, or text-based method, to use in their respective classrooms; then their students' test scores are compared at the end of the course. A second approach involved comparing classroom test scores following implementation of dissimilar types of curricula. The test scores obtained from learners in two different classes with different curricula were compared, and

conclusions made. The third research approach involved using surveys to determine the quantity of hands-on activities in a classroom, gathering learners' test scores, and then examining the results.

Experimental research has found positive correlations between hands-on activities and lab skills. Acquiring lab skills rests on the ability to effectively use lab equipment, which is partly dependent on the instructional techniques of the teacher. The majority of research has failed to confirm that inquiry-based, hands-on lab techniques are more effective at improving test scores when compared to other instructional techniques. According to Hofstein and Lunnetta (1982), lab teaching did not show any substantial advantages over other techniques when matching scores on tests for critical thinking, achievement, and understanding the process skills of science. A review of teachers' and students' surveys found out that there was little agreement on the professed gains of the hands-on learning approach (Sawyer, 2006). However, reviews on the impact of curriculum with an abundance of hands-on activities generated more positive results (Duschl, 2008). When a meta-analysis combined studies on these beneficial curricula, substantial positive results regarding the relationship between learners' test scores and the hands-on approach to learning were reported, both for knowledge content and analytical skills (Haynie, 2007; Shymansky, Kyle, & Alport, 1983).

A study conducted by Bredderman (1983), on the other hand, reported wide disparity in impacts of three elementary science curricula: (a) the Science-A Process Approach (SAPA), which involves the process approach, (b) Elementary Science Study (ESS), which involves the discovery approach, and (c) Science Curriculum Improvement Study (SCIS), which involves the exploratory approach. However, there was reported sensitivity to the teaching approach employed. For example, learners using the SAPA recorded higher scores on process outcomes, while students using the SCIS approach scored higher marks on content outcomes. It was found that students' scores under these process-oriented approaches were

greater than the outcomes of students who were taught using the traditional textbook approach. These findings suggest that it is academically beneficial to focus on hands-on activities that emphasize the scientific process.

Evaluation of Educational Achievement

Much of the current research on the relationship between an inquiry-based, hands-on learning approach and student achievement is based on data from national and international science studies. The two largest organizations that conduct independent international studies are the International Association for the Evaluation of Educational Achievement (IEA) and the International Assessment of Educational Progress (IAEP). The surveys carried out by these two organizations are similar and are cross-sectional in nature, collecting data from teachers, students, and schools. Their surveys analyze student test scores, mostly utilizing tests comprised of multiple-choice questions. The majority of these studies have found that there is no positive correlation between test scores and hands-on science.

In its first international science survey carried out between 1970 and 1971, the IEA found that students who did experiments in their science class scored higher on subsequent testing. Further analysis of the data using an Ordinary least-squares OLS regression model with variables like school type, student type, home environment, and attitude also recorded positive outcomes and correlation for observations and experiments. The second science research study was carried out by IAEP found a weak correlation between test scores and a hands-on approach to learning science (1991). Further, between 1983 and 1987, the IEA conducted its classroom environmental study and found no substantial positive correlation between the number of lab exercises and the student test scores while comparing the amount of time spent on lab exercises. In 1988, the IAEP surveyed 24,000 students to conclude that the frequency of conducted experiments never reliably related to test performance. Later in 1991, the IAEP carried out the second survey involving 25,000 nine year old students and

almost 52,000 12 year old students and exhibited a positive substantial correlation between the frequency of classroom hands-on experiments and student test scores.

The National Assessment of Educational Progress (NAEP) conducted a longitudinal study that followed students between 1988-1992 in order to track their science performance (NAEP, 2012). It was noted in the results of surveys compiled in 1986, 1990, 1996, the group that utilized diverse types of science equipment more often scored significantly higher on tests than the students who used the equipment less often (NAEP, 2012).

In 1992, NAEP completed a survey questionnaire with students from three grades, fourth, eighth, and twelfth grades, and revealed that the results indicated that in grades 8 and 12, students' mean scores consistently rose five points higher than the scores from 1990 and there was significant variance in test scores between responses across categories.

Finally, in 1996, learners in all the three grades, fourth, eighth, and twelfth grades, involved in the NAEP survey found that all of the students except for grade four who gave an affirmative answer for using hands-on labs recorded higher group scores when compared to those who answered negatively (NAEP, 2012). On the contrary, learners who had not used any of the hands-on materials achieved lower scores than those who used even a few of the pieces of science equipment in all grades. This clearly indicates that use of hands-on activities in learning plays a major role in performance and test scores.

Similarly, educators reported how frequently they used hands-on activities in teaching students in fourth grade and eighth grade, with four possible responses ranging between "never" and "almost every day." The results indicated no difference in the test scores attained by the grade four students in those classes. However, in the eighth grade, the two groups that were exposed to more consistent hands-on learning scored higher than the groups who were exposed to hands-on learning less frequently. The students were also grouped depending on their science ability test scores. The eighth grade students who participated in

more hands-on activities had a higher possibility of being ranked at above the “proficient” level. The same held true for twelfth grade students with higher hands-on activities report (Sullivan & Weiss, 1999).

Horn, Hafner, and Owings (1992) grouped scores to determine the relationship between how frequently hands-on science experiments were carried out in the classroom and test performance. There was also a positive relationship between teachers’ reports on hands-on science done in the eighth grade and the subsets of the National Education Longitudinal Study, NELS tenth grade test concerned with scientific reasoning, quantitative operations, and chemistry (Hamilton et al., 1995). This positive correlation was not witnessed in related analyses of twelfth grade sub scores (Nussbaum, Hamilton, & Snow, 1997) or in investigations of the relationship between the frequency of tests and progress in test scores for tenth grade and twelfth grade students (Hoffer & Moore, 1996). Research conducted to determine the correlation between hands-on learning activities and scores from multiple choice achievement tests, and research conducted to determine the correlation between performance assessments and hands-on science activities have been few and had inconsistent results (Comber & Keeves, 1973).

It is worth noting that the results from the first IEA research were not conclusive. The second IEA international survey that was conducted was comprised of three hands-on tests for fifth grade and ninth grade students. In this survey, correlations were measured between hands-on learning activities and hands-on test scores. The correlation for fifth grade students was .00 for countries outside the United States, and - .03 for the United States. For ninth grade learners, the correlation was .09, while the teachers reported a correlation of .30. This result was, however, skewed upward by results from one country (Doran & Tamir, 1992).

A small-scale research established that fifth grade students who were taught using a strong hands-on curriculum achieved higher mean scores on their tests by one-half standard

deviation than students who used textbook centered curriculum. Similarly, it was found that students using hands-on curriculum achieved higher scores on a cognitive ability test, indicating that the use of hands-on techniques in teaching plays a role in the students' test scores (Baxter, Shavelson, Goldman, & Pine, 1992). Hands-on science has also been linked to higher test scores on lab skills. The lab skills developed from the hands-on activities also contribute to the learning of science.

These past studies have provided tentative conclusions concerning the correlation of an inquiry based, hands-on learning approach to student science achievement. This study, therefore, seeks to provide an answer in regard to this problem.

Criterion-Referenced Competency Test

The debate over the use of standardized testing continues to be a divisive topic. Pressure from high-stake testing appears to be an issue for debate because some say that we need the data for accountability, while others feel like “standardized test scores offer nothing more than snapshots, often fuzzy ones, of student achievement at a single moment in time” (Guisbond & Neill, 2004, p. 13). Educators realize that assessing student learning involves more than just looking at one test (Harris, 2009). Students should be provided with learning activities that are at their ability level. Gamble-Risley (2006) stated, “School officials are accountable for every school within the boundaries of the district; all must succeed. But a one-size-fits-all strategy doesn't apply when a district has a diverse mix of schools, each with unique needs” (p. 4).

Standardized test data is being used as the accountability measure for the schools in the state of Georgia because it shows how well students at specific grade levels perform after implementation of the GPS. Since schools must prove AYP to continue to receive funding, there has been an increase in the administration of standardized testing. Kohn (2000) wrote, “Officials who require students to be tested year after year after year presumably believe

either that this is necessary for providing adequate information about achievement or that it will improve the quality of instruction” (p. 318).

The National Science Education Standards (1996) and the NCLB Act (2002) called for increased student achievement in science (Spelling, 2007). The state of Georgia chooses to use the Criterion-Referenced Competency Test (CRCT) as a measure for AYP, as required by NCLB. The CRCT measures student learning, as defined by the Georgia Performance Standards (GPS). The GPS were introduced as the new curriculum in 2005, and were first tested in 2006. The CRCT is the combination of tests administered in public schools in Georgia that assesses the knowledge and skills of students from the first through the eighth grades in English/language arts (ELA), reading, and mathematics. It also assesses the proficiency of students in general science and social studies in grades three through eight. The assessment provides information on students’ academic achievement, as well as the success of each school district, school, classroom, and teacher (Georgia Department of Education, 2012). This information is significant in establishing the level of strength or weakness that an individual student has in relation to the standards of the GPS. Thus, it helps to quantify the quality of education in the State of Georgia. The CRCT is mandatory and is administered at the end of the year, after required curriculum has been taught. The assessments contain only selected-response items. However, several constructed-response items may possibly be included in the future (Georgia Department of Education, 2012). The CRCT has been used to measure student achievement for many research studies (Adams, 2011; Arnold, 2013; Hobbs, 2012; Hudson, 2013). Therefore, this study utilized the CRCT as a measure of student achievement in seventh grade Life Science classes.

Standards Based Classroom

There are two types of assessments for standardized tests: mastery and performance. The state used the Quality Core Curriculum (QCC) to guide learning prior to the Georgia

Performance Standards (GPS). The QCC tests students on the process of learning. With the change to performance standards, the CRCT had to alter the test so that students were assessed on ability, outcomes, and comparisons with other students.

NCLB supports a Standards-Based Classroom (SBC) where educators utilize problem solving, inquiry, and ask questions that are open-ended to meliorate students' achievement (Spring, 2008). The National Science Education Standards states that there is a need for the teachers to have access to programs like the Lab-Aids program so that they can encourage a high level of performance from all students in standards based science classrooms, "regardless of race, family background or disability status" (President's Commission on Excellence in Special Education, 2002, p. 4). The Georgia Department of Education (2011) defined a SBC as one that aligns the curriculum, instruction, student learning, and assessments to the performance standards that they adopted in 2006. It also mandated schools to enhance teachers' content knowledge. This recommendation was supported by research that indicated improving teachers' content knowledge positively affects teaching practices (Cohen, Manion, & Morrison, 2007; Kahle & Boone, 2000). For example, when teachers cover topics using inquiry-based, hands-on teaching techniques, and are themselves knowledgeable about the content, discussions can move in new directions based on students' interests. This becomes a more effective way for students to learn the difficult content outlined in the standards (Kahle & Rennie, 1993; Lederman, 2004; Williams, 1998). This was also proven by the first administration of the revised CRCT in 2006, when the curriculum was rolled out for the first time. In 2006, the Department of Education for the state of Georgia would not release the science test scores because the percentage of students passing the test dropped to only 63% passing for the whole state. The state evaluated the performance standards and the CRCT in order to identify the problem. The standards did not change, but the test has changed over the past few years, which has revealed a larger

percentage of students passing the seventh grade Life Science portion of the CRCT. Georgia Department of Education (2013) statistics showed that “Eighty (80) percent of students passed the science CRCT, a one-year increase of four points and an increase of 17 points since GPS implementation”(Press Release, para. 1). Apparently, the standards being taught are matched with the ones that are being tested. Allison (2012) stated, “Assessment is one of the most important components of the SBC, and must expressly measure the standards that are being taught” (p. 20).

Students’ Course Interest

The number of students studying science has risen considerably in the last few years. The kindergarten through twelfth grade education system and the adoption of the No Child Left Behind Act, has led to growing inspiration among students to study science, but educators find it difficult to plan interactive lessons as a result of the increased pressure to cover the designed curricula.

Enthusiastic teachers who motivate students to become active participants in science should expect to have successful science classrooms (Staver, 1998). According to the NSES, “teachers who are more enthusiastic, interested, and who speak of the power and beauty of scientific understanding instill in their students some of those same attitudes” (National Research Council, 1996, p.37). Research on student motivation revealed that an increased interest in science does positively correlate with higher science achievement (Fraser, 1994). An additional study in 2000 by Neatherly concluded that students having high interest and optimistic attitudes toward science had a significantly positive correlation with scientific ability. Past research indicated that motivated teachers endorsed their curricula and engaged in more constructivist based learning activities in the classroom, which promoted higher student interest in science (Ward et al., 1996).

When students are allowed to solve real-life problems or situations that occur in their lives, student interest in science increased (National Research Council, 1996; Neatherly, 2000; Novak, 2000). Teachers that utilize constructivist learning techniques and inquiry-based, hands-on labs to help students investigate issues and topics that they can relate to will cultivate an increase in course interest for science, therefore posing the potential to increase achievement (Morrison et al., 2002). Science programs, like the Lab-Aids program, enhance student interest in science by engaging the learner through inquiry and hands-on labs, which can possibly promote an increase in student achievement (Fraser, 1994). Since this study observed an educational system enacting a new science curriculum, the Lab-Aids program, measuring student interest in science did provide another method of assessment to evaluate the effectiveness of the program.

Didactic Teaching Methods

Didactic teaching is a method of instruction wherein an educator presents content material to a class, often through graphic aids such as whiteboards and PowerPoint slides, accompanied by a demonstration to clarify a concept (Estes & Dettloff, 2008). Most science educators criticize this technique, reasoning that it does not allow students to retain the science concepts that were taught (DeVries & Zan, 2005). Lord and Orkwiszewski (2006) found that teachers using didactic methods while teaching lab activities does not give the teachers or students room for creative contribution (Lord & Orkwiszewski, 2006). Instead, students memorized every section of the lab report. Consequently, students simply inserted those answers in the lab assignment sheets without carrying out the experiments. Inquiry-based, hands-on lab sessions, on the other hand, allow students to design experiments to help them confirm their hypotheses. This type of inquiry-based learning ensures that students understand and retain science knowledge (DeVries & Zan, 2005; Lord & Orkwiszewski, 2006).

Foster (2011) also noted that using a didactic instructional approach, inquiry-based approach, or a combination of the two is a crucial demarcation when lower functioning students need to discover ways to learn and retain information. Didactic methods are effective when handling higher functioning students (Rossi & Mustaro, 2013). The goal of integrating these teaching methods is to improve knowledge retention for students and to increase their academic performance (Manlove, Lazonder, & deJong, 2006). An inquiry-based instructional approach encourages an active learning process necessary for knowledge retention, and subsequently, academic improvement.

Summary

The use of inquiry-based, hands on labs can be used as a framework for science instruction and with the support of the teacher have a potential to tackle the challenges, like time, that educators face in their attempt to improve students' achievement in science (Adb-Hamid, Campbell, Der & Wolf, 2012; Crawford, 2000; Gibson & Chase, 2002; Guzman & Bartlett, 2012, Keys & Bryan, 2001). Researchers reported that inquiry-based instruction in science improved academic achievement more than traditional science instruction because it required the student to develop and follow a process for thinking and solving problems (Berns & Lawton, 2004; Duschl, Shouse, & Schwingruber, 2008; Jorgenson, 2005; Lumpe, Czerniak, & Handy, 2008; Price & Felder, 2007). Through the implementation of the Lab-Aids program, this study will be able to add to the research or even make a determination about motivation in learning science by using inquiry-based, hands-on labs. While the existing studies in the literature make contributions to how teachers teach and students learn science, a clear next step is to investigate the impact on student achievement when students are allowed to become active participants in the learning/teaching process, and given the opportunity to construct their conceptual understanding through the guidance of their teacher. The use of inquiry-based, hands-on labs process pushes the students to use their existing

knowledge as the basis for their conceptual understanding of the standards. Teachers are active within the classroom environment; however, their role does need to change so that they can facilitate learning for students, rather than to use direct instruction and just impose or transfer knowledge.

Research has revealed that student interest and motivation increases in science when the teacher presents the scientific material using real situations in a student's life (National Research Council, 1996; Neatherly, 2000; Novak, 2000). The employment of constructivist learning techniques and inquiry-based questioning about issues and topics that students can relate to while using hands-on materials to investigate the standards being taught will increase motivation to do science, thus increasing potential achievement (Morrison et al., 2002). In 1994, Fraser stated, "curricula that boost student motivation also enhance student interest in science and can possibly promote an increase in student achievement" (p. 503). Therefore, measuring student interest in science and student achievement on a state mandated standardized test could provide needed assessment for the determination of the success of implementing a new program, Lab-Aids, to teach the science curriculum. In practice, inquiry based approach is a demanding and time-consuming technique. Leonard and Penick summarized that "under the constructivist theory, students come into the classroom with pre-existing knowledge about a given subject; instructors should identify what students know and build upon their prior knowledge; thus, help students construct new understandings as a result of new experiences" (2009, p. 42).

CHAPTER THREE: METHODOLOGY

The purpose of this quasi-experimental study was to determine whether implementing an inquiry-based, hands-on lab instructional approach in seventh grade life science classes in Georgia schools resulted in improvement in students' academic achievement, as measured by Criterion Referenced Competency Test (CRCT) scores. This chapter begins with the presentation of the study design, and then lists the research questions, hypotheses, and null hypotheses. Next, the study participants are described, followed by the setting of the research and the instruments used to conduct the research. Then the procedures utilized to carry out the study are delineated, and the chapter ends with an explanation of the methods that were employed to analyze the gathered data.

Research Design

A quasi-experimental control group design was utilized for this study to evaluate if an inquiry-based approach to science instruction had any influence on the academic performance of the participants (Michael, 2006). Quasi-experimental methodology often involves the use of treatment and control groups, either a preintervention or postintervention (or both) test, and random assignment of the study participants (Shapley, Sheehan, Maloney & Caranikas, 2011). This experiment included all of these elements, but the preintervention. This study employed the use of a control group and a treatment group will be adopted to determine whether there was a difference in performance between them when different instructional approaches were used. The study involved a nonequivalent control-group design since the researcher compared the treatment group with the control group (Borg & Gall, 1998).

The research design was also quasi-experimental because the data collected during the research was combined with results from previous CRCT tests for analysis (Creswell, 2003; Galt & Pharm, 2009). The quasi-experimental design encompassed a posttest design to

evaluate the use of inquiry-based, hands-on learning approaches, and whether the learning approach had any correlation with the academic performance of students.

Research Questions and Hypotheses

This study examined the following research questions:

Research Question 1: Do seventh grade Life Science students who are taught using an inquiry-based, hands-on approach to science instruction score higher on the Criterion Referenced Competency Test (CRCT) than those who receive traditional, lecture-based instruction?

Research Question 2: Are seventh grade Life Science students who are taught using an inquiry-based, hands-on approach to science instruction more interested in science class than those who receive traditional, lecture-based instruction?

Null Hypotheses

The associated null hypotheses are as follows:

Null Hypothesis 1: Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not achieve statistically significantly different standardized CRCT science scores from students who received traditional science instruction.

Null Hypothesis 2: Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not rate their classroom experiences statistically differently than students who received traditional science instruction.

Participants

This study utilized seventh grade Life Science students from two school districts in the state of Georgia. The study involved two schools from one district and three schools from another district. The sample was comprised of 336 students from the two target districts. Additionally, there were 14 teachers (a minimum of two per school) involved in

instructing those students. The schools were similarly comprised in regards to the following subgroups: free and reduced lunch, limited English proficiency, Asian, African-American, Hispanic, multi-racial, Caucasian, and special education (see Table 1). The treatment group, which consisted of all the seventh grade students from three schools in one of the school districts, had just started using the inquiry-based, hands-on lab program at the beginning of the 2011-2012 school year. The control group was comprised of all the seventh graders in two schools in the other school district that used the traditional textbook and lecture-model, and only supported student learning with a limited number of labs.

Table 1

Demographic Comparison of the Target School Districts

District Group	Free and Reduced Lunch	Limited English Proficiency	Special Education	Race
Control Group	84%	1%	11%	Asian – 0%
				Black – 69%
				Hispanic – 3%
				Multi-racial – 2%
				White – 26%
Treatment Group	77%	2%	10%	Asian – 2%
				Black – 73%
				Hispanic – 3%
				Multi-racial – 2%
				White – 21%

The study consisted of seventh grade Life Science classes, containing approximately 28 students in each class. The sample included all the students enrolled in seventh grade Life Science classes within two similar school districts in the state of Georgia. The sample contained students identified as Specific Learning Disabled, Emotional/Behavioral Disabled, English as a Second Language, and Gifted. There were at least four classes with one teacher from each school in the treatment group school district. There were a total of ten teachers from the treatment group school district that participated in the study. The control group was

comprised of seventh grade Life Science classes, with approximately 28 students in each class. There were at least four classes with one teacher from each school in the control group school district. There were four teachers from the control group school district that participated in the study.

Setting

The study was conducted in the state of Georgia in the United States of America. Five different schools were identified for inclusion in the study from two school districts in Georgia. One district contributed three schools to the study for a treatment group, while the other district contributed two schools for a control group. These school districts were several miles away from each other, but had very similar demographics. Once the treatment group was selected, the researcher utilized the following website to select a similar school district as a control: www.gsci.org (see Appendix A). Within the Georgia school district that was chosen for this study students are randomly placed into the academic schedule by a computer based system. However, the placement of gifted and special education students into classrooms was completed manually to meet their needs and alternated from year to year with the final decision to place them on the different teams coming from the administrators.

Treatment and Control Groups

The treatment group consisted of 165 seventh grade students enrolled in class in three of the schools within the district that began using the Lab-Aids program during the 2011-2012 school year to teach the performance standards that are outlined by the state. The control group was comprised of 171 seventh graders in another school district that utilize a traditional textbook and lecture model of science instruction. These two groups were studied to determine if implementing an inquiry-based program that uses hands-on labs into the seventh grade life science curriculum improved student academic achievement.

The treatment group was selected as a result of email correspondence from the Georgia sales representative for the Lab-Aids program. The sales representative for the State of Georgia provided the researcher with a list of systems that had adopted the Lab-Aids program. To ensure that the treatment group was using only inquiry-based, hands-on labs for instruction, the researcher selected the school system that was in the process of implementing it for the first time and had received training the previous year; this indicated to the researcher that they were ready to fully implement the program. The Lab-Aids representative and the teachers within the treatment schools confirmed that the training for each teacher would continue throughout the implementation year as well. The teachers were allowed to contact support at any time and the principals of each individual school scheduled face-to-face trainings periodically. This helped to insure that the program would be followed.

Once the treatment group was selected and contacted, the researcher found out that to obtain permission to utilize this county she had to complete an Internal Review Board (IRB). The application was submitted for approval to the local Board of Education (BOE). After several months of calling and emailing, the teacher was granted permission from the review committee by email (see Appendix B).

Once permission was granted the researcher used the following website: www.gsci.org to match a possible control county. She selected three counties to contact. She was asked to submit an IRB to two of the ones that she contacted. She was turned down by one because she did not work full time in that county. She was turned down by another one because they had already approved the limit of studies that their policy allowed for that year. The third choice was approved by each of the principals from each middle school after the researcher gained a recommendation from the superintendent (see Appendix C).

Fourteen teachers, two regular education teachers and at least one special education teacher from every school that was chosen for the study, were involved in this research.

The Georgia County that adopted the Lab-Aids program for the 2011-2012 school year to implement within all middle schools in this district was selected as the treatment group. The Lab-Aids program is an inquiry-based, hands-on approach where the teacher guides the students through scientific investigations by allowing the students to pose questions and explore the concepts through promoting the constructivist approach. Teachers have noted that students who engaged in inquiry-based strategies gain content knowledge that allows them to become effective problem solvers, decision makers, and investigators.

This study used the 2001 inquiry-based course for the middle school titled the Science and Life Issues (SALI). SALI includes an embedded assessment system adapted from the system of an earlier SEPUP course named *Issues, Evidence, and You*. There are also several multiple choice and short answer assessments within the course that have been correlated to the National Science Education (NSE) content learning standards, in addition to the evidence of deeper understanding provided by the SEPUP assessment system. The Likert-scale survey that appears in Appendix D was administered to the treatment groups, control groups, and teachers to identify their perceptions of their students' achievement. The surveys were conducted during the spring of 2012 for the treatment group that adopted the different instructional methods identified and the control group that used a traditional science textbook. This was done in all the five schools drawn from the two districts.

Instrumentation

This quasi-experimental research employed a standardized testing instrument and surveys to answer the research questions. Following is a detailed description of those instruments. The state does require that teachers within all state middle schools give the same CRCT. This data will be available for the study.

All the students, irrespective of the district the school was in, were administered the same standardized performance science test after completion of the curriculum, as required

by the State of Georgia. This means that all the teachers involved in the study had taught the same performance standards for 7th grade Life Science.

Students who refused to participate in this study had their scores removed from the final analyses. However, the students were still taught the required curriculum provided in the performance standards from the state of Georgia and were expected to participate in the inquiry-based, hands-on labs and activities with their classmates, because these programs have been adopted by their districts and were used by the teachers as outlined by their county board of education. They also had to take the same tests as other students in their same grade, as determined by their school districts and the state of Georgia. All the teachers were required by the state of Georgia to administer the same CRCT science test. The researcher compared the CRCT scores before and after implementation of the inquiry-based, hands-on lab approach to determine whether the implementation of an inquiry-based, hands-on labs resulted in an increase in student achievement.

Georgia Criterion Referenced Competency Test

The CRCT measures student learning, as defined by the Georgia Performance Standards (GPS). The CRCT is the combination of tests administered in public schools in Georgia that assesses the knowledge and skills of students from the first through the eighth grades in English/language arts (ELA), reading, and mathematics. It also assesses the proficiency of students in general science and social studies in grade 8. The assessment provides information on the students' academic achievement, as well as the success of each school district, school, classroom, and teacher (Georgia Department of Education, 2012). This information is significant in establishing the level of strength or weakness that an individual student has in relation to the standards of the GPS. Thus, it helps to quantify the quality of education in the State of Georgia. The CRCT is mandatory and is administered at the end of the year, after required curriculum has been taught. The assessments contain only

selected-response items. However, several constructed-response items may possibly be included in the future (Georgia Department of Education, 2012).

Georgia state law, which was amended by the A+ Education Reform Act of 2000, demands that all learners between grade 3 and grade 8 must take the English/language arts, reading, and mathematics CRCT assessments. Since 2002, students in grades three through eight have also been evaluated in the areas of science and social studies. It is important to note that CRCT only evaluates students on the content standards defined in the GPS (Georgia Department of Education, 2012). Presently, all students in grades 3, 5, and 8 are expected to pass the CRCT in order to be promoted to the next grade (Georgia Department of Education, 2012). Further, a new education bill known as Bill HB501, which is presently circulating through the Georgia General Assembly, would require that grade 1 and grade 2 students pass the CRCT in order to be promoted to the next grade (Cox, 2010). The test administered in this study will already be created before the treatment begins.

The CRCT science test is a multiple-choice test that assesses the GPS. Fifty percent of the questions covered the interdependence of life standard. Thirty-five percent of the questions covered the cells and heredity standards. The remaining 15% of the questions covered the evolution standard. These percentages are prescribed by the state. The students received an overall scale score on the test. "A scale score is a mathematical transformation of a raw score. Scale scores provide a uniform metric for interpreting and comparing scores within each grade and content area" (Georgia Department of Education, 2012). The scores fell into performance levels. There were three performance levels for each of the CRCTs: Exceeds the Standard, Meets the Standard, and Does Not Meet the Standard. The mean score for Exceeds the Standard must be above 850. The mean score for Meets the Standard must be in the range of 800 up to 849. The mean score for Does Not Meet the Standard is below 800.

The CRCT is a valid and reliable instrument for measuring student academic performance (Georgia Department of Education, 2012). The state of Georgia goes through a very extensive review process to ensure valid questions are included on the test. They actually utilize certified teachers to help construct the questions, then a review committee made up of teachers from every subject area and all districts in the state review each question before it is included on the test. These committee members have the opportunity to reject, edit, or accept a question. If a question is accepted, it must go through a field test and must be reviewed an additional time by a separate review community of certified teachers from all districts in the state. If it is accepted again, then it becomes a test question on an operational test. After every question has been accepted and field tested, it continues to be reviewed each year by a new review committee, and if rejected at any point, it is removed from the test. This process helps validate the test. The state of Georgia reported the Cronbach's alpha score for the 2012 CRCT as .94. The raw score, which is the number of questions answered correctly, was reported as 3.17. These scores are consistent with previous assessments, which means that it is reliable for the intended purpose of assessing the mastery level of the students who have been taught using the GPS.

Surveys

Another instrument used for this study was the Course Interest Survey (CIS), which was modified for this study to include 37 questions that was administered to the treatment group and the control group to identify their perceptions regarding course interest of science (See Appendix D). The CIS used a 34 Likert-type scale to measure student motivation as related to the student's reactions to course instruction (Keller, 2006). Scores are determined numerically (e.g. strongly agree = 5 points and strongly disagree = 1 point).

The Course Interest Survey (CIS) was created by Keller in 1987 and has been used several times by researchers (Carpenter, 2011; Cooke, 2008; Stefaniak, 2013). John Keller

established reliability and validity in his publication *Development of Two Measures of Learner Motivation* in 2006. He administered the survey three different times to groups: a group of 45 undergraduates, a group of 65 undergraduates, and finally a group of 200 undergraduates and graduates from the School of Education at the University of Georgia in Valdosta. The Cronbach's Alpha was calculated with a consistency of .95. Keller also reported "all of the correlations with course grade are significant at or beyond the .05 level, and none of the correlations with grade point average are significant at the .05 level. This supports the validity of the CIS as a situation specific measure of motivation, and not as a generalized motivation measure, or "construct" measure, for school learning" (Keller, 2006, p. 5). The ARCS model's principles have proven their validity and stability over the years at all levels of education (Keller, 1999, 2008, 2010).

To avoid wasting time, the researcher identified one teacher in each class of the five schools in the two districts to be an organizer, who ensured that all arrangements were made within the time allocated. The teachers read the CIS orally, since it was likely to motivate students to respond to all survey questions.

The structured surveys were employed to determine the relationship between the inquiry-based, hands-on learning approach and student test scores. The survey also helped to analyze the level of interest students had in science. This information was then compared to the CRCT tests that were administered at the end of the 2012 school year using an independent samples t-test.

Procedures

Prior to submitting research plans to Liberty University's Institutional Review Board (IRB), the researcher first had to make IRB proposals to 14 different districts; six were targeted as treatment groups and eight as control groups. Two of the districts intended as treatment groups approved the request. One of those two districts was utilizing the inquiry-based,

hands-on approach to science instruction, so that district was selected as the treatment group. In an attempt to identify a demographically similar control group, the researcher used the demographic information that is found on the Georgia Department of Education website for each of the state's school districts. An email was sent to each of the eight school systems identified during this search requesting permission to use their schools as control groups for the study. Five of those districts explained that the researcher had to be employed within that county to use the district's data for the study. The other three districts asked the researcher to submit IRB forms to their local Board of Education for approval. After submitting all three IRB forms, the researcher was approved by two of the school districts. One system had been using the program for seven years, but was omitted from the study because they reported that they had modified the program and supplemented it with other materials for instruction. The remaining district was chosen as the control group. After receiving permission to conduct the study in both the treatment and control districts, the Liberty University IRB proposal was submitted as well (See Appendix E). This proposal contained the signed consent forms that the researcher had secured from the principals, teachers, parents, and students of the schools that had been identified as target schools (See Appendix F).

The researcher then contacted the treatment group and control group schools to set up times to meet with the teachers who would be teaching the classes during the research. These meetings were held in order to discuss the study and the teachers' classes. The researcher was also able to observe each class, explain how to administer the student survey, and collect the permission slips at this time. A box was provided to each school to facilitate return of the surveys to the researcher.

Prior to the commencement of the interview portion of the study, the researcher received authorization from the respective school administrators and arranged for a time that was convenient for both parties. The teachers were expected to sign consent letters before the

interviews were carried out. The interview sessions lasted approximately 30 minutes and were followed by a classroom observation to see what type of delivery methods were occurring within the classrooms.

Official documents authorizing the researcher to conduct research within the schools were also necessary to prove the legality of the research. In addition, parents of the chosen student subjects were requested to sign authorization letters to allow their children to participate in the study. These documents were essential to guard against any changes of mind and/or malicious prosecutions. The permission forms were distributed and collected prior to the onset of the research.

Data Gathering Procedures

After the site visits, the researcher began to receive the completed student surveys. The researcher then created a spreadsheets using Excel to store all of the study's data. A column was dedicated to each data source, except the first column, which contained only student numbers. The researcher recorded the survey results on this spreadsheet until all survey data had been imported for each school. Then the data was divided into a treatment group and a control group within an EXCEL spreadsheet based on their response to question number 37 on the Course Interest Survey that was coded as a 1 for yes for the treatment and a 2 for no for the control group. The spreadsheet also contained the CRCT scores that were collected and compiled. Once the CRCT test was administered and the scores recorded, the scores were compared. Through this the researcher determined the statistical connection between hands-on science and achievement in order to satisfy the Hypothesis 1.

The researcher also conducted face-to-face, semi-structured interviews with twelve teachers, at least two teachers per school. Three interest areas generally examined during the interviews were (a) the instructional approach preferred by teachers, (b) teachers' perceptions

on students' performance in science courses, and (c) students' interest in science in relation to the instructional methods used by teachers (Gibson & Chase, 2002).

Data Analysis Procedures

Rationale for type of data analysis. This research was quasi-experimental and utilized static-group comparison methods to compare group means. The form that the data took was measurement, as opposed to frequency data. Since the researcher desired to compare mean scores between the two groups on two different variables of interest, *t*-tests were used to analyze those mean scores (Creswell, 2003). In this study, the *t*-tests were utilized to determine whether 2012 CRCT scores and course interest differed significantly according to instructional type.

Analysis of Hypothesis 1. Null Hypothesis 1 stated that there would not be a statistically significant difference between the academic achievement of students who were taught using an inquiry-based, hands-on approach to science instruction (as measured by CRCT science scores) and the academic achievement of students who were not taught using an inquiry-based, hands-on approach to science instruction (as measured by CRCT science scores). A *t*-test analysis was used to analyze the group differences. Preliminary analyses were used to examine the assumptions of normality, homoscedasticity, and independence of observations. The only assumption tested was homoscedasticity. It was assessed using a Levene's test of homogeneity of variances.

A $p < .05$ level of significance was used for the analysis of Hypothesis 1 to determine if the null hypothesis could be rejected. The practical significance (effect size) of the *t*-test was interpreted by Cohen's *d* (1988).

Analysis of Hypothesis 2. Null Hypothesis 2 stated that there would not be a statistically significant difference between the course interest of students who were taught using an inquiry-based, hands-on approach to science instruction (as measured by the CIS)

and the course interest of students who were not taught using an inquiry-based, hands-on approach to science instruction (as measured by the CIS). A *t*-test analysis was used to analyze the group differences. Preliminary analyses were used to examine the assumptions of normality, homoscedasticity, and independence of observations. The only assumption tested was homoscedasticity. It was assessed using a Levene's test of homogeneity of variances.

A $p < .05$ level of significance was used for the analysis of Hypothesis 2 to determine if the null hypothesis could be rejected. The practical significance (effect size) of the *t*-test was interpreted by Cohen's *d* (1988).

CHAPTER FOUR: RESULTS

The purpose of this quasi experimental research was to determine whether implementing an inquiry-based, hands-on instructional approach to seventh grade Life Science instruction in Georgia schools would result in an improvement in students' achievement, as measured by the state required CRCT science test. The independent variable was the method of instruction: either the implementation of an inquiry-based, hands-on learning strategy, or the use of a more traditional method of teaching, such as lecture with demonstration and some labs. The dependent variables were performance on the state mandated CRCT science test and Life Science course interest. This chapter first presents the research questions and hypotheses followed by the assumption testing results for the two study variables. Next is an analysis of the data according to hypothesis. A summary of the findings concludes the chapter.

Research Questions and Null Hypotheses

The research questions and null hypotheses that this paper seeks to answer are as indicated below;

Research Question 1: Do seventh grade Life Science students who are taught using an inquiry-based, hands-on approach to science instruction score higher on the Criterion Referenced Competency Test (CRCT) than those who receive traditional, lecture-based instruction?

Null Hypothesis 1: Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not achieve statistically significantly different standardized CRCT science scores from students who received traditional science instruction.

Research Question 2: Are seventh grade Life Science students who are taught using an inquiry-based, hands-on approach to science instruction more interested in science class than those who receive traditional, lecture-based instruction?

Null Hypothesis 2: Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not rate their classroom experiences statistically differently than students who received traditional science instruction.

Assumption Testing

Preliminary assumption testing for *t*-test analyses was conducted. The assumptions tested were normality, homogeneity of variances, and independence of scores (Green & Salkind, 2011). The assumption that data was normally distributed was determined by visual examination of a normality histogram (approximately one-third of the cases should be one standard deviation from the mean). The normality histograms for the two variables in this study can be seen in Figure 2 and Figure 3. The histograms both indicated normality. Therefore, the data was determined to be normally distributed, allowing the use of the *t*-test for data analysis.

The assumption of homogeneity of variances means that a similar variability in scores exists at all values of the dependent variable (Tabachnik & Fidell, 2001). Homoscedasticity can be easily determined by examination of Levene's Test, seen in Table 2. The significant result of the Levene's test for CRCT means that the "equal variances not assumed" statistic had to be utilized for the analysis of H1 because homogeneity of variances could not be assumed for the variables that were used in the analysis of H1. However, H2 used the "equal variances assumed" statistic due to the nonsignificance of the Levene's Test on the INTEREST variable.

Figure 2. *Normality Histogram for CRCT Science scores*

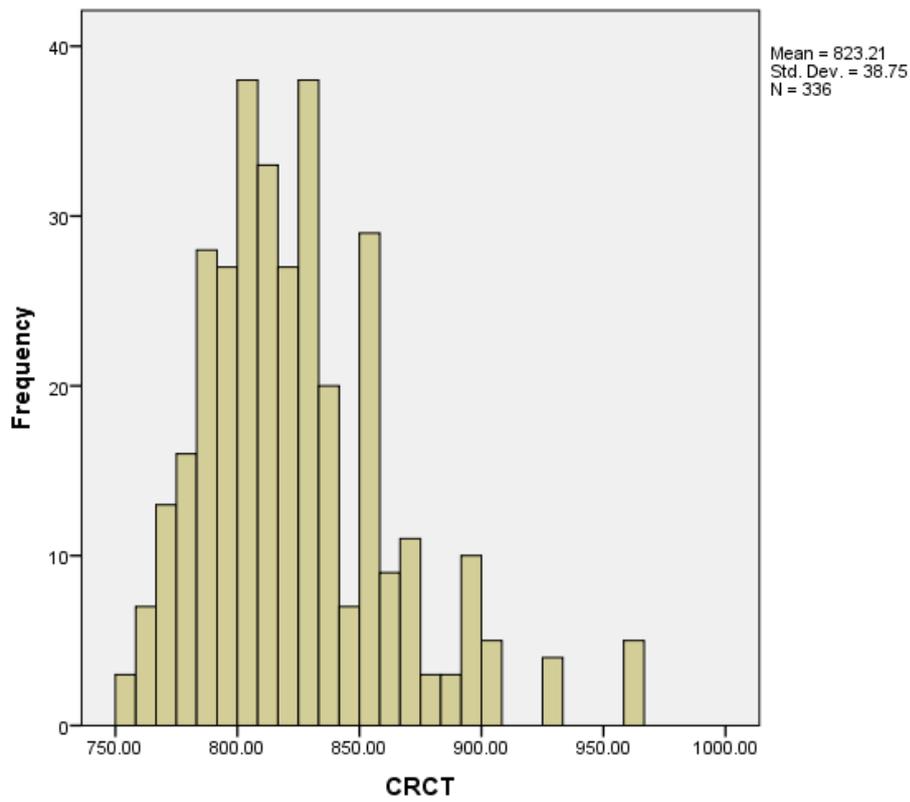


Figure 3. *Normality Histogram Course Interest*

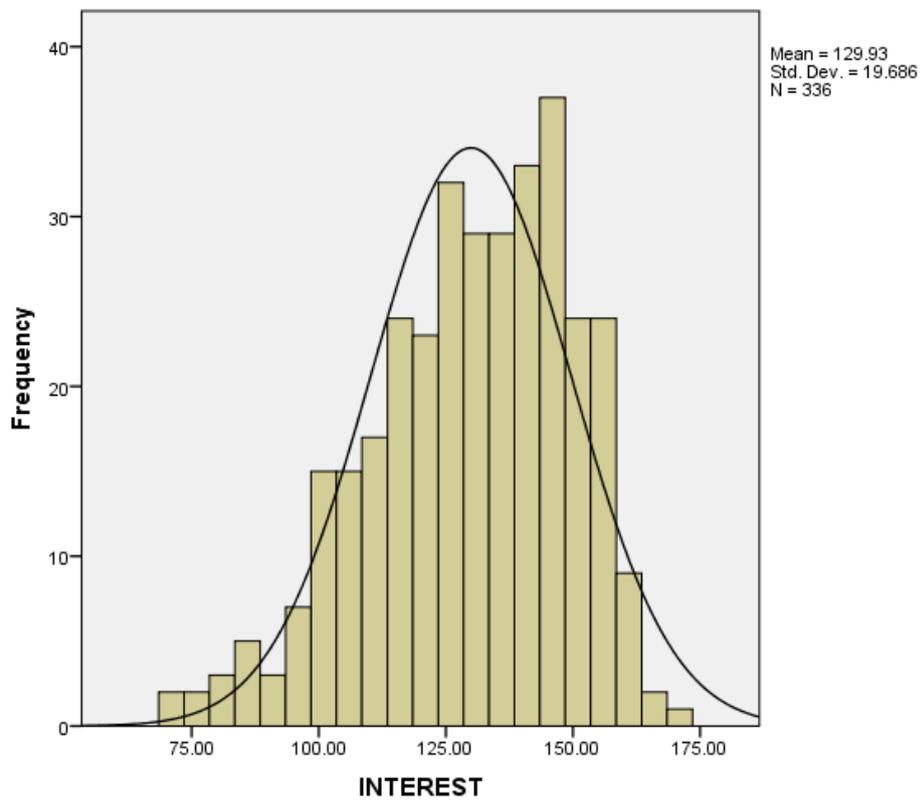


Table 2

Levene's Test for Homogeneity of Variances

	Levene	df1	df2	Sig.
Variable	Statistic			
CRCT	5.516	1	334	.019
INTEREST	1.879	1	334	.171

The assumption of independence of observations was addressed in this study through the research design. No participant was measured more than once on any one variable. Therefore, the assumption of independence of observations was met. The assumptions of normality, homogeneity of variances, and independence of scores were all met, allowing the use of *t*-tests to analyze H1 and H2 (Green & Salkind, 2011)

Data Analysis Results for Hypothesis 1

Null Hypothesis 1

Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not achieve statistically significantly different standardized CRCT science scores from students who received traditional science instruction.

Descriptive Statistics for Hypothesis 1

The descriptive statistics in Table 3 indicate that the mean 2012 CRCT score of the seventh grade Life Science students in the traditional instruction group had a mean score of 822.573. The mean score for students in the inquiry-based instruction group was 823.878.

Results for Hypothesis 1

Hypothesis 1 was tested by conducting a *t*-test analysis, using SPSS 21, between the traditional instruction group and inquiry-based instruction group on the CRCT variable. A *t*-test was used because of the researcher's desire to determine differences in group means

(Green & Salkind, 2011). The results can be seen in Table 4. The test was nonsignificant, $t(315.945) = -.307, p = .758$. Null Hypothesis 1 could not be rejected. Students in the traditional instruction group ($M = 822.573, SD = 34.683$) on the average scored almost exactly the same as the inquiry-based group ($M = 823.878, SD = 42.655$). The 95% confidence interval for the difference in means ranged from -9.667 to 7.056 .

Table 3

Descriptive Statistics for the CRCT Variable

Variable	N	Minimum	Maximum	Mean	Std. Deviation
CRCT	171	754.000	960.000	822.573	34.683
Traditional Instruction	Valid N (list wise)	171			
CRCT	165	751.000	960.000	823.878	42.655
Inquiry-based Instruction	Valid N (list wise)	165			

Data Analysis Results for Hypothesis 2

Null Hypothesis 2

Students who participate in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes will not rate their classroom experiences statistically differently than students who received traditional science instruction.

Descriptive Statistics for Hypothesis 2

The descriptive statistics in Table 5 indicate that the mean course interest score of the seventh grade Life Science students in the traditional instruction group was 133.497.

Students in the inquiry-based instruction group had a mean score of 126.224.

Table 4

*T-test Results for Hypothesis 1***Independent Samples Test**

		t-test for Equality of Means						
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							<i>Lower</i>	<i>Upper</i>
CRCT	Equal variances assumed	.308	334	.758	-1.30569	4.234	-9.635	7.024
	Equal variances not assumed	.307	315.945	.759	-1.30569	4.250	-9.667	7.056

Results for Hypothesis 2

Hypothesis 2 was tested by conducting a *t*-test analysis, using SPSS 21, between the traditional instruction group and inquiry-based instruction group on the INTEREST variable. A *t*-test was used because of the researcher's desire to determine differences in group means (Green & Salkind, 2011). The results can be seen in Table 6. The test was significant, $t(334.000) = 3.440, p < .001$. Null Hypothesis 2 was rejected. Students in the traditional instruction group ($M = 133.49, SD = 20.324$) on the average scored higher than those in the inquiry-based group ($M = 126.22, SD = 18.340$). The 95% confidence interval for the difference in means ranged from 3.114 to 11.432.

Table 5

Descriptive Statistics for the Interest Variable

Variable	N	Minimum	Maximum	Mean	Std. Deviation	
Traditional Instruction	INTEREST Valid N (list wise)	171	72.000	170.000	133.497	20.323
Inquiry- based Instruction	INTEREST Valid N (list wise)	165	71.000	164.000	126.224	18.340

Summary of the Findings

This chapter presented the descriptive statistics, assumption testing, and tests of hypotheses for this study. The data analysis revealed that the assumptions were met for Hypothesis 1. For Hypothesis 1, the “equal variances not assumed statistic” was used, making the independent samples *t*-test an appropriate choice for data analysis (Green & Salkind, 2011). This led the researcher to accept the use of a *t*-test statistical analysis.

The study addressed two research questions and their corresponding hypotheses. Research Hypothesis 1 tested the difference between the traditional instruction group and the inquiry-based instruction group on the CRCT science test. The difference was found to be statistically nonsignificant. Research Hypothesis 2 tested the difference between the traditional instruction group and the inquiry-based instruction group on their interest in the Life Science course. The difference was found to be statistically significant ($\eta^2 = .37$). The significance of these and other results are discussed.

Table 6

T-test Results for Hypothesis 2

Independent Samples Test

		t-test for Equality of Means						
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							<i>Lower</i>	<i>Upper</i>
CRCT	Equal variances assumed	3.440	334	.001	7.272	4.114	3.114	11.432
	Equal variances not assumed	3.446	332.552	.001	7.272	4.110	3.121	11.425

CHAPTER FIVE: DISCUSSION

The previous chapter presented data analysis, which utilized an independent samples *t*-test to compare the differences in student achievement scores and course interest between seventh grade students who participated in an inquiry-based, hands-on program designed by Lab-Aids Corporation and seventh grade students who participated in a more traditional lecture program, with the use of only one lab per unit. The descriptive statistics, the assumptions testing results, and the findings by hypothesis are also presented.

The purpose of this chapter is to review the findings of this research study and discuss them as they relate to research that was presented in the literature review. The chapter is divided into the following sections: restatement of the problem, summary of the findings by hypothesis, discussion on the results, implications, limitations, recommendations, and the conclusion.

Restatement of the Problem

In 2013, science test results began to count toward AYP for all the schools in the state of Georgia, so there needs to be research to support instructional strategies that will help improve student science achievement. The researcher sought to investigate two instructional science teaching methods (the use of an inquiry-based, hands-on lab approach versus the traditional lecture approach) in an attempt to pinpoint which of the two methods are most effective for teaching science at the middle school level in Georgia. Because schools must now meet AYP in science in order to maintain funding, many schools have employed a didactic approach to teaching that emphasizes transmitting the content of scientific theories to students, to the exclusion of hands-on learning. This didactic teaching approach has resulted in educators who rely on textbooks alone to impart scientific knowledge to passive student audiences. This means that learners are seldom involved in direct and real experiences with scientific phenomena that allow them to fully understand their environments and appreciate

science. To improve this poor understanding of science, effective instructional methods must be adopted. The state has required all teachers to use standards-based teaching strategies that have a high likelihood of increasing performance in science (Georgia Department of Education, 2012). This state requirement, in conjunction with the need to meet AYP, forms the fundamental problem that was addressed in this study.

Summary of the Results

Research Question 1 and Null Hypothesis 1

The first research question asked whether there was a difference in mean achievement scores between grade seven Life Science students who were taught using an inquiry-based, hands-on instructional method and those who received traditional lecture based instruction, as measured by the CRCT. This general determination of the difference between the results of an inquiry-based, hands-on lab teaching approach and the results of a traditional approach to teaching science was meant to enlighten educators and education policy makers on the possible benefits of the hands-on approach to science instruction. The researcher's hypothesis was that students in one school district in the state of Georgia who participated in daily inquiry-based, hands-on labs and activities during their seventh grade Life Science classes would score higher on the science CRCT than the students who received traditional science instruction (Gadoe.org, 2012). Results indicated that students in the traditional instruction group ($M = 822.573$, $SD = 34.683$) scored almost exactly the same as the inquiry-based group ($M = 823.878$, $SD = 42.655$). The 95% confidence interval for the difference in means ranged from -9.667 to 7.056 . The test was nonsignificant, $t(315.945) = -.307$, $p = .758$; therefore, Null Hypothesis 1 was not rejected.

Since this is just one study and it does contradict findings of many other studies (Akins, Durham, Smit, & VanDenend, 2008; Chang & Mao, 1998; Padilla, Okey, & Garrand, 1984), there may be a need to look at future research studies more closely to make sure that

the methodologies examine a wider range of limitations. While reviewing all the literature and examining other studies, it was determined that “inquiry-based instruction complements traditional instruction by providing a vehicle for extending and applying the learning in a way that connects with their interest within a broader thematic framework” (Varnado, 2011, p. 83). The research indicated that a mixture of both of these methods should be explored to determine if there are greater gains for student achievement and course interest if they are utilized simultaneously. The current study does contribute to the field of existing research by providing a quantitative, quasi-experimental study on student achievement and course interest, but the results provide contrary evidence to many past research studies on similar topics (See Table 7).

Table 7

Means, Standard Deviations, and t-tests (STUDENT ACHIEVEMENT Measure)					
Group	n	M	SD	t	p=
Inquiry-based Group (Treatment)	165	823.878	42.655	.308	.758
Traditional method (Control)	171	822.573	34.683		

Research Question 2 and Null Hypothesis 2

The second question asked whether there was a difference in mean course interest scores between grade seven Life Science students who were taught using an inquiry-based, hands-on instructional method and those who received traditional lecture based instruction, as measured by the CIS. Results indicated that students in the traditional instruction group ($M = 133.49$, $SD = 20.32$) scored higher than those in the inquiry-based group ($M = 126.22$, $SD = 18.34$). The 95% confidence interval for the difference in means ranged from 3.114 to 11.432. The test was significant, $t(334.000) = 3.440$, $p < .001$; therefore, Null Hypothesis 2 was rejected (See Table 8).

Table 8

Means, Standard Deviations, and t-tests (INTEREST Measure)					
Group	n	M	SD	t	p=
Inquiry-based Group (Treatment)	165	126.224	18.340	3.440	.001
Traditional method (Control)	171	133.497	20.323		

Discussion

The literature review confirmed the importance of inquiry-based, hands-on instructional methods in every area of teaching, but especially in science courses. The Constructivist Theory supports inquiry-based learning because students are encouraged to be actively involved in their learning by connecting prior experiences with new information (Ozmon & Craver, 2008). There are several research studies that have investigated student interest and student achievement. This study sought to determine if an inquiry-based, hands-on labs approach to science instruction improved student achievement and student interest. The difference in mean scores for Hypothesis 1 was so small that it could not be determined by this study if students taught using the hands-on instructional methods gain better understanding of science concepts and achieve higher test scores than their counterparts who were taught using traditional methods.

Poderoso (2013) explored the relationship between instructional programs and curricular changes affecting student outcomes. The results revealed that the students using a traditional, textbook method outscored the students in the inquiry-based group. Varnado (2011) conducted a study with four classes, two traditional and two inquiry-based to determine if one approach is more effective than the other, while also examining the perceptions of the teachers and students on the effectiveness of the program. Based on posttest results, there was not a significant difference in student achievement on the language

arts and mathematics posttests when taught using didactic instruction as compared to inquiry-based instruction. Both Varnado (2011) and Poderosa (2013) are consistent with the findings from this study, which showed there was no significant improvement in student achievement when utilizing an inquiry-based, hands-on model for teaching the curriculum. Mergendoller et al. (2006) compared student achievement results between high school students that were taught either traditional or inquiry-based strategies to determine which method produced higher student achievement. The data from his study revealed that there was not a significant difference in performance when using traditional or inquiry-based, hands-on teaching methods, which supports the findings from this study. In 2003, Keegan also conducted a study comparing traditional and inquiry-based classrooms. He compared students that participated in the discovery learning method (an inquiry-based method) to students taught with traditional methods and determined that there was not a significant difference in performance between the two groups based on instructional strategy, which also supports the findings of this study. This makes the researcher question several of the theoretical frameworks from the literature review. If Dewey, Montessori, Kolb, Piaget, Lewin, and Williams developed their learning models based on the constructivist theory that supports inquiry-based learning because the students are encouraged to be actively involved in their learning by connecting prior experiences with new information (Ozmon & Craver, 2008), then this leads the researcher to want to search for a better way to assess learning because maybe one standardized assessment like within this research study and the studies mentioned above are not enough to truly measure student achievement.

Akins, Durham, Smit, and VanDenend (2008) assessed the effectiveness of two instructional models on student achievement using two fourth grade classes. The posttest results demonstrated higher performance by the students in the inquiry-based classroom. The research collected by Akkus, Gunel, and Hand (2007) established that the quality of the

implementation technique does have great impact on students' posttest scores when they compared the effectiveness of inquiry-based science to traditional teaching practices. Padilla, Okey, and Garrand (1984) found that middle school students showed considerably higher scores in process skills than the control group when inquiry-based learning was employed. Thus, the researcher is led to believe that the inquiry-based, hands-on labs would be significantly higher because of the review from the literature that was grounded in the Constructivist Theory, where Dewey (1929) stressed the importance of using scientific inquiry as an essential part of learning (Nodding, 2007). However, all three of these studies contradicted the findings in the previous studies by documenting significant improvement in student achievement using the inquiry-based, hands-on model. Now the researcher feels the need to further research this topic and try to pinpoint the error that is either in the current study or in past studies. There may need to be a balance of both strategies, since there is research to support both.

Poderosa (2013) also determined that students who participated in inquiry-based, hands-on learning showed a more positive attitude about science than students that participated in the traditional learning environment. Those results are not consistent with the findings from this study. This study showed that the traditionally instructed control group had slightly higher interest in science than the inquiry-based treatment group. Chang and Mao (1998) explored the long-term impact of the inquiry-based instructional method on students' attitudes towards learning science. They found that learners taught by the inquiry-based teaching technique scored considerably higher on achievement tests than those taught using the traditional lecture approach when they had a more positive attitude towards learning science. Selim and Shrigley (1983) found that learners engaged in the discovery approach (also known as the inquiry-based, hands-on approach) for a 21 day class treatment period had a more positive attitude toward science courses when compared to the control group, who

were instructed using traditional lecture methods. A number of research studies involving middle level and high school students established that inquiry-based learning activities had a positive impact on student achievement in science courses, laboratory skills, cognitive development, science process skills, and general understanding of science facts when compared to students trained using a traditional instructional approach (Chang & Mao, 1998). As stated in the Ego Development Theory (Erickson, 1968), teachers need to view their students as more than scores on a standardized test if they want them to become future scientists. This statement may help explain why this study's CIS results contradicted past research that inquiry-based, hands-on learning developed a positive student attitude toward science. This leads the research to believe that the perceptions of teachers may carry over to the students if they feel like the only thing that is important is the test score, then the interest level may not be as high as when the teacher demonstrates that the students are the most important factors.

The increased student interest in studying science, as shown by the John Keller survey report (2010), was partly attributable to the adoption of an inquiry-based, hands-on learning approach that actively engages students throughout the course. Interest in science was also influenced by certain external factors, such as the recommendations made by the AAAS of 1999 and the National Research Council (NRC) of 1996 that science curricula should be taught using inquiry-based learning approaches that keenly engage learners in science activities. Additionally, NCLB (2001) promoted standards-based teaching (Spring, 2008). However, the results of this study contradict these results because the traditional instruction group actually had a higher mean score on the course interest survey than the inquiry-based instruction group. Therefore, this study demonstrated that interest might not influence performance on standardized tests because the inquiry-based instruction group did show a

higher mean score on the CRCT while having a lower mean score on the course interest survey.

Limitations

This study had limitations due to the quasi-experimental design, the statistical test used, the data collected, the program utilized, and the limited experience of implementing the treatment.

This study did use the quasi-experimental posttest only design. This was necessitated due to the subject area that the study was examining. The CRCT data that was collected was abnormal, perhaps due to the fact that the schools were not randomly assigned. Due to the strict guidelines imposed by several of the school districts in the study, which required the research to work within their systems, the researcher had to hand pick subjects and wait for approval before proceeding to collect any data. Once the treatment group had been established, the task of matching the control group became a tedious task as well. However, through the use of the online data system from the state of Georgia, approval was gained from one system that matched the treatment system in demographics and subgroups. Currently, the state has started publishing more data, and the schools are now being ranked by performance, which would have allowed the researcher to not only match demographics, but also to match the performance levels before treatment started. This could have ensured that the data would have been more normal and allowed for more statistical tests to be run.

This study only investigated one inquiry-based, hands-on instructional approach. There are several hands-on instructional techniques other than the inquiry approach that can be employed concurrently that could have provided additional results. There are diverse instructional approaches that can be classified as “hands-on science,” and educators can adopt and use them in any combination throughout the school year.

Within the treatment group, the faculty was trained to use the Lab-Aids program during the year before implementation, and was given additional training during this initial year. However, this is still a limited amount of experience that may have made the complete implementation of the program difficult, thus influencing the results.

Another limitation was that the overall success and achievement of the students in the study might have been the result of other factors not related to the instructional methods used. This study did not consider these possible confounding variables. This research also limits the definition of student success to academic test scores alone. However, other aspects of a student's life, such as their social, physical, and psychological wellbeing may also impact the success (including success on the science CRCT test) of each individual student.

Implications

Educational standards and curriculum are constantly being modified in an attempt to attain a higher quality of education, improve academic performance by all students, and meet AYP (Hord, 2004). The NCLB Act of 2001 was a federal mandate for schools to use inquiry-based strategies to teach science (Spring, 2008). The findings of this research study indicated that these NCLB mandates might need to be altered if there are no significant academic gains that result from the use of inquiry-based strategies. The result of having these mandates placed on the school systems was a heightened need for states to search for valid research methodologies in order to provide evidence to implement various programs that help improve student achievement. This may also explain why the state of Georgia is switching to a different evaluation system for calculating AYP. The state plans to give the schools an index rating of 1-100. The major advantage of implementing new AYP standards is that school systems will not be evaluated on how well the students perform on just one standardized test (Georgia Department of Education, 2012).

There have been several years of debate over how to apply and implement the inquiry-based approach within the classroom (Abrams, Southerland, & Silva, 2008; Chinn & Malhorta, 2002). There appears to be some resistance by teachers and students because it does require some changes in what is expected from the teacher and the student (Anderson, 2007; Sundberg, 1992). The teacher becomes more of a facilitator and the student becomes an active learner, which appears to present a problem for some students because they struggle to work independently or to attempt to problem-solve before asking an expert (Loughran & Derry, 1997). Research has revealed that some students prefer to use memorization skills and just repeat the information back to the teacher rather than learning how to apply the knowledge so that they can gain a deeper understanding (Hughes & Wood, 2003; Watters, D. & Watters, J., 2007). There are additional research findings that show that some learners have a difficult time transferring the knowledge they should have gained through the inquiry-based, hands-on activities to written work (Wellington, 1998). Therefore, the use of only one standardized test may prevent the demonstration of student achievement. The use of different types of assessment should be considered to ensure that a true picture for student achievement is being presented.

Teacher insecurity about changing their normal routine could have definitely affected student achievement and student interest if the students saw the teacher's stress level increase due to lack of preparation. Teachers have expressed that the limited amount of time to teach during the school year and the extra effort that is required to prepare for the daily labs is two of the reasons that they are resistant to changing their strategies (Adb-Hamid, Campbell, Der, & Wolf, 2012; Buxton & Provenzo, 2007; Crawford, 2000; Gibson & Chase, 2002; Guzman & Bartlett, 2012, Keys & Bryan, 2001; Lane, 2007; Marilla & McKeachie, 2011; Moss, 1997; Taylor & Watson, 2000). Erikson (1988) explained that "each strength has a 'time-

specific developmental confrontation,' which must occur in a sequential order, thus making it an epigenetic theory" (p. 74).

Recommendations for Future Research

There are several possibilities for future research after close investigation of the results of this study. First, a future research study could incorporate more grade levels, such as the inclusion of all of middle school as opposed to just one grade. This would allow for a larger variety of grades to participate in the study. Future studies could also include longitudinal data to determine if schools that have been using inquiry-based, hands-on instructional methods for a number of years indicate an increase in standardized science test scores as teachers acquire more experience.

Future studies should consider using a variety of different inquiry-based, hands-on approaches or different programs that implement these strategies. Although these studies could still utilize quantitative approaches with a pretest/posttest method and different statistical tests like ANCOVA and repeated measures testing, a qualitative study could prove to be very beneficial because the student and teacher interviews could provide more insight into what variables truly influence student achievement and student interest. A mixed study that incorporates multiple methodologies, such as interviews and focus groups, could better assess the overall student achievement and student interest in both the traditional and inquiry-based, hands-on groups. Therefore, there is a need for more research using both quantitative and qualitative methods to continue to thoroughly investigate the true reasons for student achievement and course interest.

Finally, future research could be conducted to investigate several factors that affect student achievement and student interest. Some of the factors that could be included are the demographics of the student population, the location of each school district, the use of additional support (such as tutors), and even the amount of teacher training that each method

provides during the school year. These factors could be investigated separately or in any combination with each other. Further investigation should provide more insight into what is needed to improve science education so that student achievement increases while raising student interest in the science field.

Summary

The quasi-experimental research methodology adopted in this study allowed a comprehensive comparison and analysis of the data collected. The use of the quasi-experimental design made it possible for the researcher to examine the effects on student achievement when inquiry-based, hands-on labs were implemented into a standards-based Life Science class as the primary instructional approach. Hands-on labs include all hands-on activities carried out by students during their science classes. The research indicated that there was not a significant difference in student achievement based on the mean scores on the CRCT for the two groups. There was a significant difference in the mean scores for student interest, with the traditional group out scoring the inquiry-based, hands-on group.

This study was conducted using all the 7th grade Life Science students from five schools in the State of Georgia; two schools were the control group that used a more traditional method of teaching, and the other three schools were the treatment group that utilized the inquiry-based, hands-on labs program by Lab-Aids for the first time to present the curriculum as outlined by the State of Georgia. Results for Hypothesis 1 revealed that there was not a significant difference in student achievement on the CRCT that was administered in 2012 after one year of implementation of the newly adopted Lab-Aids program. There are many other studies that are available to support and dispute these findings (Chang & Mao, 1998; Hughes & Wood, 2003; Poderosa, 2013; Selim & Shrigley, 1983; Varnado, 2011; Watters, D. & Watters, J., 2007). Teaching science courses in the middle school class has been a challenge for a long time. Despite the fact that all students attend science classes,

many do not acquire and improve upon the required science knowledge. Therefore, they may be unable to recognize the functions and significance of science in society. To change this trend, several learning techniques have been designed to ensure that students appreciate and understand the relevance of science in society. Inquiry-based learning is one such technique, which attempts to improve the teaching of science by actively engaging learners in authentic and practical investigations that enable them to develop more realistic ideas about scientific study, as well as offer a more motivating and learner-centered environment.

The majority of teachers interviewed in several studies revealed that teachers did perceive that they presented science content effectively and efficiently using inquiry-based learning, while adding some true appeal with the assignment choices provided to the students (Gay & Kirkland, 2003; Killen, 2013; Kyriacou, 1998; Marzano, 2007; Stronge, Ward, & Grant, 2011). Marzano (2007) reported that students are successful when they are motivated to learn the curriculum standards that are outlined by the state; therefore, students should be expected to do their best regardless of the teaching methodology being utilized (Akey, 2006). Teachers must strive to understand the curriculum and utilize a variety of strategies to ensure that all students learn (Akey, 2006; Garcia-Reid et al., 2005; Kiriakidis, 2011a, 2011b, 2011c).

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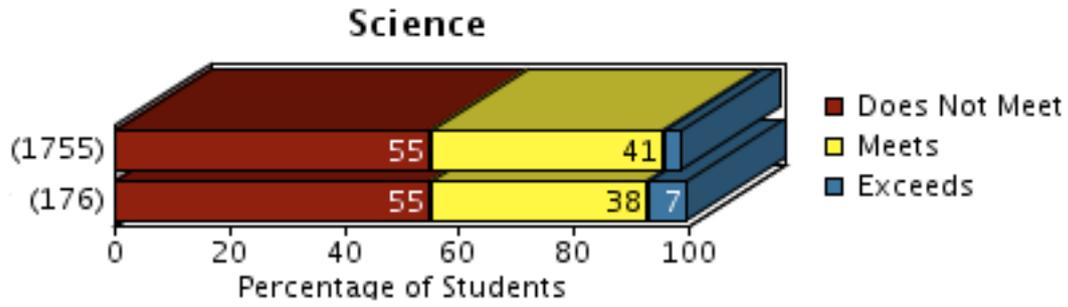
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Appendix A: Similar School Website



* Test results are not reported on fewer than 10 students.

FRL	LEP	Asian	Black	Hisp	Multi	Native Amer	White	Spec Ed	Sim Index
77	2	2	73	3	2	0	21	10	-
84	1	0	69	3	2	0	26	11	2

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Appendix B: Treatment IRB Approval Letter



December 8, 2011

Ms. Donna Miller
790 Daniel Road
Demorest, GA 30535

Dear Ms. Miller:

After review of your proposal, general approval for this action research has been granted. Please note that any [REDACTED] County School District employee system-wide "may choose" to participate in the survey. They are not mandated to participate in independent projects. You stated that your area of study will involve "*Does Hands-on, Inquiry Based Labs Improve Student Achievement?*"

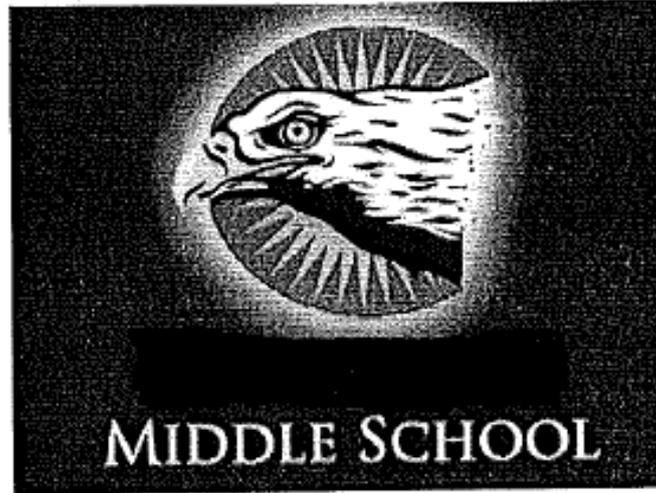
Enclosed you will find a copy of Board Policy ICC that details the requirements for conducting research or surveying individuals within the school district. Please review the policy before beginning the research process. You are required to sign the form provided stating that you have reviewed and understand Board Policy ICC.

We wish you well in your research endeavors.

Sincerely,

Deputy Superintendent

Appendix C: Control Group Principal Approval Letter



[Redacted], Principal [Redacted] School Street
[Redacted], GA [Redacted] [Redacted]

February 14, 2012

To Whom It May Concern:

I, [Redacted] Principal of [Redacted] Middle School grants permission to allow Donna Miller to conduct a quantitative study examining the impact of inquiry-based, hands-on labs upon student achievement and student motivation of middle school students to be conducted at [Redacted] Middle School. I understand that the information gathered would be for research purposes only, and the identity and all identifying information of all participants will be kept confidential and anonymous.

Sincerely,

[Redacted Signature]

Principal, [Redacted] Middle School
[Redacted] County

Appendix D: Course Interest Survey (CIS)

Instructions Course Interest Survey

There are 34 statements in this questionnaire. Please think about each statement in relation to the class you have just taken and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true, or what you think others want to hear.

Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements.

Record your responses on the answer sheet that is provided and follow any additional instructions that may be provided in regard to the answer sheet that is being used with this survey.

Use the following values to indicate your response to each item.

- 1 (or A) = Not true
- 2 (or B) = Slightly true
- 3 (or C) = Moderately true
- 4 (or D) = Mostly true
- 5 (or E) = Very true

Circle your response to each statement.

1. The instructor knows how to make us feel enthusiastic about the subject matter of this course.

Not true Slightly true Moderately true Mostly true Very true

2. The things I am learning in this course will be useful to me.

Not true Slightly true Moderately true Mostly true Very true

3. I feel confident that I will do well in this course.

Not true Slightly true Moderately true Mostly true Very true

4. This class has very little in it that captures my attention.

Not true Slightly true Moderately true Mostly true Very true

5. The instructor makes the subject matter of this course seem important.

Not true Slightly true Moderately true Mostly true Very true

6. You have to be lucky to get good grades in this course.

Not true Slightly true Moderately true Mostly true Very true

7. I have to work too hard to succeed in this course.
- Not true Slightly true Moderately true Mostly true Very true
8. I do NOT see how the content of this course relates to anything I already know.
- Not true Slightly true Moderately true Mostly true Very true
9. Whether or not I succeed in this course is up to me.
- Not true Slightly true Moderately true Mostly true Very true
10. The instructor creates suspense when building up to a point.
- Not true Slightly true Moderately true Mostly true Very true
11. The subject matter of this course is just too difficult for me.
- Not true Slightly true Moderately true Mostly true Very true
12. I feel that this course gives me a lot of satisfaction.
- Not true Slightly true Moderately true Mostly true Very true
13. In this class, I try to set and achieve high standards of excellence.
- Not true Slightly true Moderately true Mostly true Very true
14. I feel that the grades or other recognition I receive are fair compared to other students.
- Not true Slightly true Moderately true Mostly true Very true
15. The students in this class seem curious about the subject matter.
- Not true Slightly true Moderately true Mostly true Very true
16. I enjoy working for this course.
- Not true Slightly true Moderately true Mostly true Very true
17. It is difficult to predict what the instructor's evaluations of my work compared to how well I think I have done.
- Not true Slightly true Moderately true Mostly true Very true
18. I am pleased with the instructor's evaluation of my work compared to how well I think I have done.

- | | Not true | Slightly true | Moderately true | Mostly true | Very true |
|--|----------|---------------|-----------------|-------------|-----------|
| 19. I feel satisfied with what I am getting from this course. | | | | | |
| 20. The content of this course relates to my expectations and goals. | | | | | |
| 21. The instructor does unusual or surprising things that are interesting. | | | | | |
| 22. The students actively participate in this class. | | | | | |
| 23. To accomplish my goals, it is important that I do well in this course. | | | | | |
| 24. The instructor uses an interesting variety of teaching techniques. | | | | | |
| 25. I do NOT think I will benefit much from this course. | | | | | |
| 26. I often daydream while in this class. | | | | | |
| 27. As I am taking this class, I believe that I can succeed if I try hard enough. | | | | | |
| 28. The personal benefits of this course are clear to me. | | | | | |
| 29. My curiosity is often stimulated by the questions asked or the problems given on the subject matter in this class. | | | | | |
| 30. I find the challenge level in this course to be about right: neither too easy not too hard. | | | | | |

31. I feel rather disappointed with this course.

Not true Slightly true Moderately true Mostly true Very true

32. I feel that I get enough recognition of my work in this course by means of grades, comments, or other feedback.

Not true Slightly true Moderately true Mostly true Very true

33. The amount of work I have to do is appropriate for this type of course.

Not true Slightly true Moderately true Mostly true Very true

34. I get enough feedback to know how well I am doing.

Not true Slightly true Moderately true Mostly true Very true

35. What is your gender?

Male Female

36. What is your ethnicity/race?

Caucasian/White African American Hispanic Asian Other

37. Did you use the Lab-Aids program in class this year?

Yes No

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Appendix E: Liberty Internal Review Approval Letter



The Graduate School at Liberty University

February 27, 2012

Donna Miller

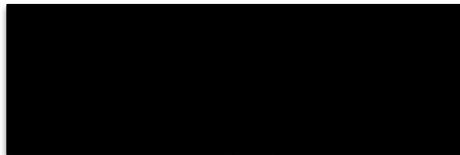
IRB Approval 1222.022712: Improving Student Achievement: Using Inquiry-Based, Hands-On Labs to Raise Test Scores in a Middle School Class

Dear Donna,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Thank you for your cooperation with the IRB and we wish you well with your research project.

Sincerely,



IRB Chair, Associate Professor
Center for Counseling & Family Studies

(434) 592-5054



40 Years of Training Champions for Christ: 1971-2011

Appendix F: Teacher and Student Permission Forms

Adult Participant Consent Form

You are being asked to participate in a project as a doctoral class assignment under the direction of Dr. Scott Watson and conducted through Liberty University. The University in accordance with its policy regarding the Protection of Human Research Subjects asks that you give your signed agreement to participate in this project. Please ask the doctoral student researcher, Donna K. Miller, any questions you have to help you understand this research project. A basic explanation of the research is given below.

The researcher intends to examine the impact of the implementation inquiry-based, hands-on labs through the Lab-Aids program, in 7th grade Life Science classes upon student achievement and to assess student motivation using such instructional strategies. The researcher will ask you teacher to take and administer one student survey at the end of the unit. The evaluation of the research proposal will include pre- and post- CRCT data compilation and interpretation and scheduled survey after parent permission is obtained. Your name will remain confidential at all times. You will not be identified in the research report.

Your name will remain confidential at all times. You will not be identified in the research report.

Liberty University is an equal opportunity educational institution. It is not the intent of the institution to discriminate against any person based on sex, race, religion, color, national origin or handicap of the individual.

Questions regarding the conduct of this research may be directed to (1) Donna K. Miller, at (706) 778-7121 or dkmiller2@liberty.edu; (2) Dr. Scott Watson at 1-800-424-9595 or swatson@liberty.edu; or (3) the Liberty University IRB at irb@liberty.edu.

Refusal to participate in this study will have no effect on any future services you may be entitled to from the school system. Should you agree to participate in this study and decide later that you wish to withdraw, you will be free to withdraw from the study at any time without penalty. If you agree to participate at this time, please sign and date this statement. You may keep a copy of this consent form for your records. Thank you very much for your willingness to participate in this research project.

Teacher Name (printed):

Teacher Signature:

Date: 2/21/12

School Administrator Signature:

Date: 2-21-12

Copy on File

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