Effects of using inquiry-based learning on science achievement for fifth-grade students

Deborah O. MAXWELL
Royston Elementary School
660 College Street, Royston, GA 30662, USA
Email: deborah.maxwell@franklin.k12.ga.us

Dawn T. LAMBETH
Department of Middle, Secondary, Reading, & Deaf Education
Dewar College of Education & Human Services
Valdosta State University
1500 North Patterson Street, Valdosta, GA 31698, USA
Email: dtlambeth@valdosta.edu

J.T. COX
Department of Middle, Secondary, Reading, & Deaf Education
Dewar College of Education & Human Services
Valdosta State University
1500 North Patterson Street, Valdosta, GA 31698, USA
Email: jtcox@valdosta.edu

Received 8 Sept., 2014
Revised 23 Jun., 2015

Contents

Abstract

The purpose of this research was to examine the effects of Inquiry-Based Learning (IBL) on the academic achievement, attitudes, and engagement of fifth-grade science students. Participants were from two science classes (*N* = 42). The experimental group received IBL instruction, while the control group received traditional instruction. Pretests and posttests were used to measure students' academic achievement during the 6-week study. The Science Attitudes Survey was administered to students pre-intervention and post-intervention to assess overall student attitudes about science. Student engagement was measured 3 days a week with a student engagement checklist. Fieldnotes recorded by the teacher-researcher were used for additional documentation. Students in the IBL group scored higher than students in the traditional group on the academic achievement posttest, although not statistically significant. Students who received IBL instruction showed a slight statistically insignificant decrease in their positive attitudes towards science but higher engagement as compared to students who received traditional instruction.

Keywords: Inquiry-Based Learning; student achievement; attitude and engagement.

Introduction

Educators and many advocates from the field of science have recognized the need for revising methods used for teaching science in schools in the United States in order to improve student performance on high-stakes testing. Student scores are not the only concern in science education. Many science education researchers are concerned by the lack of depth of understanding of scientific concepts that students have exhibited for many decades. Liu, Lee, and Linn (2010) stated the performance of 12th-grade students on science assessments declined from 1996 to 2005 when compared to international students. Miller, McNeal, and Herbert (2010) stated that students should assume the role of a scientist by developing concepts and gathering knowledge to support those concepts. According to Drake and Long (2009), in many classrooms across the United States, science instruction does not support the need for developing student scientists. Due to the pressure to make Annual Yearly

Progress (AYP) through the No Child Left Behind Act (NCLB), administrators in many schools placed an emphasis on reading and mathematics skills in order to increase test scores in those areas. In many schools, the importance of science instruction was diminished because of the emphasis on reading and mathematics instruction. The Common Core Curriculum (CCC) was implemented in the 2012-2013 school year. The Common Core Curriculum also required science in high-stakes testing as a measure of AYP. What students gain as a result of the study of science through real-life problem-solving skills and understanding the world needs to increase as well as their scores on the end of the year tests. Varma, Volkmann, and Hanuscin (2009) observed that science should be taught and learned through inquiry. Activities in science classrooms should involve observations, questioning, reading books and other sources of information, investigating, gathering, analyzing, predicting, explaining, and communicating results. Memorizing facts will not increase skills in students of science, but the freedom to explore and investigate through inquiry-based learning (IBL) will.

One approach to promoting meaningful science learning is via greater student involvement via inquiry-based learning (IBL). New knowledge is acquired as students collect data, analyze data, and solve problems. Memorizing facts does not promote or develop problem-solving skills, but when students are allowed to investigate, reason, and organize knowledge; they are able to incorporate new knowledge into their understanding (Miller et al., 2010). Miller et al. (2010) further assert that IBL helps develop students' understanding of the world around them through gathering knowledge. Students' scientific understanding is supported through the expansion of habits of the mind and using problem solving skills. Using prior knowledge, students make connections with their new knowledge. IBL is seen as a system of learning that supports the development of students' problem solving and critical thinking skills, which is important for them in everyday activities. Through IBL, students learn not only how to ask questions and figure out the answers, but they also learn what questions are important to ask. A learning environment that supports these kinds of cognitive skills enables students to assimilate these skills in other areas of learning.

In Georgia, both fifth and eighth grades are considered benchmark years. Data from fifth and eighth grades is used to document achievement in science at the state level. A goal of fifth-grade science instructors is to find and use strategies, such as IBL, that promote science habits of mind for use in future years beyond the fifth grade, and thus increase achievement.

According to the Science Assessment from the U.S. Department of Education (2011), eighth-grade science scores increased from 150 in 2009 to 152 in 2011, both of which were in the basic category of scores, which was below the proficient and advanced levels. The percentage of students performing at the proficient level was higher in 2011 than in 2009. There was no significant change at the advanced level. The gap in scores between White and Black students, and between White and Hispanic students narrowed from 2009 to 2011. There was not a significant difference in 2011 from 2009 in the gap between male and female students. Scores for students eligible for free or reduced lunch did not significantly change between 2009 and 2011. Georgia was one of 16 states where eighth-grade students scored higher in 2011 than in 2009. According to the results of these comparisons of test scores, there was a slight improvement in science achievement nationally (U.S. Department of Education, 2011).

The Governor's Office of Student Achievement (2011) reported that 77% of Georgia fifth-grade students met the state standards in science. Science scores for the research school were slightly higher for fifth grade (79%) than the state scores according to the State of Georgia K-12 Report Card (2010-2011). Substantial differences occurred among subgroups that met state standards on the science subtest of the Georgia Criterion Referenced Competency Test (CRCT). White students scored 79% and Black students scored 60%. Females recorded a score of 82% and males recorded a score of 71%. Economically disadvantaged students in the research school scored 68% while economically disadvantaged students in the state, as a whole, scored 67%. Among the students in the research group, the sub-population of students with disabilities (SWD) consisted of less than 10 students. With the implementation of CCC in the 2012-2013 school year, teachers at the research school faced the challenge of using evidence-based strategies to improve student achievement in science.

In Georgia, schools develop an improvement plan. The research school's 2012 School Improvement Plan (SIP) data indicate that the state targets in science are lower than the district and school outcomes. According to the research school's SIP, Black students meet or exceed the state targets (68.9%) in science. The research school's SIP supports an increase in the percentage of students exceeding on the science section of the CRCT from 36% to 41%. The goals are set in the area of science to increase student achievement and student engagement. The question thus arises as to whether IBL can provide the basis for improvements in science education at the level of fifth grade.

In order for the science goals of the research school's SIP to be achieved, a revision in teaching methods needed to occur. In order to increase student engagement and the number of students' scores in the exceeds category on the Georgia Criterion Referenced Competency Test (CRCT), IBL was implemented. Varma, Volkmann, and Hanuscin (2009) stated that the National Science Education Standards (NSES) noted "the first of five essential features of classroom inquiry is learners are engaged by questions that are scientifically oriented" (p. 1). Although traditional methods of lecturing and experimenting have proven effective, additional IBL methods were implemented to provide students with the opportunity to engage, discover, draw conclusions, and report findings with supporting information.

The reason for this research was to compare any differences between IBL methods versus traditional methods to teach science in fifth grade. To find these differences, the following research questions were asked:

1. Will the science achievement scores of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies?
2. Will the attitudes of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies?
3. Will the levels of engagement of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies?

Review of Literature

With the implementation of No Child Left Behind (NCLB) in 2001, teaching science in elementary classrooms has been on the decline. Furtado (2010) stated that science has been neglected or taught by a method where the instructor relays information to students who are given a textbook or worksheet assignment to complete. Students were sometimes allowed to find solutions to real life situations through activities completed in the lab or modeled experiments. These methods of teaching science might have been effective for test scores, but proved ineffective for increasing literacy in science. Furtado (2010), Varma, et al. (2009), and Buxton, et al. (2008) suggested that in order to increase student engagement, higher order thinking skills, and achievement, students must be instructed in an inductive process such as IBL. In implementing IBL, the teacher in Furtado's study presented a complex real-world problem for students to solve. Furtado (2010) reported that in the process of solving this real-world problem students do not just memorize facts, but they also observe, inquire, and problem-solve, which assists them in realizing the importance of the facts. In order for students to receive the maximum benefit from IBL, teachers must be informed and confident in using this method of instruction. Kazempour (2009) stated professional development (PD) would help increase teachers' knowledge and change beliefs about how their students learn and how effective their teaching is in the classroom. In order to implement IBL effectively, teachers must become comfortable with employing basic instructional methods in their classrooms and acquire a basic knowledge of subject matter. Continued research of IBL in the area of science instruction would have important implications that assist in drawing conclusions about the effectiveness of this method of instruction. Research of science instruction conducted using IBL may assist teachers in increasing students' achievement scores, and facilitate schools with the goal of meeting AYP. Kazempour (2009) asserted that research of IBL methods might reveal whether students gain a more positive attitude toward science and have higher engagement in science activities.

According to the United States Department of Education (2009), a high percentage of students moving through the United States educational system were achieving below the proficient level in science. Low performance in science placed students in the United States at a disadvantage when competing with students from other nations. Students not performing at the proficient level were unprepared for the world outside of school. The United States Department of Education (USDE) (2009) reported that in the year 2000 in the United States, 82% of 12th-grade students scored below the proficient level on the science section of the National Assessment of Educational Progress (NAEP) test ("The Facts About," 2005). The longer students stayed in the U.S. educational system, the worse they performed. Students in the fourth-grade were second in the world in science performance in 1995, but by the 12th-grade they fell to 16th place, ahead of Cyprus and South Africa and behind nearly every other industrialized nation.

The NCLB (2001) legislation prompted a variety of educational reforms, including requiring that elementary teachers acquire more knowledge and pedagogy in the areas of science content. Science teachers must use methods and programs that are supported by evidence that work (USDE, 2009). IBL is a tool that teachers use to facilitate and scaffold knowledge and experiences for students. Furtado (2010) stated that traditionally it was thought that K-4 learners were too young to learn and function within the habits of the mind of science learning and experiments. Waiting until the last year of elementary school before beginning science instruction would put students at a disadvantage. Children's natural curiosity to investigate and explore needs to be nurtured in the classroom. According to Aydeniz, Cihak, Graham, and Retinger (2012), in order to improve the quality of education and make sure that each child achieves in science, inquiry skills must be emphasized over rote memorization of facts. Aydeniz, et al. (2012) stated that using IBL facilitates students' understanding the facts, applying science concepts to real life problems, and using science reasoning to complete processes of measurement.

According to the research school's School Improvement Plan (2012), elementary students will meet all state targets in science or make significant growth in achievement. Subgroups such as Black students, students with disabilities, and SES students will meet targets in all subject areas, which includes science. The School Improvement Plan (SIP) of the research school also stated that there would be an increase in engagement and positive perceptions about school. IBL, by its very nature, will engage students in the activity and cause them to use higher order thinking to solve problems.

Furtado (2010) states that elementary teachers teach all of the subjects in school and often do not have adequate background knowledge or pedagogical skills required to teach science to the level it needs to be taught (p. 105). The National Science Education Standards (NSES) recommends inquiry as the method of teaching science. Varma, Volkmann, and Hanuscin (2009) stated that inquiry has not been a part of teacher preparation in science instruction and teachers do not feel comfortable using this method in their teaching. Buxton, Lee, and Santau (2008) revealed teachers graduating from college are neither prepared nor confident about using IBL with their students. According to Buxton et al. (2008), it is important for teachers to receive quality professional development as an essential way to improve schools in the United States. Teachers are under a lot of pressure to implement curriculum and instruction that fosters academic growth in a growing diverse population. Teachers must work with classes of students who are culturally and linguistically diverse as well as students with disabilities and who come from different socioeconomic (SES) backgrounds. Buxton et al. (2008) assert that teachers are often unprepared to teach children from diverse backgrounds and with great needs such as language differences and learning disabilities. Now with science as a requirement of AYP, teachers must learn how to teach science to achieve maximum results. In order to be confident and informed, teachers need to participate in quality professional development to enable them to learn quality methods of science instruction. Using these new methods of inquiry in science instruction may bring about the inclusion of students who are often overlooked due to learning disabilities, language differences, and socioeconomic levels.

According to Kazempour (2009), teachers are often hesitant to utilize inquiry-based methods in their classroom because they are unfamiliar with these practices. Teachers were never taught with IBL when in school, thus, it is an abstract idea to them. Kazempour (2009) asserts that in order to transform the way teachers teach in their classrooms there must be a change in the way they understand science, the learning process, their students, and effective teaching processes. Elementary level science teachers perceive other obstacles to teaching science in the classroom as a lack of time, the need to address all of the state mandated standards, and preparing students for high-stakes tests. Professional development (PD) needs to be viewed as a way to teach IBL as a method for achieving the goals set forth by the state and not as an impediment to them. Thoron and Myers (2011) state that educators need to model inquiry-based instruction, participate in in-service opportunities on IBL, use IBL curricula and lesson plans, and mentor other teachers as a strategy of facilitating IBL in the classroom. Modeling, professional development, using IBL curricula, and mentoring other teachers are sound methods for assisting teachers in learning about the use of inquiry in science.

Kazempour (2009) states that science teachers need to guide and facilitate learning and students need to take an active role in constructing their own learning experience. Assessment was also critical in this study of IBL in helping assess prior knowledge and checking student understanding throughout the learning experience. Kazempour (2009) supports the theory that there is a need for teachers to receive professional development that brings about changes in their views about what enhances the students' learning experiences in the science classroom. There must also be an opportunity for teachers to communicate after PD to share ideas, lesson plans, frustrations, and reflections. Kazempour (2009) argues that one frustration for teachers is a lack of time allowed for inquiry activities, and plans for IBL activities are scarce. A lack of funding for resources and the need to share materials is also a hindrance to IBL. Other issues teachers face includes a lack of support from the school administration and isolation from other teachers. Thus, collaboration with other teachers is a useful tool when implementing IBL. Kazempour (2009) concludes that the ultimate goal is to prepare teachers to be literate in science and effective in their practices, citing that professional development may assist in calling attention to these needs. Thoron and Myers (2011) agreed with the Kazempour (2009) study by recommending that teachers receive PD in inquiry-based instruction. Teachers using IBL instruction developed better skills with using the inquiry method and mentored other teachers in IBL. Thoron and Myers (2011) concluded that students taught with IBL scored higher on content knowledge assessments as compared to students who were taught through traditional methods.

Aydeniz et al. (2012) suggested that to ensure that all students achieve in science inquiry, skills should be emphasized over rote memory of facts. Students with learning disabilities were expected to understand and apply science concepts to situations in real life. Teachers who taught students with learning disabilities often reported they had a lack of content knowledge needed to succeed in teaching science. Kits were developed and professional development provided to assist teachers who worked with students with learning disabilities.

Kit-based curriculum has been effectively used with students in the regular classroom to increase students' learning in science. Science inquiry kits were used with students with learning disabilities to measure the effect of their learning in science. These kits allowed students with learning disabilities the chance to investigate electrical circuits and magnetism. Aydeniz et al. (2012) reported that students' knowledge of electricity improved from a baseline of 4.7% to 76% after the implementation of the IBL activity. Students' attitudes also improved from a mean score of 52.8 at the beginning of the unit to 73.0 at the conclusion of the unit (p. 199-200). IBL had a positive impact on student's attitude toward learning in science. In another study by Drake and Long (2009), fourth-grade students were presented with a problem-based science question of how could a young woman maintain the use of her lights despite frequent power outages. Students in the class assumed the role of scientists while the teacher assessed what students already knew and where they could find information needed to solve the problem. Watters and Ginns (2000) stated that IBL gave teachers greater confidence in their ability to teach science and facilitate strategies for student-centered activities. IBL students showed a deeper understanding of content in science. Kazempour (2009) recommended that IBL practices encouraged a deeper understanding of science about the real world than traditional methods. The practice of IBL is student-centered where the learning environment uses active learning in a small-group setting. Drake and Long (2009) stated the curriculum centers around problems rather than disciplines, and also concluded that the IBL group showed an increase in on task behavior (68.72%) over the comparison group (58.75%), in addition to significant growth in the IBL group's content knowledge (p. 8).

The teacher-researcher in the current study used a combination of strategies including lectures, demonstrations, worksheets, experiments, and technology. The attitude and methods of the teacher participating in the case study presented by Kazempour (2009), was very similar to the attitude and methods used by the teacher-researcher. The teacher in Kazempour's study had taken creativity out of the aspect of science and his students were seen as a class and not individuals. After implementing IBL strategies in his science classroom the unique needs and gifts students became visible to the teacher from Kazempour's study. The science teacher in this study was able to see the learning differences of his students and identified that each student had something to contribute to the class. The teacher in Kazempour's study, initially used lectures, occasional lab sheets and hands-on experiences when teaching, but after professional development, began using IBL methods of instruction. The teacher began including opportunities for students to pose questions and investigate them using science processing skills and problem solving. Kazempour (2009) asserted that by using IBL, students are doing most of the work as the teacher facilitates. Students work as collaborative teams to explore scientific problems and find solutions. Students allowed to problem solve and think critically will transfer those skills over into everyday life and into adulthood.

Liu et al. (2010), Kazempour (2009), and Thoron and Myers (2011) revealed that some research was available on the achievement of middle and high school aged students using IBL methods. However, more research is needed at the elementary level. With the implementation of NCLB (2001), the emphasis has been on subjects that contribute to AYP, such as reading and mathematics. Science now requires the same accountability for AYP, yet there is limited research on teaching methods to improve science achievement in elementary schools. Teachers in elementary schools have focused a majority of their time on teaching Reading and Mathematics and the teaching of science has not been emphasized. Students enter fifth grade at the research school with little or no exposure to science concepts. The teacher-researcher observed evidence of the students' eagerness to participate in science activities. However, science activities require funding, supplies, and planning time. The constraints of time for constructing IBL projects and a lack of money for supplies are two limitations. Teachers have little control over instructional budgets, but setting up the curriculum for IBL must take priority if students are to learn problem solving and higher order thinking skills through science. The teacher-researcher hoped to use IBL methods to improve achievement in science at the elementary level. Despite limited resources and time, IBL teaching methods may be used in science instruction in order to assist students in the use of higher order thinking skills and to make gains in science achievement.

Purpose statement. Swartz and Gess-Newsome (2008) indicated that science, as a subject of focus, has not been taught in elementary schools as intensively as in the past because of mandates to teach reading, writing, and mathematics from NCLB. In classrooms where science was taught, it most often was with a textbook, worksheets, and an occasional hands-on experiment. Students need to explore and investigate for answers. Elementary students must learn what questions to ask if they are to become competitive in the real world. Inquiry-based learning assists elementary students with acquiring higher order thinking skills by engaging them in problem solving. When properly used, IBL prepares students for solving real life situations, increases engagement in science, and skills transfer from school to problem solving in everyday situations. The findings of the current study may be of interest to all science teachers, and to administrators and school districts.

Research Questions

Research question 1. Will the science achievement scores of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies?

Research question 2. Will the attitudes of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies?

Research question 3. Will the levels of engagement of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies?

Definition of Variables

Inquiry-based science instruction. Inquiry-based science instruction is posing a problem to students and providing students with the materials to investigate and solve the problem. In the current study, one group of students participated in inquiry-based instruction. Students created the questions that needed to be answered in order to solve the problem. Students were required to read science trade books or other science picture books on the research topic in order to gather background knowledge. Materials were then provided to students for them to use in problem-solving tasks. When inquiry tasks were completed, students shared their discoveries with other members of the class. Students in the inquiry class wrote entries in their science journals about the process and their findings after each task. Journals provided the teacher with information about the students' understanding of the problem and how it could be solved.

Traditional science instruction. Traditional science instruction is the use of a science textbook, worksheets, and a weekly experiment or demonstration. In the current study, traditional methods of science instruction involved the use of a science textbook, worksheets, and a weekly experiment or demonstration. The teacher-researcher read information from the textbook to the students. Students answered questions about the science topic on a worksheet. The teacher-researcher guided students through the process of conducting an experiment, and also modeled experiments for the class to witness.

Science achievement. Science achievement is a gain in scores toward mastery of the Georgia Performance Standard (GPS). In the current study, science achievement was assessed with the use of a pre and posttest created from elements of the GPS. Achievement was also measured by the quality of journal entries written by science students.

Attitude towards science. Attitude is defined as how students think or feel about science. In the current study, attitude was measured using a teacher-created survey. Students completed the survey prior to beginning the science unit and after the completion of the science unit. Pre and post surveys were compared to measure any positive changes in attitudes toward science.

Engagement in science class. Engagement is defined as whether or not a student is on task and is actively involved in the teaching and learning activities throughout the lesson. In the current study, out of seat behavior, talking, laughing out loud, daydreaming, and playing with materials in a way they were not intended to be used during lab time were examples of students failure to be engaged. Examples of engagement were attentiveness in classroom discussion, participating in classroom discussions, completing assigned reading, and being actively involved in group work. An engagement checklist was used to record student on task engagement throughout the lessons.

Methods

Setting and Participants

According to statistics from the U.S. Census Bureau (2011), the research school in the current study was located in rural northeast Georgia and served students from kindergarten through fifth grade. In this northeastern Georgia county, the research school was one of three elementary schools, and qualified as a Title I school. The county in which the school was located had a population of 22,084 in 2009. In 2008, the per capita income was $29,131, and in 2010, 18% of people living in the county were living below the poverty level. According to the Profile of General Demographic Characteristics (2011), the demographics of the county was 87% White, 8% Black, and 4% Hispanic (pg. 1). During the 2012-2013 school year, 447 students were enrolled in the research school, of which 75 students were enrolled in fifth grade.

According to the Governor's Office of Student Achievement (2011), the research schools' demographics were 77% White, 15% Black, 6% Hispanic, and 2% multi-racial. Students in the research school who qualified for the free or reduced lunch program totaled 65%. Students in the research school who received special education services were 12%, while 5% were gifted, and 4% were students with Limited English Proficiency. According to the Governor's Office of Student Achievement (2011), 23% of students were enrolled in early intervention programs

(EIP) at the research school (Student and School Demographics section, Percentage of Enrollment, p. 1).

Research Design

The research participants were fifth-grade students (*N* = 42) in two science classes at the research school. Students were randomly assigned to fifth-grade science classes by the school administration. Convenience sampling was used to select participants from two of the 4 fifth-grade classes. Students within the classes selected for the current research were in two heterogeneously grouped regular education science classes. There were no students classified as ELL who participated in the study. The study included five students classified as special education, and six students classified as gifted.

The traditional class was the control group. Students in the traditional class (*N* = 20) included 10 females and 10 males. The number of students receiving special education services was six, while two students received gifted services.

The inquiry class was the experimental group. Students in the experimental class (*N* = 22) included 11 males and 11 females. There were no students receiving special education services, while four students received gifted services.

Students' achievement data were determined from the previous year's science section of the Georgia Criterion Referenced Competency Test (CRCT) for students who scored 800 or higher, met or exceeded the standards on the CRCT. The average score for student participants on the science section of the CRCT was 850.6. The mean score on the CRCT for the traditional group was 846.35, and the mean score on the CRCT for the inquiry group was 854.9.

The adult participant in this study was the teacher-researcher. The teacher-researcher was a fifth-grade math, social studies, and science teacher with 25 years of teaching experience, who held a master's degree in exceptional education and an additional certification in early childhood education. The teaching experience of the teacher-researcher included nine years of teaching students in exceptional education and 16 years of teaching students in the regular classroom.

Demographic and achievement scores for student participants are shown in Table 1.

Table 1. Demographic Characteristics of the Fifth Grade, Traditional Class and Inquiry Class

Characteristics	Traditional Class N = 2	Inquiry Class N =22
Gender		
Female	10	11
Male	10	11
Race/Ethnicity		
White	16	18
Black	3	3
Hispanic	1	1
Students with Disabilities	5	0
Early Intervention Program (EIP)	7	6
Gifted	2	4
Achievement		
2013 April science Score on CRCT	846.35	854.90
Standard Deviation	37.52	37.76

Intervention

This research study was conducted during the first 8-weeks of the school year. The intervention was conducted during science classes lasting 50 minutes per day, five days per week. The first 5 minutes of each class were spent reviewing of the previous day's lesson and introducing the present day's learning target. The last 5 minutes of the instructional period were used to bring closure to the lesson and assess understanding. Students in both the inquiry and traditional groups were presented with the same physical science learning targets from the Georgia Performance Standards (GPS), and required to perform the same number of experimental tasks. The teacher-researcher taught students in both the traditional and the inquiry class. Comparisons were made between students in the traditional and inquiry classes in terms of science achievement, impact of science attitudes, and engagement in science activities. The pretest, Physical Science Knowledge Assessment, (PSKA), (Appendix A) was administered to both groups during the first week of classes and prior to the implementation of the intervention. The PSKA was a Likert scale with 15 questions. Students in both groups also completed the Science Attitudes Survey, (SAS), (Appendix B) prior to beginning the unit of study. The SAS was a Likert scale with 10 questions.

The teacher-researcher hypothesized that using IBL methods to teach science may have a positive impact on student academic achievement, and also expected improvement of student attitudes toward science and growth in engagement in classroom activities through the use of IBL.

Students in the traditional class began a physical science unit during the third week of classes. The teacher-researcher guided students in a step-by-step process of structured learning experiences, presented the learning target goals and provided students with the information and definitions of terms that were required in the standards of the unit. Materials essential for experimentation were provided to student groups by the teacher-researcher. Students conducted experiments following step-by-step instructions regarding procedures and were told what data to collect. The teacher-researcher explained the concepts and responded to all questions posed by students in the traditional group. The process was repeated on various days for a minimum of three times each week over the course of a 6-week period. Science investigations were completed Monday through Thursday for the initial three weeks and Tuesday through Thursday for the remaining three weeks.

The intervention for the inquiry group began during week three of the current study. The teacher-researcher selected the curriculum content of study from the physical science section of the GPS and set the guidelines for inquiry. Students were presented with a question or problem from the standard and were instructed to investigate for the solution. Informational reading materials were provided to students in groups of four or five for the purpose of research to gain background knowledge about the problem. Students were allocated time to read materials and discuss the content. In small groups, students created questions to present to the whole class about physical and chemical changes and electricity. The teacher-researcher scaffolded instruction by guiding the students' questions and modeling information on the curriculum content. Students were provided the necessary materials to solve the problem. Students worked independently of teacher instructions by thinking about the questions, engaging in discussion with group members, and deciding how to proceed with the experiment to solve the problem. As student groups performed the inquiry tasks, the teacher-researcher circulated between groups in order to facilitate learning, but did not provide direct answers for students. When all groups had reached a consensus, a whole class discussion was conducted to share with their peers the important facts that had been identified. At the conclusion of the lesson, students wrote about what they had learned and how they solved the problem in their science journals. The procedure was repeated Monday through Thursday of each week for 6 weeks.

At the conclusion of the physical science unit, students in the traditional and the inquiry groups completed the PSKA (Appendix A) as a posttest. Scores from the posttest were compared to the pretest to assess growth in knowledge and achievement. Students in both groups were also administered the SAS (Appendix B) during week 6 to determine any change in attitudes toward science from the beginning of the current research study. Both classes participated in the study for a 6-week period.

Data Collection. In order to determine the effectiveness of using IBL strategies in science instruction for fifth-grade students, three data collection instruments were developed by the teacher-researcher.

Physical Science Knowledge Assessment (Appendix A). A pretest was created by the teacher-researcher to assess students' prior knowledge about physical science. The pretest, the Physical Science Knowledge Assessment (PSKA) was administered to students in both the traditional and inquiry groups in the first week of the 2013-2014 school year and prior to week 1 of the research study. The PSKA was used as the posttest in week 8 of the intervention. The teacher-researcher developed questions for the PSKA (Appendix A) from the Georgia Performance Standards, (GPS), (2012) for fifth-grade science, standards S5P1, S5P2, and S5P3. The teacher-researcher determined validity through a peer review team. The peer review team consisted of the assistant superintendent for curriculum instruction for the research school's school system, the academic coach at the research school, a science teacher from the fourth grade, and a science teacher from the third grade. The PSKA was administered to both classes using identical verbal instructions. The questions were rearranged on the posttest to accurately assess students' acquisition of knowledge. The data from the traditional and the inquiry groups were analyzed using descriptive statistics and a paired one-tailed *t*-test to determine if the Inquiry-Based Learning method had an impact on students' academic achievement in science.

Survey of Science Attitudes (Appendix B). The Survey of Science Attitudes (SSA) was a 10-item Likert-scale analysis of student attitudes about science learning and instruction (scored 1 = *strongly disagree* and 5 = *strongly agree*). The SSA (Appendix B) was developed by the teacher-researcher and validated by a peer review team. The peer review team consisted of the assistant superintendent for curriculum instruction for the research school's school system, the academic coach, and science teachers from the third and fourth grades at the research school. All students in the traditional and inquiry groups were asked to rate their attitudes toward science before the intervention began in week 1 of the study and again in week 7 at the conclusion of the study. The survey was used to analyze student attitudes about science prior to the intervention and at the conclusion of the intervention. Included in the survey were basic demographic questions about gender, race, and age. The data from the traditional and the inquiry groups were analyzed using descriptive statistics and a paired one-tailed *t*-test to determine whether the intervention had any effect on students' attitudes toward science.

Fieldnotes. Fieldnotes were used by the teacher-researcher to record on-task and off-task student behaviors during science investigations. The teacher-researcher noted observations of each student's behavior while monitoring student lab investigations. Fieldnotes were recorded during the lesson activities and immediately after lessons and activities ended.

Engagement checklist. The teacher-researcher used fieldnote observations to record scores on the Student Engagement Checklist (Appendix C). The scores were written on the checklist on Friday of each week for each student. Students who were fully engaged and remained on task were given a score of two. Students who were engaged in the task with very little deviation were given a score of one. The students who were frequently off task and had to be redirected back to the task were given a score of zero. Each student in the traditional class was assigned a number 1T through 25T while each student in the inquiry class was assigned a number 1I through 25I. The corresponding numbers were used by the teacher-researcher to identify students in the fieldnotes and on the engagement checklist. Fieldnotes were recorded by the teacher-researcher about comments, questions asked, behaviors, and attitudes of participating students. Behaviors noted in the fieldnotes were categorized according to themes and patterns to determine whether students in the inquiry class were more engaged in the learning process versus the level of engagement of students in the traditional class. Percentages of on-task behaviors were compared with off-task behaviors to determine whether the IBL method of teaching significantly affected students' engagement in science.

Results and Discussion

Pertinent information was gained through the data collection for the current research study about the effects of Inquiry-Based Learning in science with fifth-grade students. Due to the decline of student scores on high-stakes tests in the area of science and a lack of in-depth understanding of science among students in the United States, there was a need to research effective methods of teaching science and to collect data on which methods were most effective in teaching science to young students. Science students in the United States had lower achievement than science students of other nations, were not able to compete with students of other nations, and did not exhibit a deep understanding of subject areas in science. Traditional methods of teaching science, such as lecturing and experiments, have been effective, but further research on the effectiveness of using IBL methods to teach science to elementary students was needed. Of the four fifth-grade science classes at the research school, two classes participated in the current research study. The data collection instruments used to determine the effectiveness of using IBL for improving science instruction compared to traditional instruction were the pretest/posttest, attitude survey, engagement checklist, and fieldnotes.

The mean scores, standard deviations, and a comparison of the means for the two groups from the pretest and posttest results are provided in Table 2.

Table 2. Comparisons of Pretest and Posttest Results for Traditional Instruction and Inquiry-Based Instruction

Class	**Pretest**		**Posttest**		**Comparison**	
	M	***SD***	***M***	***SD***	***t-value***	***p***
Traditional Instruction Group	50.65	15.02	74.95	17.45	9.11	.00
Inquiry Instruction Group	51.14	14.02	78.82	15.73	9.37	.00

The results of the data analysis revealed that the science pretest scores for the traditional group were lower than the posttest scores. The science pretest scores for the inquiry group were also lower than the posttest scores. Paired samples *t*-tests indicated that both the traditional instruction group and the inquiry instruction group made significant gains from pretest to posttest.

Cohen's *d* was computed to determine the practical significance of the difference between posttest scores of the traditional instruction group and the inquiry instruction group. The treatment had a small effect (*d*=.22) on achievement scores. Students participating in traditional instruction would be expected to score 58% below a person participating in the inquiry instruction group.

The mean gain for the traditional instruction group was insignificant compared to the mean gain for the inquiry-based instruction group. The scores indicated that students who received inquiry-based instruction made minimal gains in achievement compared to students who received traditional, teacher-centered instruction. Table 3 compares the mean gain for students who received traditional instruction to the mean gain for students who received inquiry-based instruction.

Table 3. Comparisons of Traditional Instruction Group and Inquiry-Based Learning Group Gains from Pretest to Posttest

Class	**Pretest *M***	**Posttest *M***	**Gains**		
			Mean	***t-value***	***p***
Traditional Instruction Group	50.65	74.95	24.30	.88	.19
Inquiry Instruction Group	51.14	78.82	27.68	-9.83	4.63

The teacher-researcher administered a Science Attitudes Survey (SAS) prior to the intervention and again at the conclusion of the intervention. The survey was used to gather data about the overall attitudes of students toward learning science and the importance of using science in their everyday lives. Prior to the intervention, SAS results indicated that students in the traditional instruction group enjoyed learning about science. At the conclusion of the intervention, SAS results indicated that the attitudes of students in traditional instruction regarding learning about science had improved significantly. The statistical significant difference in the traditional instruction students' attitudes towards science from pre-intervention to post-intervention was in the category of enjoying learning about science, which ultimately resulted in higher student engagement. Students' attitudes about the importance of science showed a slight increase on the survey by the completion of the unit. Student's attitudes around the inquiry about science had a slightly larger increase compared to attitudes about importance of science. However, student attitudes that science is important in their understanding of the world around them showed an insignificant increase at the conclusion of the intervention. Overall, SAS results indicated that students in the traditional group ranked each question by its importance to them in the following order (a) enjoyed learning about science, (b) wanted to know about science, (c) thought science would help them understand the world, and (d) thought science was important. According to students' comments on the SAS, a majority of students in the traditional group remarked that they enjoyed doing experiments in science. The second most frequently written response on the SAS by students in the traditional group was that they liked to learn about science. A comment written by one student in the traditional group was, "I love to learn what things do." All four questions revealed positive gains in attitudes that students had about learning in science. The mean, standard deviation, and gains in attitudes from the traditional instruction students' pre- and post-intervention SAS are reported in Table 4.

Table 4. Comparison of Traditional Instruction Group Pre- and Post-Intervention Science Attitude Survey Responses

Class	Pre-Intervention Survey		Post-Intervention Survey			
	Mean	***SD***	***Mean***	***SD***	***p***	**Gain**
I enjoy learning about science.	4.37	.68	4.84	.37	.004**	.47
I think learning about science is important.	4.67	.49	4.74	.45	.25	.07
I want to know about science.	4.58	.69	4.84	.37	.07	.27
Learning more about science will help me understand the world around me.	4.68	.58	5.89	.31	.08	.21

**p*.05. ***p*<.01

Table 5 reported means and standard deviations for the SAS responses from the inquiry-based learning instruction students' pre- and post-intervention. SAS results indicated a minimal change in student attitudes over the course of the intervention in science. Students' attitudes increased slightly by the conclusion of the intervention when asked if they wanted to know about science. The mean scores did not change when students in the inquiry-based learning group were asked if they thought learning about science was important. The SAS results indicated a decrease from the pre- and post intervention results when IBL students were asked whether they liked learning about science. A decrease was observed from the pre- to posttest responses when students in the IBL group were asked whether science would help them understand the world around them.

Overall, SAS results indicated that students in the IBL group ranked each question by importance about science in the following order (a) wanted to know about science, (b) thought learning about science was important, (c) enjoyed learning about science, and (d) thought learning about science would help them understand the world around them. A positive gain was revealed in one of the four questions, and the mean score declined in two of the SAS questions. There was no statistically significant difference in the IBL instruction students' attitudes towards science from pre-intervention to post-intervention. The mean, standard deviation, and gains in attitudes from the IBL students are reported in Table 5.

Table 5. Comparison of Inquiry Instruction Group Pre- and Post-Intervention Science Attitude Survey Responses

Class	Pre-Intervention Survey		Post-Intervention Survey			
	Mean	***SD***	***Mean***	***SD***	***p***	**Gain**
I enjoy learning about science.	4.36	.79	4.32	.73	.5	-.04
I think learning about science is important.	4.38	1.16	4.38	.59	.5	.00
I want to know about science.	4.52	.51	4.57	.68	.4	.05
Learning more about science will help me understand the world around me.	4.67	.57	4.38	.92	.14	-.29

In order to determine the effect of IBL strategies on student engagement during the intervention period, the teacher-researcher implemented a Student Engagement Checklist (Appendix C). The checklist was used three times each week during the 6-week intervention period for the traditional and the inquiry groups. Students who were fully engaged and participated in all aspects of the lesson activities earned a score of two for the class period. To be considered fully engaged a student was observed paying attention in classroom discussion, participating in classroom discussions, completing assigned reading, and being actively involved in group work. Students who were engaged and participated in the lessons with no more than one redirection from the teacher-researcher earned a score of one. Students who had to be frequently redirected by the teacher-researcher to properly participate exhibited out of seat behavior, talked, daydreamed, and played with materials in a way they were not intended earned a score of zero and were examples of not being engaged in the lesson. Of the 20 students in the traditional class, 13 exhibited full engagement

63% of the time. The IBL group, however, had 22 students with 79% full engagement, which was 17 students. As shown in Table 6, students who received the IBL intervention exhibited greater engagement behaviors than students who participated in the class with traditional instruction.

Table 6. Student Engagement Results

Class	Fully Engaged	Engaged	Not Engaged
Traditional Instruction	63%	23%	14%
Inquiry-Based Instruction	79%	15%	6%

The teacher-researcher recorded fieldnotes during the intervention period to record off task behaviors of students, document comments made by students about the tasks, and record the percentage of on task behaviors exhibited by students. Data from fieldnotes indicated that students in both groups who earned a zero on the Student Engagement Checklist (Appendix C) exhibited behaviors such as talking, playing with materials, and out of seat conduct.

Fieldnotes recorded during IBL intervention indicated that students were more engaged, focused, and on task. The IBL students engaged daily in problem-solving discussions that led them to complete tasks quickly and with little redirection from the teacher-researcher. Comments such as, "This is fun," and "Oh, I see how you do it!" were noted from students in the IBL group indicating an excitement about solving a problem through discovery. The IBL students participated in more brainstorming and sharing of ideas during small group time, as students worked together as partners to solve problems. An example of a problem that students were required to solve included using a battery, light bulb, and paper clip to light the bulb. By working cooperatively, students assigned tasks to each other, for example, holding the bulb in a certain position or touching the wire in a particular area to make the bulb light up. Entries from student journals revealed a high level of understanding about science concepts. Students wrote more detailed journal entries, which indicated a higher level of understanding and engagement. Overall, a higher level of student engagement was observed in the IBL group.

Fieldnotes recorded during the traditional instruction time indicated that students did not engage in as much idea sharing about science and had to be frequently redirected back to the task and discussions. As the teacher-researcher assisted one group, other groups frequently exhibited off task and out of seat behaviors. Observations were recorded of students who played with materials inappropriately, such as making a balloon fly across the room as opposed to using the balloon to create static electricity. Students frequently did not follow directions, which resulted in a loss of instructional time. While performing a lab about chemical change, students had been instructed to perform the task once. However, it was recorded in fieldnotes that one group of students in the traditional class continued to perform the task repeatedly, which resulted in a loss of time and wasted materials. Comments such as, “This isn’t working!” and “How do we do this?” were recorded in the fieldnotes when students were not properly following directions. Although students had been assigned lab partners prior to beginning a lab, students in the traditional group frequently tried to change lab partners before the lessons started. The students who attempted to change partners and students who did not willingly participate in the lesson because they were not seated in a preferred chair, also resulted in a loss of class time. Off task behaviors were observed when students used materials for experiments in inappropriate ways such as throwing objects or bending and breaking materials. Entries in traditional students’ journals were brief and contained less detail about tasks performed in science lab. As students in the traditional group shared journal entries with the class, they provided a brief synopsis of the lesson that had been completed with little or no in depth analysis as to why they observed the results from the experiment. Overall, a lower level of student engagement was observed in the traditional group. Based on the SAS and fieldnotes, the teacher-researcher determined that students participating in the IBL intervention exhibited a higher level of engagement and on task behaviors.

Conclusions

The purpose of the current research study was to determine if the use of Inquiry-Based Learning (IBL) instruction in science would improve achievement, attitudes, and engagement in fifth-grade students. The teacher-researcher compared the results of 6 weeks of instruction with the use of IBL and the use of traditional instruction by administering the Physical Science Knowledge Assessment (PSKA), and a Student Attitudes Survey as a pretest and posttest to the IBL and traditional instruction groups. A Student Behavior Checklist and fieldnotes were used to document student engagement. By the end of the 6-week unit of study, students in the IBL group showed an increase in academic achievement, attitudes, and engagement.

Research question one stated, will the science achievement scores of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies? The PSKA revealed that the IBL group showed a gain between the pretest and the posttest. While the students in the group that received the IBL intervention showed gains, the difference was not statistically significant. The results were consistent with results reported by Kazempour (2009), Aydeniz et al. (2012), and Drake and Long (2009) who found that students taught with IBL methods scored higher on content knowledge assessments as compared to students taught in a traditional manner.

Research question two stated, will the attitudes of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies? Both the Science Attitudes Survey (SAS) and fieldnotes revealed that with the use of IBL methods there was an insignificant decrease in positive attitudes toward science. The attitudes survey revealed that attitudes about enjoying science decreased by 4% after using IBL interventions. Student attitudes toward learning about science helping them understand the world around them decreased by 29% as revealed on the SAS. The mean scores in attitudes on the importance of learning about science showed no change, and the desire to know about science showed only a slight increase of 5%. The decrease observed in attitudes of students on learning about science is in contrast to the research by Aydeniz et al. (2012) where it was reported that student attitudes improved and that IBL had a positive impact on student attitudes. The teacher-researcher noted in the fieldnotes that students complained about writing in journals about their IBL experiences in the science lab, did not always like being paired with certain students as lab partners, and did not enjoy reading and researching information about topics in science by themselves.

Research question three stated, will the levels of engagement of fifth-grade students increase with the implementation of inquiry-based learning strategies as compared with traditional instructional strategies? Data from the Student Engagement Checklist revealed that students in the IBL group were engaged and on task 16% more often than students in the traditional group. Although the IBL group showed a greater level of engagement than the traditional group, the difference was not statistically significant. The data from the current study validates the research question of whether IBL instruction results in greater engagement of students during science. The research findings of the current study were consistent with the literature where Drake and Long (2009) found an increase of on task behavior in students in IBL classes.

Fieldnotes recorded by the teacher-researcher also provided engagement data, which revealed that students asked daily if they were going to work in the science lab. When assigned a task to complete, students involved in inquiry were focused more often on resolving the problem posed in the task than those who had traditional instruction and teacher direction. Students in the IBL group worked cooperatively with other group members to research the task and find a resolution to the assigned problem. According to the fieldnotes, students exhibited in seat behaviors and helped each other to understand what steps were being taken in their group to complete the task. IBL student's brainstormed ideas for solutions and as a whole class shared their ideas about the order of steps to perform in the activity. Students in the IBL group made comments such as, "I will hold this wire and you hold the battery and you can hold the light bulb." These kinds of comments revealed that the students remained on task, assigned tasks within the group, and completed the task with very little assistance from the teacher-researcher.

Significance/Impact on Student Learning

According to research reported by Liu, Lee, and Linn (2010), science scores for students in the United States have been on the decline for decades. Instruction in science has not been an area of emphasis, and the United States has fallen behind other countries of the world in science achievement. The research school's SIP (2012) goal for science indicated that students scoring in the meets or exceeds performance level in science achievement on the CRCT would increase by 5%. The current research study intervention did result in an increase in science scores from the pretest to the posttest for students in the IBL group, although the increase in scores was not significant. In post intervention surveys, a majority of students stated "doing experiments" was the most enjoyable part of learning in science. Learning, attitude, and engagement increased as a result of participating in hands-on experimentation and inquiry. Students in the IBL group of the present study had greater scores in achievement and higher levels of engagement. PSKA results indicated an improvement in achievement from 74.95 to 78.82. The IBL class exhibited engagement in lessons 79% of the time as compared to the traditional class that was engaged in lessons 63% of the time. Student engagement was positive; indicating that the IBL method provided support for the hypothesis that student engagement in science would increase.

Factors Influencing Implementation

Several factors influenced the outcome of the current research to varying degrees. In both the IBL and Traditional classes, six participants were absent one or more days due to illness, discipline, and unknown issues. In the IBL group, one participant was absent one-third of the intervention time, while another was absent four days. Replication of the discussions and participation during the IBL lessons for students who were absent was not possible. Absent students had gaps in their knowledge because they did not have access to discussions, reviews, and experimentation with their fellow students. The results may have been influenced substantially if all students had been present for all classes.

In both the IBL and traditional groups, there were students who had displayed attention deficits by exhibiting behaviors that revealed their distractibility. The fact that these students were frequently off task and displayed difficulty in attending to the task at hand was evident in their achievement scores on the posttest and on the engagement checklist. Not only did the behaviors of the students who were off task affect their achievement, but it also affected the ability of those in their lab groups to attend to the research, organize materials, and perform inquiry tasks in the science lab.

Although a calendar of events and lessons were prepared by the teacher-researcher, several unscheduled occurrences interfered with the current study. The teacher-researcher was unable to attend class on two days. On these days, participants were not able to participate in inquiry or experimentation and observations were not performed. Another interference was the scheduling of a local law enforcement officer to present to the classes an educational program on drug awareness, which replaced one day of the study. Although there were several unforeseen events that disrupted the schedule of the teacher-researcher, adjustments to the instructional calendar provided the additional instructional time required to complete the study. The disruptions were not significant enough to affect the study results.

Implications

The implications of this study are important for the research school because of the positive impact in achievement that resulted in the IBL group and the percentage of engagement students exhibited. The findings of this study supported the research regarding positive gains in the engagement of students participating in IBL. The teacher-participant has used experimentation in classes for over a decade, but has been hesitant to relinquish control of the inquiry to the students. Using this strategy revealed that allowing students to engage, discover, draw conclusions and report their findings increased their abilities to reason and problem solve. As students participated in IBL, they gradually learned to investigate, reason, and organize knowledge and then to incorporate that knowledge into their understanding without intervention from the teacher-participant. The current research study challenged the teacher-researcher to relinquish control of the science lesson content information and allow students to control participation in their own acquisition of knowledge and develop higher-order thinking skills. During the intervention, the teacher-researcher became a facilitator, and not merely a distributor of scientific facts and methods on how to perform experiments.

The findings from the current research study have implications beyond the grade level at which the current research was performed. The teacher-researcher sought permission to share the results of the current study with members of the faculty at the research school during a faculty meeting or professional development day. The teacher-researcher also intended to share the results of the study with other schools in the county during professional development. Using methods of inquiry would be beneficial to students in all grade levels for increasing achievement and implementing higher-order thinking skills and assists in assimilating these skills in other areas of study such as social studies, mathematics, and language arts where they must make connections and relate information to themes in their studies. IBL is a system of learning that supports the development of problem solving and critical thinking that transfers from school into everyday activities.

There were many implications for the teacher-researcher from the current research study, which influenced teaching practice and pedagogy. The importance of allowing students the opportunity to investigate problems and reach their own conclusions by using scientific processing skills was magnified in the current study. The teacher-researcher realized the importance of being a facilitator and allowing students to participate in the inductive process of reasoning. The materials were provided and the problem presented by the teacher-researcher in the role of facilitator, however the students conducted the majority of the work. The students were given the opportunity to construct questions, develop concepts, and inquire as to how to accurately solve a problem. The teacher-researcher realized that not only did achievement increase, but also discipline problems decreased when IBL methods were utilized due to the higher level of engagement of students.

Limitations

Although there was a positive impact on student achievement and engagement, a few limitations must be addressed. The participant convenience sample was composed of a relatively small number of students. The significance of the impact of the intervention may have been different had there been a larger sample of participants. The data were narrow because of so few participants observed in the present study. The two classes differed in the numbers of students with disabilities and the number of students labeled as gifted. There may have been a different outcome had the two class populations been more similar.

The length of time for the study was another limitation. The study was performed over a period of six weeks, which was not a significant amount of time to measure extensive changes during the current research. If the current research study had continued throughout the entire school year, additional pre- and posttests, and the CRCT scores could also have served to provide data for increases in student achievement.

A further limitation of the study was having only one teacher-researcher implementing the study. Another participant may have helped to reduce teacher bias with fieldnotes by conducting additional observations on engagement and by assisting with tallying behaviors on the student engagement checklist. Although the PKSA and the SAS were quantitative and were easily measured, the student behavior checklist and fieldnotes were qualitative and could unintentionally have been subjected to bias.

Further research is needed to investigate whether the intervention may significantly increase achievement, attitudes, and engagement over a longer period of time and with larger groups of students. Additionally, it would be interesting to observe whether students who were given the opportunity to use IBL strategies in science began to use them in other areas of study. Further studies may investigate whether the use of higher-order thinking skills increased in students, and whether there was a transfer of the use of critical thinking to real-world situations.

References

Aydeniz, M., Cihak, D., Graham, S., & Retinger, L. (2012). Using inquiry-based instruction for teaching science to students with learning disabilities. *International Journal of Special Education, 27*(2), 189-206.

Buxton, C., Lee, O., & Santau, A. (2008). Promoting science among English language learners: Professional development for today's culturally and linguistically diverse classrooms. *Journal of science Teacher Education, 19*, 495-511.

Drake, K., & Long, D. (2009). Rebecca's in the dark: A comparative study of problem-based learning and direct instruction/experiential learning in two 4th-grade classrooms. *Journal of Elementary science Education, 21*(1), 1-16.

Furtado, L. (2010). Kindergarten teachers' perceptions of an inquiry-based science teaching and learning professional development intervention. *New Horizons in Education, 58*(2), 104-120.

Governor's Office of Student Achievement. (2011). *2010-2011 Report Card*. Retrieved from http://gaosa.org/Report.aspx

Kazempour, M. (2009). Impact of inquiry-based professional development on core conceptions and teaching practices: A case study. *science Educator, 18*(2), 56-67.

Levy, A., Pasquale, M., & Marco, L. (2008). Models of providing science instruction in the elementary grades: A research agenda to inform decision makers. *science Educator, 17*(2), 1-18.

Liu, O., Lee, H., & Linn, M. (2010). Multifaceted assessment of inquiry-based science learning. *Educational Assessment, 15*, 69-86.

Marshall, S. (2010). Re-imagining specialized STEM academies: Igniting and nurturing decidedly different minds, by design. *Roeper Review, 32*, 48-60.

Miller, H., McNeal, K., & Herbert, B. (2010). Inquiry in the physical geology classroom: Supporting students' conceptual model development. *Journal of Geography in Higher Education, 34*(4), 595-615.

National Center for Education Statistics, (2012). *The Nation's Report Card: science 2011* (NCES 2012-465). Institute of Education science. U.S. Department of Education, Washington, DC.

School Improvement Plan. (2012). Available from the County Board of Education, GA.

Swartz, R., & Gess-Newsome, J. (2008). Elementary science specialists: A pilot study of current models and a call for participation in the research. *Proquest Education Journals, 17*(2), 19-30.

Thoron, A., & Myers, B. (2011). Effects of inquiry-based agriscience instruction on student achievement. *Journal of Aricultural Education, 52*(4), 175-187.

U.S. Census Bureau. (2010). State and county quick facts. Retrieved from http://quickfacts.census. gov/qfd/states/13/13303.html.

United States Department of Education. (2009). *The facts about science achievement*. Retrieved from http://www.ed.gov/nclb/methods/science/science.html.

U.S. Department of Education. (2011). *National center for education statistics, national assessment of educational progress (NAEP), science assessment*. Retrieved from http://nces.ed.gov/nationsreportcard/naepdata/.

Varma, T., Volkmann, M., & Hanuscin, D. (2009). Preservice elementary teachers' perceptions of their understanding of inquiry and inquiry-based science pedagogy: Influence of an elementary science education methods course and a science field experience. *Journal of Elementary science Education, 21*(4), 1-22.

Watters, J., & Ginns, I. (2000). Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of science Teacher Education, 11*(4), 301-321.