IMPACT OF INTEGRATED SCIENCE AND ENGLISH LANGUAGE ARTS LITERACY SUPPLEMENTAL INSTRUCTIONAL INTERVENTION ON SCIENCE ACADEMIC ACHIEVEMENT OF ELEMENTARY STUDENTS

by

Jamar Terry Marks

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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ABSTRACT

The purpose of this quasi-experimental, nonequivalent pretest-posttest control group design study was to determine if any differences existed in upper elementary school students' science academic achievement when instructed using an 8-week integrated science and English language arts literacy supplemental instructional intervention in conjunction with traditional science classroom instruction as compared to when instructed using solely traditional science classroom instruction. The targeted sample population consisted of fourth-grade students enrolled in a public elementary school located in the southeastern region of the United States. The convenience sample size consisted of 115 fourth-grade students enrolled in science classes. The pretest and posttest academic achievement data collected consisted of the science segment from the Spring 2015, and Spring 2016 state standardized assessments. Pretest and posttest academic achievement data were analyzed using an ANCOVA statistical procedure to test for differences, and the researcher reported the results of the statistical analysis. The results of the study show no significant difference in science academic achievement between treatment and control groups. An interpretation of the results and recommendations for future research were provided by the researcher upon completion of the statistical analysis.

Keywords: academic achievement, elementary, literacy, supplemental instructional intervention, science, reading, English language arts.

Dedication

I would like to dedicate this project to anybody with a goal or dream greater than anything they ever thought was possible to achieve in their lifetime. I encourage you to stay positive, motivated, and confident in your ability to achieve that goal or dream.

I would also like to dedicate this project to my parents, John and Kathleen, my twin brother John, Jr, and my younger brother Jajuan. Through all the trials and tribulations that we experienced as a family, we continued to move forward and stand strong with one another in the spirit of sacrifice and prosperity. I know at times it appeared as if I were disconnected from you, but know that I am thankful for you, and that I love you eternally. To Zayleigh, the first born of hopefully many more nieces, nephews, and, hopefully, children of my own to come, remember always to believe in yourself and never let the circumstances surrounding you prevent you from achieving your goals. You are kings and queens in the eyes of God. This achievement is for all of us.

Acknowledgment

I would like to express my sincerest thanks to Dr. Jessica Talada, my dissertation chairperson. You took a chance and believed in me even though you knew nothing about me or my circumstances and ability to complete this dissertation. You have an open mind and a kind heart, which I will admire forever, thank you!

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I want to give a sincere thank you to all the education professionals who made an investment in me and my dream to make an impact in our field of study. I absolutely would not have accomplished this goal without you, thank you! I want to give a sincere thank you to all the people who took a chance on me and believed in me even when I did not believe in myself. To Lyndsey Smith, you remained by my side through the darkest hours and most challenging events during this journey, despite any situations or circumstances that may arise between us, I am forever thankful for you! To Ms. Cheryl Blandon, you provided the recommendation that allowed me access into the doctoral program at Liberty University, I am forever thankful for you.

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List of Abbreviations

Adequate Yearly Progress (AYP)

Analysis of Covariance (ANCOVA)

Common Core State Standards (CCSS)

Elementary and Secondary Education Act of 1965 (ESEA)

Georgia Department of Education (GaDOE)

Georgia Milestones End-Of-Grade Assessments (GMEOGA)

Georgia Performance Standards (GPS)

Georgia Standards of Excellence (GSE)

Integrated Science and English Language Arts Literacy Skill Supplemental Instructional Intervention (ISLES)

Kindergarten through 12th grade (K-12)

Next Generation Science Standards (NGSS)

No Child Left Behind Act of 2001 (NCLB)

Race to the Top (RT3)

Science, Technology, Engineering, and Mathematics (STEM)

CHAPTER ONE: INTRODUCTION

Overview

In this chapter, the researcher provided a rationale for the relevance of this study to the historical, social, and contemporary issues related to the topic. The information in this chapter provides context for the purpose and significance of this study. The contents of this chapter include the background, historical, social, and theoretical context, problem statement, significance of the study, research questions, and definitions.

Background

Science is a core content area within the larger framework of the traditional Kindergarten-12th grade (K-12) education continuum (Chen, 2009). Science is also recognized as a component within the group of technology, engineering, and mathematics (STEM) (Chen, 2009). The United States is transitioning toward an information and service-based STEM economy (Pinnell et al., 2013). The transition emphasizes that the United States needs to prioritize a focus on science education beginning at the elementary school level (Conley, 2014; Elementary and Secondary Education Act of 1965 [ESEA, Pub. L. 89-10], 2012; Obama, 2009; Provasnik et al., 2012, 2016). Pinnell et al. (2013) declared that focusing on science education, beginning at the elementary school level, was essential to long-term success in STEM. The focus should be aimed to address longitudinally stagnant science academic achievement and a concurrently dwindling American workforce prepared to participate in STEM post-secondary fields of study and jobs (Conley, 2014; GaDOE, 2015c, 2016e; Holdren, Marrett, & Suresh, 2013; Kelly et al., 2013; Miller, 2010; National Science Board, National Science Foundation [NSB, NSF], 2016; Obama, 2009; Provasnik et al., 2012; Pub. L. 89-10).

Priorities continue to escalate for interventions to support elementary science education in K-12 schools. Research indicates that elementary schools had become accustomed to focusing on reading and math education from NCLB's accountability measures era (Griffith & Scharmann, 2008; Miller, 2010; Penuel & Fishman, 2012). The focus on reading and math education has resulted into diminishing instructional time, resources, and capacity for science education (Griffith & Scharmann, 2008; Miller, 2010; Penuel & Fishman, 2012). Furthermore, pressure continues to escalate for interventions to address the gender gap and under-representation of females in STEM.

Research indicates that instructional strategies, gender bias, and gender equity, beginning at the elementary school level, impact science academic achievement (Hughes, Nzekwe, & Molyneaux, 2013; Ramsey, Betz, & Sekaquaptewa, 2013; Shanahan & Shanahan, 2012; Teo, 2014; Wyss, Heulskamp, & Siebert, 2012). Research also indicates that instructional strategies, gender bias, and gender equity, beginning at the elementary school level, impact attitudes, enthusiasm, motivation, and self-esteem in female student decision-making processes for participation in post-secondary STEM fields of study and jobs (Hughes et al., 2013; Ramsey et al., 2013; Shanahan & Shanahan, 2012; Teo, 2014; Wyss et al., 2012).

The implications from the lack of focus on science education, particularly at the elementary school level, garnered the attention of educational stakeholders (i.e., legislators, school administrators, teachers, researchers, and parents) (Banilower et al., 2013; Obama, 2009; Romance & Vitale, 2012). Research in the K-12 science education domain, particularly at the elementary level, has been aimed to address the ramifications of historical and contemporary factors, which affect science education. The aim has been to impact longitudinally stagnant science academic achievement positively and a concurrently dwindling American workforce prepared to participate in STEM post-secondary fields of study and jobs (Conley, 2014; Holdren et al., 2013).

Historical Context

Several historical factors, largely related to policies in-line with the No Child Left Behind Act (NCLB, Pub. L. 107-110), have affected instructional time, resources, and capacity for science education in elementary schools (Ozel & Luft, 2013). Challenges with instructional time, resources, and capacity for science education at the elementary school level have subsequently impacted students' science academic achievement (Ozel & Luft, 2013). NCLB influenced a diminished focus on science education regarding curricular demands for the other progress monitored subjects (i.e., reading and math) (Johnson, 2007; Levy, Pasquale, & Marco, 2008). Beginning in 2007, under NCLB, science as a content area was mandatory for testing but was not required by the Unites States federal government to be included in Adequate Yearly Progress (AYP) statistics (Johnson, 2007; Judson, 2013). The voluntary inclusion of science assessment statistics within AYP subsequently led to weakened stances on effectively teaching science (Johnson, 2007; Judson, 2013).

During the years between 2009 and 2012, President Obama, with educational policy and political leaders, responded to scrutiny in K-12 science education (Conley, 2014; Obama, 2009). The President and government officials supported the importance of STEM education and programs with legislation and grants such as Race to the Top (RT3) and the Educate to Innovate: Campaign for Excellence in STEM (Conley, 2014; Obama, 2009). In 2012, the United States Congress reauthorized the ESEA, which was a fundamental shift away from policies in-line with NCLB. The reauthorization moved educational assessments toward measuring student growth and college and career readiness across reading, math, social studies, and science rather than a focus on minimum competency achievement in reading and math under AYP (DeLuca & Bellara, 2013; Jones & King, 2012; Pub. L. 89-10). The ESEA's reauthorization also allowed states to apply for waivers from certain aspects of NCLB in agreement that they would adjust state-adopted policies to monitor academic achievement in all content areas (DeLuca & Bellara, 2013; Pub. L. 89-10). With the reauthorization of the ESEA came the reawakening of science research and an emphasis on instructional practices to help students develop proficiency within science content areas and STEM within the K-12 education continuum (Next Generation Science Standards [NGSS]: Lead States, 2013; Obama, 2009; Pub. L. 89-10; Quinn, Schweingruber, & Keller, 2012).

Social Context

The United States transition from a manufacturing-based economy toward an information and service-based STEM economy established a critical need for a proficiently educated workforce to participate in the STEM jobs market (Pinnell et al., 2013). Moreover, a critical need exists for a proficiently educated workforce that extensively targets, recruits, and retains female participants as they have comparatively disengaged from post-secondary STEM fields of study and jobs (Nnachi & Okpube, 2015; Shanahan & Shanahan, 2012; Stout, Dasgupta, Hunsinger, & McManus, 2011; Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012; Walters & McNeely, 2010). The United States needs to promote possibilities for its K-12 student populations to attain relevant STEM skills if the country seeks to maintain a realization as pioneers of innovation in an information and service-based STEM global economy (Conley, 2014; Holdren et al., 2013; Pinnell et al., 2013).

Within the K-12 education continuum, however, a problem has been that science education at the elementary school level has generally been observed as an ever-changing instructional practice rather than a nonnegotiable part of a traditional K-12 education (Century, Rudnick, & Freeman, 2008; Judson, 2013; Lee, Deaktor, Hart, Cuevas, & Enders, 2005). The consequences for the lack of focus on science education, particularly at the elementary school level, lead to an alarming trend of longitudinally stagnant K-12 science academic achievement (GaDOE, 2015c, 2016e; Kelly et al., 2013; NSB, NSF, 2016; Provasnik et al., 2012). Longitudinally stagnant K-12 science academic achievement could also be linked to a diminishing American workforce prepared to participate in STEM post-secondary fields of study and jobs (Conley, 2014; Obama, 2009; Pub. L. 89-10).

Theoretical Context

Acknowledging challenges with instructional time, resources, and capacity for science education indicates educators need to use effective instructional strategies or interventions to promote the learning of abstract science concepts and content (Fang & Wei, 2010; Johnson, 2007). The instructional strategies or interventions should be aimed to increase science academic achievement particularly at the elementary level of the K-12 education continuum (Fang & Wei, 2010; Johnson, 2007). Researchers have found that inquiry-based learning was an effective research-based instructional model that encompassed first degree (hands-on), second degree (text-based), third degree (literacy skills) investigation activities in education (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Fang & Wei, 2010).

Integrated English language arts literacy and science instruction are research-based instructional strategies that share a direct connection to inquiry-based learning through the third degree of investigations (Cervetti et al., 2012; Fang & Wei, 2010). Integrated science and English language arts literacy skill instruction requires students to demonstrate understanding of content through inquiry by communicating learning through reading, writing, and speaking literacy skills (third degree) during learning (Cervetti et al., 2012; Fang, 2013; Fang & Wei, 2010; Pearson, Moje, & Greenleaf, 2010).

Various researchers have studied the impact of implementing integrated science and English language arts literacy instruction deployed through a variety of instructional delivery models (i.e., supplemental, replacement, augmented) in relation to traditional-based (i.e., business-as-usual, conventional, customary) science instruction across the K-12 education continuum (Cervetti et al., 2012; Ødegaard, Haug, Mork, & Sørvik. 2014; Romance & Vitale, 1992, 2012; Spear-Swerling & Zibulsky, 2014; Vitale & Romance, 2012). The integrated science and English language arts literacy instruction were proven to be effective in increasing academic achievement in science (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 1992, 2012; Spear-Swerling & Zibulsky, 2014; Vitale & Romance, 2012).

Problem Statement

In elementary schools, the condition of science education is fragile (Sandholtz & Ringstaff, 2011). The fragility is partially related to elementary school science educators who face the challenges of diminishing instructional time, resources, and capacity, while attempting to increase student interest and academic achievement in science (Bell, Lewenstein, Shouse, & Feder, 2009; Fang, 2013). Contemporary research exists on interventions that expand upon integrated science and English language arts literacy skill instruction for science education at the elementary school level. One research-based intervention completely replaced traditional reading/language arts instruction in grades 3 to 5 with integrated science and English language arts literacy instruction (Romance & Vitale, 2012). Another research-based intervention complemented traditional reading/language arts instruction with integrated science and English language arts literacy instructional activities in grades K-2 (Vitale & Romance, 2012). Similarly, Cervetti et al.'s (2012) study included 4th-grade treatment group teachers who provide integrated science and English language arts literacy instruction by replacing traditional science classroom instruction, traditional literacy instruction, and district-adopted instructional materials. Meanwhile, the control groups teachers provided traditional science classroom instruction and traditional literacy instruction using only district-adopted instructional materials.

Little contemporary research exists, however, on integrated science and English language arts literacy skill instruction as a supplemental instructional intervention strategy in conjunction with traditional science classroom instruction at the upper elementary level of the K-12 education continuum. The problem for this study was a gap in the literature existed on the addition of integrated science and English language arts literacy skill supplemental instructional intervention (ISLES) in conjunction with traditional science classroom instruction in upper elementary grades. The purpose of this study was to determine the impact of ISLES in conjunction with traditional science classroom instruction on science academic achievement at the upper elementary school level.

Purpose Statement

The purpose of this quantitative quasi-experimental pretest-posttest control group design study was to analyze for any difference in science academic achievement in students instructed using ISLES in conjunction with traditional science classroom instruction while controlling for prior academic achievement. The sample population came from previously intact 4th-grade homeroom classes within an urban elementary school located in the southeastern region of the United States. The independent variables were types of instruction. The independent variable, type of instruction, was generally defined as traditional and/or integrated content area instruction based on state adopted content standards through instructional lesson plans during school assigned master scheduled or nonmaster scheduled periods. The dependent variable, academic achievement, was archived Spring 2016 Georgia Milestones End-of-Grade Assessments (GMEOGA) for science. The statistical control variable, prior academic achievement, was archived Spring 2015 GMEOGA for Science.

Significance of the Study

Elementary school educators reported they used supplemental instructional interventions activities to teach science at the elementary school level because of challenges with instructional time, resources, and capacity (Banilower et al., 2013). In the 21st century, reform-based materials in conjunction with instructional interventions have been in place to improve science instruction at the elementary level, but there needed to be a determination as to whether the wide range of interventions increases science academic achievement (Penuel & Fishman, 2012). The research demonstrated that ISLES increased science academic achievement, particularly at the elementary level, by innovatively taking advantage of instructional time, resources, and capacity (Carney & Indrisano, 2013; Krajcik & Sutherland, 2010; Riegle-Crumb et al., 2015; Robertson, Dougherty, Ford-Connors, & Paratore, 2014; Spear-Swerling & Zibulsky, 2014; Webb & Rule, 2012). The research indicated that ISLES, as a complementary research-based instructional strategy, could increase science academic achievement (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 2012; Vitale & Romance, 2012). In addition, the research demonstrated that elementary school educators lacked instructional capacity for science education and confidence in commercial science textbook materials, (Banilower et al., 2013; Foster, 2006; Judson, 2013; Sandholtz & Ringstaff, 2011).

This research study may assist educational stakeholders with identifying whether ISLES could complement, not disrupt, master-scheduled traditional science classroom instruction time and instructional delivery models at the upper elementary level of the K-12 education continuum. This research study possibly informs principals on the usefulness of providing additional time allotments for science instruction during the total contact time with students during the school day at the upper elementary level of the K-12 education continuum (Penuel & Fishman, 2012). This research study could assist educational stakeholders with identifying and adopting instructional frameworks and programs that promote ISLES in conjunction with traditional science classroom instruction to increase science academic achievement at the upper elementary level of the K-12 education continuum (Miller, 2010; Penuel & Fishman, 2012).

Research Question

The research questions for this study include the following:

RQ1: Does the addition of an 8-week supplemental curricular intervention to traditional instruction make a difference in fourth-grade student achievement scores?

Null Hypothesis

H_{o1}: There is no significant difference among the student achievement scores in science of fourth-grade students who are provided either traditional curricular instruction plus an 8-week supplemental curricular intervention or solely traditional curricular instruction while controlling for prior achievement.

Definitions

1. *Academic Achievement* – The attainment of facts or skills through cognitive processing as quantified by formative, summative, or standardized assessments (Ferrara, Svetina, Skucha, & Davidson, 2011).
2. *Adequate Yearly Progress* (AYP) – A set of performance indicators that are informed by student attendance, academic achievement and participation on criterion-referenced

assessments in student subcategories including but not limited to English language learners, students with disabilities, and economically disadvantaged (Thompson, Meyers, & Oshima, 2011).

3. *Curriculum* – Standards-based content area facts or skills instructed by educators and requisite for student learning (Quinn et al., 2012).
4. *Georgia Milestone End-of-Grade Assessments* (GMEOGA) – A criterion-referenced standardized test that measures the proficiency of students' acquisition of knowledge and skills outlined by state-adopted content standards (GaDOE, 2015a)
5. *Instruction* – Guidance strategies and educational task used during learning to advance student mastery of content area curriculum standards (Quinn et al., 2012).
6. *Instructional Intervention* – A research-based teaching method, strategy, or program that increases understanding on the state of educational practices that advances academic achievement (O'Donnell, 2008).
7. *Integrated Instruction* – The conjoining of separate fields of study during the learning experience that encompasses a concurrent learning experience in those respective fields (Schleigh, Bosse, & Lee, 2011).
8. *Science, Technology, Engineering, and Mathematics* (STEM) – STEM is a subfield of academic disciplines, which broadly defines and categorizes major fields of study within learning institutions and job descriptions (Chen, 2009).
9. *Traditional Based Education* – A teacher-centered, textbook-focused instructional approach to learning subject specific curriculum during pre-established time periods delivered within approximately 190 school days per calendar school year where students

earn performance grade ratings and grade point averages, and are administered standardized assessments (Silva, White, & Toch, 2015).

10. *Traditional Science Classroom Instruction* – Teacher-created science lesson plans and instructional activities based on adopted science content standards and curriculum instructed to students during master scheduled instructional periods (Ornstein & Hunkins, 2014).

CHAPTER TWO: LITERATURE REVIEW

Overview

In this chapter, the researcher provides a review of the body of literature related to the topic of this study. The information in this chapter provides context for the theoretical framework and gap in the literature in which this study is situated. The contents of this chapter include an introduction, theoretical context, related literature, and a summary.

Introduction

Progress in science education and STEM are essential for a nation's viability in the 21st century global economy (Conley, 2014; Holdren et al., 2013; Pinnell et al., 2013). Success for students in science education at the elementary school level could be connected to positive gains in future participation in STEM fields of study and jobs (Cheryan et al., 2013; Diekman et al., 2016; Robnett & Leaper, 2013; Wyss et al., 2012). Researchers have identified that at the elementary school level, science education had failed to obtain a pronounced and perpetual role in curriculum and instruction (Miller, 2010). Researchers suggested science education struggled to be recognized as a nonnegotiable core content area within the larger framework of a traditional K-12 education (Century et al., 2008; Miller, 2010). Researchers have found that instructional time, resources, and capacity at the elementary school level have been focused on reading and math and not on science education (Banilower et al., 2013; Century et al., 2008; Eidietis & Jewkes, 2011; Griffith & Scharmann, 2008; Johnson, 2007; Judson, 2013; Levy et al., 2008; Miller, 2010; Pearson et al., 2010; Sandholtz & Ringstaff, 2011; Sikma & Osborne, 2014).

With the challenges to science education in elementary schools and significance of STEM instruction to the global economy, a progressive, inquiry-based approach potentially helps address issues and concerns with longitudinally stagnant science academic achievement and projected STEM job growth in the future (Cervetti et al., 2012; Fang & Wei, 2010). Theories suggest a strategy to address the challenges with instructional time, resources, and capacity for science education in elementary schools could be to provide integrated inquiry-based learning intervention (Casteel & Isom, 1994; Cervetti et al., 2012; Fang & Wei, 2010; Krajcik & Sutherland, 2010; Romance & Vitale, 1992, 2012; Vitale & Romance, 2012). All the research reviewed in this chapter for this study can only help broaden and inform the focus toward education reform and finding intervention strategies to increase science academic achievement, and enthusiasm, motivation, and attitudes toward post-secondary STEM fields of study and jobs.

Theoretical Context

The theoretical context of this study corresponds to inquiry-based learning of John Dewey's experiential learning theory developed during the progressive education movement (Barrow, 2006; Dewey, 1910, 1938). Dewey's (1916, 1938) experiential learning theory emphasizes "learning by doing" (Cremin, 1959, p. 163). Experiential learning occurs through varied experiences and purposeful social responsibility (Conner & Bohan, 2014). John Dewey is widely considered as the originator of the progressive education movement (Conner & Bohan, 2014; Cremin, 1959; George, 2011). The progressive education movement began in late 19th century from direct opposition to traditional pedagogical methodologies (Cremin, 1959). Dewey championed the progressive education movement with scholarly articles, which connected science education to democracy, schools, and society (Dewey, 1907, 1910).

John Dewey endorsed the progressive education movement with his definitive work, *Democracy and Education* (Dewey, 1916). Progressive education is rooted in learning through experiences, which is the opposite of rote learning found in traditional education practices (Conner & Bohan, 2014). Supporters of progressive education argue that academic achievement and purposeful learning are not mutually exclusive of each other (George, 2011). Furthermore, supporters believe that student perceptions of the relevance of learning within a content area to their individual lives cultivates purposeful learning experiences (George, 2011). Progressive education focuses attention on a student-centralized, topic-centralized methodology of learning (Conner & Bohan, 2014). Progressive education also draws attention to experiential programs of study and a vital evaluation of society (Conner & Bohan, 2014). The progressive education movement was guided by philosophical traditions of pragmatism (Hall, 2013).

John Dewey is acknowledged as the foremost pragmatic thinker during the twentieth century (Brick, 2008). The objective of John Dewey's philosophy of pragmatism was to problem solve societal challenges with science education based on predictive, action-oriented, practical principles (Hall, 2013). Pragmatism in science education with experiential learning theory and inquiry-based learning shares a connection to integrated curriculum and instruction through progressive education principles (Conner & Bohan, 2014; Cremin, 1959; Garrison, 1995; George, 2011; Hall, 2013; Hildebrand, Bilica, & Capps, 2008). Progressive education emphasizes problem solving societal challenges in science with predictive, action-oriented, practical education experiences (Cremin, 1959; Taatila & Raij, 2012).

In 1938, Dewey proposed his experiential learning theory with the publication of his scholarly work, *Experience and Education*. Dewey identified two principles for the characteristics of experiential learning. The two foundational principles of experiential learning, which were based on interaction and continuity, are summarized as the transaction of experiences among the person and environment and quality of experiences leading to connected successive experiences (Dewey, 1938; Wojcikiewicz, 2010). Dewey's experiential learning theory is renowned as an excellent tool to connect learning and real-world experiences to problem-solving (Cremin, 1959). Wojcikiewicz explained Dewey's experiential learning theory as an intelligence focused, intuitively captivating instructional experience guided by the needs of meaningful social activity.

Inquiry-based learning is considered a direct descendant of Dewey's experiential learning theory (Spronken-Smith & Walker, 2010). John Dewey's philosophy is the foundation of inquiry-based learning in which he proposed that the eagerness of the learner was the way learning began (Savery, 2006). Experiential learning and inquiry-based learning share a relationship through constructivism (Garrison, 1995; Spronken-Smith & Walker, 2010). Constructivism is based on the learner's ability actively to build new ideas or concepts situated through their prior knowledge (Sharma, 2014). Inquiry-based learning and experiential learning theory through constructivism involve the nature of investigations and problem-solving while making meaning through personal learning experiences and social learning experiences (Gehrke, 1998; Hildebrand et al., 2008).

Inquiry-based learning is linked to pragmatic, progressive, experiential learning theory through John Dewey's epistemological view of social constructivism (Dewey, 1916; Garrison, 1995; Hildebrand et al., 2008). Dewey's epistemological views of social constructivism are (a) the process of inquiry fosters knowledge, (b) knowledge is labeled as societal and experimental while capable of being erroneous, (c) inquiry begins with definitive problematic situations, and (d) inquiry in science is successful when modified and deployed to solve principled issues within other realms of life (Hildebrand et al., 2008). Inquiry-based learning through social constructivism involves creating meaningful learning opportunities by focusing on purposeful, experiential, child-centered, issues-centered learning experiences driven toward solving societal challenges (Conner & Bohan, 2014; George, 2011; Hildebrand et al, 2008; Spronken-Smith &

Walker, 2010). Inquiry-based instruction is rooted in scientific inquiry and places prominence on asking questions, data collection and analysis, and assembling arguments based on substantiation (Krajcik & Blumenfeld, 2006; Kuhn Black, Keselman, & Kaplan, 2000; Spronken-Smith & Walker, 2010). Inquiry-based learning theory places the educator in a dual-role as the facilitator and source of information for learning (Savery, 2006; Spronken-Smith & Walker, 2010).

Integrated curriculum and instruction incorporate predictive, action-oriented, practical education experiences by de-emphasizing traditional basal resources and incorporating diverse instructional resources during the education experience (Conner & Bohan, 2014; Dewey, 1910). Furthermore, experiential learning encompasses content area needs assessments of skills and information for solving societal problems in science and creates life-long learners and citizens prepared to participate in future society (Cremin, 1959; Gehrke, 1998; Weiler, 2004). The implementation of integrated curriculum and instruction is considered pragmatic as it seeks to encourage enthusiasm and motivation in students within content areas where academic achievement is less desirable (Gehrke, 1998).

Importance of Science Education

Challenges with Science Education

An urgent societal concern with maintaining global positioning in an information and service-based economy required giving attention to the ability of students to fulfill STEM related jobs in the future (Pinnell et al., 2013). An ever-growing population of learners and citizens disinterested or inadequately prepared to participate in STEM fields of study and jobs remained a threat to a society's participation in a global economy (Conley, 2014). Wysession's (2012) study explained the significance of college and career readiness and how employers recruit for careers in STEM fields, but found it challenging to hire citizens because of severe discrepancies in their education and training in those fields. Challenges within science education in elementary schools could cause long-term effects on society, which include the ability to find citizens properly trained to fulfill STEM related jobs in the future (Bursal, 2012; Obama, 2009). A decreased emphasis on science education affects students' abilities to learn and do science as they progress from elementary through secondary and post-secondary school (Conley 2012, 2014). The United States acted to address discrepancies in K-12 science education by establishing funding through grants, such as Race to the Top, to encourage accountability reform and innovative practices in K-12 schools (Holdren et al., 2013; Pub. L. 89-10).

A research study by Traphagen (2011) placed prominence on the significance of science instruction in elementary schools. In an inventory of science education, Blank (2013) found that regardless of metrics, time for science and mathematics instruction in schools grew during the later parts of the 1980s and into the early 1990s. Blank, however, recognized that by the middle of the 1990s, instructional time for science education fell to approximately two hours per week, which represented the least amount of time based on national trend data since that process began in 1988. The challenge to instituting or increasing instructional time for science education in schools continued to be standardized testing and performance accountability (DeJarnette, 2012).

Renter et al. (2006) looked at all 50 states and indicated that in conforming to NCLB, a reduction of instruction existed during elementary instructional time for science in 71% of school districts to incorporate more instruction for reading and math. The reasons for the reduction in science education were directly linked to the high-stakes testing accountability measures set-forth by NCLB (Judson, 2013; Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012). Other researchers reported that instructional time spent on science and science academic achievement suffered from equity issues in the classroom (Eidietis & Jewkes, 2011; Judson, 2013; Traphagen, 2011). English language arts and math-learning targets took priority, which strained instructional time and resources for science education in the classroom (Milner et al., 2012; Traphagen, 2011).

Researchers advised that at the elementary level, rather than at the middle or high school levels, abundant opportunities for adaptability in the curriculum are present to promote unprecedented strategies to teach science content and incorporate STEM integration across the curriculum (Moore & Smith, 2014; Nadelson et al., 2013). Recognizing science as a component of STEM, elementary school educators have a unique opening to take advantage of eagerness in students to investigate STEM curriculum and remain positioned to foster the establishment of principle STEM knowledge (Nadelson et al., 2013). Researchers contend that elementary school educators, however, dismiss the opportunity to teach science in favor of instruction toward reading and math (Milner et al., 2012). Science education has ultimately suffered because of the emphasis school administrators have placed on math and reading instruction and performance accountability (Milner et al., 2012). Nadelson et al. (2013) warned that teachers' unpreparedness to provide instruction in science education was partially a result of those other performance accountability priorities. Elementary science educators' adverse confidence and attitudes toward science instruction in conjunction with insufficient instructional time and inconsistent instructional capacity for science education influence the complete elimination of science instruction during the school day (Bursal, 2012; Sandholtz & Ringstaff, 2011). The presence of educators within the workforce, who have negative views of efficacy and attitudes toward science instruction, remain an issue hindering science education (Holdren et al., 2013; Lakshmanan, Heath, Perlmutter, & Elder, 2011).

DeJarnette (2012) argued that science, while also recognized as a component of STEM, deserved equivalent awareness within the traditional framework of a K-12 education. In comparison, for educators and students, STEM programs are rather scarce in elementary schools in relation to the abundance of opportunities for middle and high school students (DeJarnette, 2012). Educational researchers concurred on the necessity of rigorous and relevant science education programs beginning at the elementary level (Griffith & Scharmann, 2008; Judson, 2013; Miller, 2010). The appropriate teaching and learning of science for the population of learners at the elementary level potentially change the trend of a dwindling population of qualified citizens who choose to participate in STEM fields of study and jobs in the future (Conley, 2014; DeJarnette, 2012). However, when science is not a part of a school's assessment and accountability practices, the content area loses important instructional time and instructional resources in the total instructional program (Sikma & Osborne, 2014).

The affect, which a continued lack of focus or disregard to science instruction in elementary schools could have on society, community, and education systems, may become of greater concern as the amount of instructional time, resources, and capacity for science education continues to be an issue. Milner et al. (2012) proposed that absent performance accountability in science will continue to minimize the teaching of science in elementary schools. Milner et al. insisted that the minimized teaching of science in elementary schools further stifled the United States objectives to upgrade STEM education, innovation, and participation in a global economy. Nadelson et al. (2013) and Quinn et al. (2012) supported that the prospective growth and impact of valuable instruction of STEM content in elementary schools and the formative elementary school years were essential in time for science education. Elementary students' inquisitiveness and enthusiasm for science led to endorsements for enhancing science education during those early years with educators (Quinn et al., 2012).

The Relationship Between Science Education and STEM

Research on STEM programs in schools over the years provided benchmarks on the importance of science as a content area of instruction (Blank, 2013; DeJarnette, 2012; Ejiwale, 2014; The President's Council of Advisors on Science and Technology, 2011; Quinn et al., 2012; Traphagen, 2011). A survey of K-12 science educators determined that action plans to upgrade and supplement science instruction in elementary schools were needed (Blank 2013). The survey also found that educators believed methods to assess student growth and school performance accountability reform would benefit science academic achievement (Blank, 2013). Numerous policy decisions and reports emphasized the need to address deficits in K-12 science education, while also recognizing science as a component of STEM (Holdren et al., 2013; Obama, 2009; Olson & Riordan, 2012; Pub. L. 89-10).

The Educate to Innovate Campaign (Obama, 2009) was an initiative enforced by President Obama focusing on growing young American students' performance and skills in STEM. The campaign focused on collaboration in the public and private sector and with nonprofit organizations and educational associations (Obama, 2009). STEM skills were increasingly becoming required at all levels of employment as the demand for a workforce proficient in STEM skills was growing (Ejiwale, 2014; Pinnell et al., 2013). The reality is that other nations had transcended the United States in innovative science and technology research and development, and the ramifications were significant on the nation's future economic prosperity (Milner et al., 2012; NSB, NSF, 2016). The economic progress of a nation hinges on its ability to progress in science and technology (Nnachi, & Okpube, 2015). Proficiency in a global economy with STEM jobs at the center emphasized the importance of science and STEM education K-12 schools (Holdren et al., 2013; Olson & Riordan, 2012; The President's Council of Advisors on Science and Technology, 2011; Quinn et al., 2012).

In 2012, national cause for concern prompted President Obama's administrative to focus on positive STEM job growth and America's ability to employ qualified individuals for STEM jobs (Conley, 2014). There was cause for concern about America's ability to maintain competitive participation in a global economy largely influenced by STEM jobs (Olson & Riordan, 2012; The President's Council of Advisors on Science and Technology, 2011). STEM job growth projections were promising as between 2010 to 2020, occupations based STEM would grow by at least 20% (Lockard & Wolf, 2012). Regarding labor reports and statistics for STEM job growth, advice from leaders in American educational policy suggested the need for an increase in graduates within STEM fields of study (Holdren et al., 2013; Olson & Riordan, 2012).

In response to these challenges, in 2012, the United States Department of Education prompted the reauthorization of the ESEA (Pub. L. 89-10). The legislation accentuated the need to increase the American population of properly trained professionals for STEM jobs (Holdren et al., 2013; Olson & Riordan, 2012; Pub. L. 89-10). National organizations and initiatives, such as The Partnership for 21st Century Skills (2004), intended to train young American students to participate in the global economy largely driven by STEM careers. The initiative was built on the foundation of advancing cross curricular skill sets, comprehension skills, and teamwork (DeJarnette, 2012; Partnership for 21st Century Skills, 2004). The attainment of 21st century skills, which include reasoning, partnerships, and dissemination, occurs during participation in

STEM activities. Twenty-first century skills boost preparedness to compete in a global economy (DeJarnette, 2012).

The focus on STEM education and a nation's ability to participate in a global economy continued to shift toward the population of youthful learners in K-12 schools (Conley, 2014). DeJarnette (2012) argued that the best opportunity to maintain a dominant position in STEM fields rested in America's K-12 students. Secondary and post-secondary education students increase self-awareness and self-efficacy in their abilities to perform in accelerated math and science classes by participating in STEM learning activities during elementary education years (DeJarnette, 2012). Several policies, programs, and initiatives have been introduced and implemented to help advance young students' motivation and enthusiasm to learn STEM (Holdren et al., 2013; NGSS Lead States. 2013; Obama, 2009; Olson & Riordan, 2012; Pub. L. 89-10). America's K-12 students stand to benefit from a deliberate focus on science education and STEM skills, which may translate into students choosing to study in STEM fields in post-secondary education. K-12 students are positioned to be exposed to STEM curriculum and instruction, which extends across the curriculum (Bybee, 2011; Quinn et al., 2012). At the elementary school level, educators can use instructional strategies to teach science content and incorporate STEM skills without disruptive modifications to curriculum (Bybee, 2011; Spear-Swerling & Zibulsky, 2014).

Presenting STEM education to America's youth during transitions through the primary and secondary education system is likely the deciding factor between long-term success or failure in post-secondary STEM fields of study and jobs (DeJarnette, 2012). STEM initiative programs for elementary students from public and private organizations and universities continue in offerings but likely pale in comparison to the abundance of programs in secondary schools

(DeJarnette, 2012; Smith, Kindall, Carter, & Beachner, 2016). Elementary students, however, growingly become the target population of STEM education and programs (DeJarnette, 2012; Tyler-Wood et al., 2012). Elementary students are essential candidates to establish connections, perceptions, and fondness for STEM fields of study (Bybee, 2011; Sandholtz & Ringstaff, 2011; Traphagen, 2011). However, the introduction and implementation of STEM programs in schools are affected by the way educators and administrators embrace the science content area (Bursal, 2012; Holdren et al., 2013; Lakshmanan et al., 2011; Sandholtz & Ringstaff, 2011).

Advancement in STEM areas of study in K-12 schools remain influenced by the environment and norms where learning takes place (Nnachi, & Okpube, 2015). The learning environment is critical because science curriculum is heavily constructed with abstract concepts and content, and the elementary science curriculum have increasingly become laden with engineering, math, and inquiry-based concepts (DeJarnette, 2012; NGSS Lead States; 2013; Quinn et al., 2012). Although an increase in STEM integration and science education at the elementary level occurs, the instructional capacity of educators in those schools who are responsible for teaching science content and integrating STEM is in question (Atkinson, 2012; DeJarnette, 2012).

Some experienced elementary school educators require professional development for creating academically challenging environments for science education and incorporating STEM integration across the curriculum (DeJarnette, 2012; Moore & Smith, 2014; Spear-Swerling & Zibulsky, 2014). In addition, schools frequently have a shortage of educators with an affinity for STEM and the content knowledge for science education (Quinn et al., 2012). DeJarnette (2012) indicated the need for resources to help elementary educators infuse inquiry-based learning into the science curriculum to meet the challenges of teaching and learning abstract concepts and content.

Issues with Gender and Science Education

Gender Bias in Science and STEM

STEM field jobs and the people employed in them, currently or prospectively, are often the focus of numerous policy affairs (Walters & McNeely, 2010). Policy decisions involving STEM can point to amplifying the abilities of the employee base within the field. Challenges with gender equity and the marginalized sample of women in the STEM employee base continue to be at the forefront of policy affairs (Walters & McNeely, 2010). Men dominate STEM fields and related courses of study because women hold fewer bachelor's degrees in those areas (Nnachi, & Okpube, 2015; NSB, NSF, 2016). One idea represented in the issues of gender equity in STEM is the attitude of males and females in relation to science content areas. Tyler-Wood et al. (2012) expressed the necessity of halting the growth of the gender gap in STEM careers by addressing issues in students' attitudes regarding science education. The strategies and policy decisions designed to alleviate gender bias and, subsequently, the gender gap will expand the representation of women in STEM jobs (Tyler-Wood et al., 2012). Increasing female engagement in STEM may lure coming generations of females to STEM fields using strategies that relate to them such as presence of role models and mentoring (Diekman et al., 2016; Falk, Rottinghaus, Casanova, Borgen, & Betz, 2016; Young, Rudman, Buettner, & McLean, 2013). Researcher have found that female students were less likely to engage in STEM fields of study when implicit and explicit gender bias and stereotypes were present in the learning environment, as well as during decision-making processes for future involvement in STEM fields of study and jobs (Cheryan et al., 2013; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012; Young et al., 2013).

Gender bias in science ultimately alters the growth of enthusiasm in girls toward STEM fields of study and jobs (Nnachi & Okpube, 2015). During every stage of development, from infancy to adulthood, females endure direct or subliminal communication about their inferiority to males in science education and STEM (Diekman et al., 2016; Lane, Goh, & Driver-Linn, 2012; Stout et al., 2011). Direct or subliminal communication includes the lack exposure to images and references, which depict female STEM professionals within instructional delivery resources by the time female students reach the secondary education level (Moss-Racusin et al., 2012; Stout et al., 2011). Female students arriving at the post-secondary education level face the realization of feeling misplaced in STEM fields of study because of gender disparity through bias in physical learning environments and lack of female STEM professionals (Moss-Racusin et al., 2012; Ramsey et al., 2013; Stout et al., 2011).

The byproduct of gender bias and attitudes of decreased enthusiasm toward science directly correlates to a gender gap in science between males and females (Bursal, 2013). A unifying origin of the gender gap in science, which needs acknowledgement, is the recognition of contradistinctions between males and females (Bursal, 2013). Contradistinctions are contrasts between males and females in relation to their implicit and explicit academic interest and achievement within science content areas and STEM fields of study within K-12 and post-secondary schools (Diekman et al., 2016; Lane et al., 2012; Ramsey et al., 2013).

The gender gap is also influenced by parents of female students, particularly at the elementary education level (Archer et al., 2012; Rosenthal, London, Levy, & Lobel, 2011; Shin et al., 2015; Stout et al., 2011). Parents of female students may demonstrate attitudes of apathy in their expectations for success and motivation in science content areas as compared to male students (Archer et al., 2012; Rosenthal et al., 2011; Shin et al., 2015; Stout et al., 2011). Perception, rather than facts, likely becomes the reality of the female gender group when exposed to ideas about their inferiority in science as compared to males (Stout et al., 2011).

Elementary school science instruction could be pivotal in addressing the need to close the gender gap and alleviate gender bias in science. For elementary educators, the gender gap in science between males and females may not always be tangible (Tyler-Wood et al., 2012). Female students at the elementary level may simply participate and complete learning tasks in science for extrinsically motivated purposes such as earning a passing grade or increasing grade point averages, rather than intrinsically through enthusiasm and desire (Sonnert & Fox, 2012). If the gender gap is tangible for educators, captivating female students in science throughout elementary school requires attention to their intellect and curiosity (Archer et al., 2010; Tyler-Wood et al., 2012).

Tyler-Wood et al. (2012) determined proposals to surge female success in science should center on elementary schools, or at least prior to seventh grade. Moreover, the proposals should encourage the affirmative features of science to both male and female students at the elementary school level of the K-12 education continuum (Riegle-Crumb, Moore, & Ramos-Wada, 2011; Tyler-Wood et al., 2012). Gaps in performance diminish when science and STEM educators promote opportunities for success in both males and females in science subjects (Nnachi & Okpube, 2015). Learning styles, which use instructional strategies based on English language arts in science for female students, are preferable (Lane et al., 2012; Tyler-Wood et al., 2012). Instructional materials and learning styles are essential in selecting science programs for female students to advance gender equity (Stout et al., 2011).

Gender Representation in Science and STEM

Female representation in STEM jobs continues to be at the center of research nationally and internationally (Bieri Buschor, Berweger, Keck Frei, & Kappler, 2014; Hughes et al., 2013; Ramsey et al., 2013). Women in the workforce account for roughly half of the employment in the United States economy but are only represented in nearly a quarter of STEM jobs (Beede et al., 2011; Heilbronner, 2013). According to the U.S. Congress Joint Economic Committee (2012), STEM job growth during the decade between 2020 to 2030 is expected to grow exponentially; however, so far, STEM degree attainment amongst females has fallen when compared to other post-secondary fields of study. The challenge of increasing female representation in STEM is critical as job growth projections grow, but female STEM degree attainment declines (Beede et al., 2011; U.S. Congress Joint Economic Committee, 2012).

During the 1990s, 2000s, and into contemporary time periods; primary, secondary, and post-secondary educational institutions implemented deliberately focused programs with goals for supporting female students in selecting fields of study and career paths in STEM fields (Bieri Buschor et al., 2014; Riegle-Crumb et al., 2015; Tyler-Wood et al., 2012). Programs had been created with the aim of uplifting female students into STEM fields of study and jobs. Gender related differences, however, remain prevalent in STEM programs and hinder progress for females in selecting STEM fields of study and jobs (Wegner, Strehlke, & Weber, 2014). Numerous attempts to address supporting female participation in STEM fields of study and jobs are directly affected by gender related differences, which include gender bias and stereotyping (Bieri Buschor et al., 2014). Gender bias and stereotyping against female STEM majors remain substantial threats to progress in sustaining and increasing female participation in STEM fields of study and jobs (Deemer, Smith, Carroll, & Carpenter, 2014; Teo, 2014).

Programs and policies attempting to impact the population of female students concurrently studying in fields or employed in jobs in STEM suffer from limitations (Teo, 2014). Limitations, such as gender bias and stereotyping, impact participation, achievement, and the dispositions of female students studying in STEM fields. Strategies, programs, and policies must be developed and implemented with caution to those limitations at the focus of female involvement in STEM fields of study and jobs (Teo, 2014). Female students at every level of the K-12 education continuum report direct or indirect concerns of gender bias and stereotyping in the science classrooms (Deemer et al., 2014). Female students majoring in STEM fields of study in post-secondary educational institutions, in comparison to men, disclose an increasing exposure to gender bias and stereotyping in science classrooms (Deemer et al., 2014).

Researchers describe gender bias and stereotyping as behaviors that engage differences academically and amongst personality types impacting goals, performance, and self-efficacy (Deemer et al., 2014). Gender bias and stereotyping in favor of males in STEM fields may influence female students' participation, achievement, and dispositions in STEM through subliminal programming beginning at the elementary level (Ramsey et al., 2013). Policies, programs, and strategies to address gender bias and stereotyping in STEM continue to be implemented at all levels of the K-12 education continuum. Increasing expectations while providing access to female representatives (i.e., students, educators, professionals) involved in STEM fields could minimize concerns with gender bias and stereotyping in those fields of study and career paths (Ramsey et al., 2013).

Gender bias and stereotyping in STEM fields of study and career paths for females remain a persistent concern. One area, however, could be addressed strategically to affect positively the female population engaged in STEM. Ma (2011) urged for attention to be directed toward the dwindled enthusiasm and ambition of female students toward STEM fields early in the education process, which begins at the elementary school level. Sadler, Sonnert, Hazari, and Tai (2012) supported the rationale that encouraging opportunities for promoting representations of females in STEM are embedded in accelerating enthusiasm and ambition in female students at the elementary education level. However, a challenge to the strategy of early exposure to females involved in STEM fields exists. By the time students arrive to the secondary level of education, a gender disparity issue involving enthusiasm and ambition toward STEM fields of study and jobs already exists between male and female students (Sadler et al., 2012).

Female participants in STEM are not represented in significant numbers at the secondary and post-secondary education level or in academic leadership positions (S. Jackson, Hillard, & Schneider, 2014). With the compounding effect of dwindled enthusiasm and ambition of female students toward STEM and the underrepresentation of females in academic and leadership positions, the challenge becomes significantly greater for reaching elementary education level female students (S. Jackson et al., 2014).

The lack of enthusiasm and ambition in female students early on toward STEM fields of study likely relates to men following the route to degrees in STEM fields of study in greater numbers (Ma, 2011). Early exposure to the variety of STEM fields of study and jobs is a pivotal strategy to increase the enthusiasm and ambition of female students (Wyss et al., 2012). Early exposure to information will result in all students making enlightened decisions about educational and career paths in STEM fields. The enthusiasm and ambition of male and female students who are informed about STEM and their decisions to pursue a field of study and career path in that industry are exceedingly inclined positively compared to others to participate in those employment opportunities (Wyss et al., 2012).

Gender equity issues in STEM continue to be a challenge toward opportunities for female participation in those fields of study (Hughes et al., 2013). Policies directed toward equity issues, such as enhancing pathways to opportunities in STEM for females, exist in practice (Hughes et al., 2013). Existing policies, however, have fallen short of overcoming challenges to status quo methods, which prohibit females from continuing to focus on STEM fields of study (Esiobu, 2011; Hughes et al., 2013). According to Esiobu, gender equity is defined as systematic fairness to members of both gender groups. Systematic fairness leads to providing equitable circumstances for both male and female students to participate, achieve, and learn in historically inequitable education environments (Esiobu, 2011). Gender equity in STEM remains a threat to progress for females in the field of study and their choices for career paths by maintaining the status quo methods from the previous decades (Esiobu, 2011; Hughes et al., 2013). The stigma of status quo methods has resulted in females retaining false realities about their inferiority to males in science education and STEM (Esiobu, 2011).

Gender and Self Esteem in Science and STEM

Gender bias and inequity issues impact the self-esteem of female students toward STEM fields of study (Ramsey et al., 2013). Gömleksiz (2012) found statistically significant differences between the gender groups regarding the magnitude of STEM fields of study. The strategy of providing female representatives from STEM careers to classroom learning environments is a viable option (Sadler et al., 2012). Researchers have found that females enter STEM fields of study with reduced enthusiasm and conviction as compared to males, and circumstantial guidance counseling, which includes the use of role models and mentors, may be needed to address this issue (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011; Falk et al., 2016; Young et al., 2013). The challenge is that strategy is overcoming the underrepresentation of females involved in STEM fields of study and career paths for elementary and secondary students of both genders to be inspired. Heilbronner (2013) reported self-efficacy remained a deciding indicator, which influenced the diminishing representation of females in STEM. Bieri Buschor et al. (2014) reported that self-esteem in female students regarding STEM was directly impacted by comparisons to other quintessential STEM students. Females students' self-awareness is mitigated by their explicit content self-assessments and comparisons to other quintessential STEM students (Bieri Buschor et al., 2014).

Classroom learning environments, which are conducive to gender bias and gender inequity against female students, directly impact their self-awareness toward the importance and potential of STEM fields of study and career paths (Ramsey et al., 2013). Historically, classroom learning environments with recurring gender bias and gender inequity trend toward create unfavorable self-awareness in female students in their abilities to be successful in STEM (Ramsey et al., 2013). Female students' decision-making processes regarding course registrations at the secondary education level are connected to their career goals in the future (Bieri Buschor et al., 2014). Female students at the secondary education level enroll in classes that have significance to their post-secondary plans and goals (Bieri Buschor et al., 2014). Female students will continue to be underrepresented in STEM if they have low self-assessments in those fields.

Situational factors must be considered when analyzing enthusiasm and participation in STEM fields of study between male and female students (Wyss et al., 2012). Situational factors could include the use of differentiated or innovative instructional strategies, instructional delivery models, or preferential master scheduling. Wyss et al. argued that calculated deviations in personal interest toward STEM between male and female students were related to situational experiences in the classroom learning environment. Obtaining any form of success in the classroom learning environment could have a pivotal impact on self-assessments and confidence to achieve within a field of study (Robnett & Leaper, 2013). Elementary and secondary level students begin establishing STEM career goals based on positive self-awareness and future potential for success in STEM fields of study (Robnett & Leaper, 2013; Wyss et al., 2012).

Wegner et al. (2014) reasoned that female students, when compared to male students, were at greater risk of having their personal achievement goals altered because of disruptions to their self-awareness in science. Several factors need to be considered while encouraging female students to increase self-awareness and enthusiasm for science education and STEM fields of study. According to Robnett and Leaper (2013), factors regarding friendships, personal motivation, and gender are components that influence greater male students' interest in STEM careers. Female students have been found to be less interested in STEM fields of study beginning at the elementary level (Ma, 2011; Sadler et al., 2012). The difference in interest levels for STEM between males and females can be alleviated by giving attention to motivational and social factors in the classroom learning environment (Robnett & Leaper, 2013).

The science education classroom learning environment can frustrate students when there is an absence of influential stimulations such as recognition and role-models (Wegner et al., 2014). The lack of acknowledgement for accomplishments in science education for female students can lead to increased frustration levels. The presence of gender bias and gender inequity through stereotypical thoughts and behaviors from science educators can increase frustration levels between male and female students as well (Wegner et al., 2014).

Deemer et al. (2014) discussed mastery approach goals as a strategy to address negative stereotyping against female students regarding their abilities in STEM fields of study. Mastery approach goals are targets for the progression of skills and cognition through expanding competence. Female students may benefit from the mastery approach (competence) goal strategy, which allows students to build understanding through a progression of developing skills. The strategy redirects focus from mastery avoidance (failure) through gender bias, gender inequity, and stereotyping against female students when they are compared to male students and the status quo in STEM fields of study. Educators should be encouraged to address recognizable biases, instances of gender inequity, and stereotyping to benefit female students when disadvantages are present in the science classroom learning environment and during STEM integration. Normative comparisons with benefits favoring male students remain a threat to self-awareness and confidence building for female students in STEM fields of study (Deemer et al., 2014).

Gender bias directly influences students' attitudes toward science education and STEM fields of study. Kurz, Yoder, and Ling (2015) found students' attitudes favored beliefs that males were superior in science education and STEM fields of study, and that STEM career paths were indefinitely dominated by males. Gender bias and stereotyping have led female students to concede to the premeditated ideas that males are better at science and STEM (Kurz et al., 2015). Attitudes and self-awareness suffer from negative beliefs about perceived incompetence in any academic subject (Leaper, Farkas, & Brown, 2012). Students with low self-awareness and negative attitudes toward an academic subject generally have lower academic achievement within that subject area (Leaper et al., 2012).

Gender bias has an impact on the motivation of female students in their academic achievement in STEM fields of study (Leaper et al., 2012). STEM is associated with being a male-dominated field of study and career path (Leaper et al., 2012). S. Jackson et al. (2014)

reported gender bias and stereotyping had an adverse impact on the employment, attrition, and advancement of females in STEM career paths. Increasing positive attitudes and enthusiasm in females toward STEM may reverse negative effects in beliefs from exposure to status quo gender bias and stereotyping within the fields of study (Leaper et al., 2012). In contrast, gender bias and stereotyping may have a reverse psychological effect on students as well. Lane et al. (2012) and Leaper et al. (2012) argued that historical success in English language arts could lead to female students being tolerable to status quo gender bias and stereotyping within that field of study. English language arts has historically been an academic area in which female students have great success (Lane et al., 2012; Leaper et al., 2012). Comparatively, Gömleksiz (2012) reported that male students assigned greater significance and, consequentially, increased commitment toward academic achievement in science education and STEM fields of study. Accordingly, Gömleksiz found statically significant differences in perceptions of the STEM classroom learning environment between male and female elementary students.

Gender Participation in Science and STEM

A nation's ability to participate in research and development in STEM fields is directly impacted by its societal views on the importance of industry. Nations suffer harm from the depletion of female participants in STEM fields of study and career paths (Sadler et al., 2012). The decreased participation of women in STEM fields is a threat to the economic prosperity of the United States because women are a significant percentage of the post-secondary degree awarded workforce (Beede et al., 2011; Diekman et al., 2016). Female participation in STEM is critical to meet the void of professionals who are ready to participate in STEM jobs (Sadler et al., 2012). Wegner et al. (2014) argued that the depletion of female talent, because of inadequate strategies and resources because of economic reasons, was inexplicable. Increasing females' enthusiasm and participation toward STEM fields of study and jobs is recognized as an urgent concern to contend economically on a global scale (Leaper et al., 2012). Wyss et al. (2012) echoed the importance of informing students at all levels of the K-12 education continuum about the possibilities in STEM fields of study and jobs, so they make educated decisions to prepare for participation during years.

Education industry professionals should be encouraged to use current strategies and resources to minimize the dwindled representation of females in STEM jobs (Wegner et al., 2014). The goal for educational leaders is to develop everlasting enthusiasm and commitment toward STEM in female students (Wegner et al., 2014). Deemer et al. (2014) eluded to a career development concern for the underrepresentation of females in STEM as progressively significant. According to Robnett and Leaper (2013), the conventional differences between male and female students' passion for STEM careers link to self-awareness, attitudes, and enthusiasm for STEM fields of study. Gömleksiz (2012) acknowledged a science academic achievement gender gap between male and female students aged 9 to 13, which directly correlates to students from fourth to eighth grade within the K-12 education continuum. Gömleksiz found that male students determined STEM classes as increasingly fundamental to K-12 education as compared to female students.

Discriminatory societal practices between male and female students, whether direct or subliminal, should be researched and eliminated in civilized societies (Sinnes & Løken, 2014). The avoidance of discriminatory practices requires societies to be cognizant of the equivalent talents and skills of male and female students to study in STEM fields and participate in STEM jobs (Sinnes & Løken, 2014). Esiobu (2011) reported that gender bias, stereotyping, and discriminatory practices in STEM led to erroneous perceptions in females that STEM fields of study and jobs were indefinitely the privilege of males. Leaper et al. (2012) determined that gender associated differences in self-awareness and attitudes because of individual importance could influence female students' enthusiasm and motivation for STEM and other academic content areas. Societal influences also include the general amount of inspirational uplift and support female students receive to achieve and excel in STEM fields of study (Leaper et al., 2012).

Role models can serve as inspirational figures in response to stereotypes and gender bias in STEM fields of study (Cheryan et al., 2013; Young et al., 2013). Cheryan et al. determined that women who studied in the presence of stereotypical science students, educators, and professionals had decreased interest and self-awareness in science related fields of study. Correspondingly, Moss-Racusin et al. (2012) reported that male and female members of the faculty at the post-secondary level deemed female students as less proficient in academic science, which further perpetuates gender bias between male and female students. Alternatively, Young et al. (2013) found that female role models could be linked to impacting positively biases toward science fields of study within male and female students. Moreover, male role models who do not fit the stereotypical model of a scientist are positively effective in growing female interest in science related fields (Cheryan et al., 2013). Cheryan et al. (2011), however, reported that positive influences from interaction with adult male and female role models in science could be negatively affected by the interactions with stereotypical STEM students. Role models, regardless of gender, presented in the appropriate context and environment can have a positive impact on female students with attention to addressing implicit and explicit gender biases and stereotyping (Cheryan et al., 2011, 2013; Moss-Racusin et al., 2012; Rosenthal et al., 2011; Young et al., 2013).

Societies that reach increased gender parity by increasing females' enthusiasm and participation in STEM will expand economic equality between gender groups (Leaper et al., 2012). Educators who use effectively engaging and accommodating instructional methods and strategies will inspire male and female students to participate in the science and STEM classroom learning environment and likely STEM fields of study and jobs in the future (Gömleksiz, 2012). The use of various instructional methods and strategies while integrating background knowledge that students possess could upgrade communication and cooperation among educators and student gender groups in the classroom learning environment to attain success in science education and subsequently STEM fields of study and jobs (Gömleksiz, 2012).

Science content and learning goals benefit from integrated instructional strategies or pedagogical models taught with attention to students' background knowledge (Krajcik & Blumenfeld, 2006; Wegner et al., 2014). Educators who are insensitive to students' background knowledge and the use of integrated instructional strategies or pedagogical models stand to harm female students (Wegner et al., 2014). Science education and STEM consist of academic content, which is abstract, and require teaching and learning critical thinking skills to master learning standards at all levels (Wegner et al., 2014). Gömleksiz (2012) argued for the importance of effective instructional delivery models in conjunction with unbiased classroom learning environments and how they directly influence each other. Gömleksiz lobbied for educators to endorse relevant interaction between students, classroom learning environments, instructional resources, and learning outcomes to impact personal achievement goals positively in students. Significant differences, however, have been found between male and female students regarding instructional strategies used in science and STEM classroom learning environments (Gömleksiz, 2012). Female students found instructional strategies used in science and STEM classes as inadequate and more effective for male students (Gömleksiz, 2012).

Instructional Models, Academic Achievement, and Intervention

Traditional Based Instruction

The foundation of traditional based instruction is linked to behaviorist theory, which designates that learning is achieved through the presence of distinct environmental stimulants proceeded by appropriate responses (Ertmer & Newby, 2013). William Bagley (1874-1946) was one of the earliest proponents of traditional based instruction in the United States (Null, 2007; Watras, 2012). Notably, William Bagley and John Dewey shared the same *pragmatic* view of education. Whereas Dewey was a progressivist, Bagley was an essentialist. William Bagley's view of the purpose of school was described by Watras as a process in which students' behaviors and instincts modified by content areas of instruction through instructional activities with textbooks based on teachers' desires for efficient habits of students in the ideals of society. Traditional based instruction has been labeled as a successor of education essentialism philosophy (Null, 2007; Roberson & Woody,2012; Watras, 2012).

Education essentialism philosophy is defined as a teacher-centered approach to learning (Roberson & Woody, 2012). One of the critical arguments about education essentialism philosophy is that it encompasses a diminished focus on conceptual understanding but rather emphasizes rote learning (Roberson & Woody, 2012). Ertmer and Newby (2013) described four principles for the behaviorism learning theory instructional design: (a) establishing *learning goals* that are clear and quantitative [objectives, performance task, test scores], (b) using *pre-testing* to establish benchmarks for student learning [formative, informal, or common assessments], (c) monitoring *levels of learning* to move students though learning progressions [time, lesson plans, instructional activity], and (d) issuing *reinforcement* to influence learning outcomes [standardized assessments, grades, awards, acknowledgements]. To this point, traditional based instruction is characterized a method that requires students to accumulate knowledge from a teacher as the main source of information and authoritarian of the learning environment (Jackson, Dukerich, & Hestenes, 2008).

Defining the framework of traditional based instruction remains a challenging task for researchers. Traditional based instruction linked to behaviorist theory is a teacher-centered approach to learning (Ertmer & Newby, 2013). Since the 1800s, the framework for traditional based education largely implemented within educational institutions has been connected to the Carnegie unit (Silva et al., 2015; Sullivan, & Downey, 2015). The Carnegie unit, in place since the 1800s, is linked to foundation of contemporary traditional based instruction in K-12 and post-secondary schools (Silva et al., 2015; Sullivan, & Downey, 2015). Silva et al. defined the attributes of traditional based instruction under the Carnegie unit public school model as (a) teacher-centered, (b) 180-190 school days per school year, (c) approximately 60 minutes per instructional session, (d) textbook focused curriculum and instructional delivery, (e) performance grade ratings [A-F] and grade point average scale [1.0-4.0], (f) subject specific instructional sessions, and (g) standardized assessment [normative, criterion, summative]. The completion of courses presented under the framework of traditional based education is based on motivation through reinforcement (grades, grade point averages, raw scores, scale scores) (Ertmer & Newby, 2013; Silva et al., 2015). The Carnegie unit consist of *credit hours* earned for the completion of courses to earn promotion, diplomas, or degrees signifying academic achievement within K-12 and post-secondary education institutions (Silva et al., 2015; Sullivan, & Downey, 2015).

Academic Achievement in Science

In the United States, national education policy dictates that schools must, at a minimum, evaluate and publish student academic achievement data in science from three grand bands throughout the primary and secondary levels of the K-12 education continuum (Pub. L. 89-10; U.S. Department of Education, 2012). Every year, state, national, and international standardized, norm-referenced, criterion-referenced, and summative assessment administrations occur to students across grade-bands and content areas in K-12 schools (GaDOE, 2015a, 2015b, 2016c, 2016d; Kelly et al., 2013; NSB, NSF, 2016; Provasnik et al., 2012). The U.S. Department of Education (2012), however, reported that science academic achievement counted as a benchmark in assessment and accountability for schools in only a dozen states. The Trends in International Mathematics and Science Study (TIMSS), Program for International Student Assessment (PISA), and GMEOGA are examples of standardized, norm-referenced, criterion referenced, and summative assessments that allow participants to compare academic achievement of students statewide, nationally, and internationally in K-12 schools (GaDOE, 2015a, 2015b, 2016a, 2016d; Kelly et al., 2013; Provasnik et al., 2012).

State, national, and international comparisons of student assessment data help researchers understand issues and trends in academic achievement within content areas throughout the K-12 education continuum (GaDOE, 2015c, 2016d; Kelly et al., 2013; NSB, NSF, 2016; Provasnik et al., 2012). The PISA assessment system allows participating nations to quantify and compare the performance of 15-year-old students, which generally ranges between 10th and 11th grade, in science literacy every three years; the most recent assessment occurred in 2015 (Kelly et al., 2013). TIMSS offers reliably comparative data on science academic achievement of students internationally in fourth and eighth grades every four years, and the most recent assessment data analysis occurred in 2015 (Provasnik et al., 2016). Within the United States, at the state level in Georgia, The GaDOE Assessment Guide (2015a, 2015b) reported GMEOGA's main purpose was to yield important indicators about the quality of educational services and opportunities in schools and advise intentions to increase student academic achievement by evaluating the performance of students on the learning standards distinct to every discipline, class, or grade assessed.

For comparative analysis, TIMSS and PISA academic achievement data face various challenges to cross referencing each data set against each other (NSB, NSF, 2016; Provasnik et al., 2012). TIMSS evaluates scientific thinking and comparatively analyzes the extent to which students have learned skills and concepts in science as measured by a scale score (Provasnik et al., 2012). TIMSS science assessments are centered within (a) subject-specific *content* matter and (b) process-specific *cognitive* thinking dimensions. At the fourth-grade level, TIMSS science assessments evaluate student knowledge in earth science, life science, and physical science content domains. TIMSS science assessments at the fourth-grade level also evaluate student knowledge of scientific thinking in the knowing, applying, and reasoning cognitive domains (Provasnik et al., 2012).

Meanwhile, PISA measures the application of knowledge in science literacy as measured by a scale score (Kelly et al., 2013). Scientific literacy in PISA was defined by the Organization for Economic Cooperation and Development (OECD, 2013) as:

> An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence based conclusions about science related issues; understanding of the characteristic features of science as a form of human knowledge and inquiry; awareness of how science and

technology shape our material, intellectual, and cultural environments; and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen. (p. 100)

Furthermore, PISA measures 15-year-old students regardless of their grade level, while TIMSS assesses students in fourth and eighth grades. TIMMS and PISA assessment data do, however, allow researchers to gain longitudinal viewpoints of the national and international science academic achievement in schools (Kelly et al., 2013; NSB, NSF, 2016; Provasnik et al., 2012, 2016). The NSB, NSF (2014, 2016) Science and Engineering Indicators offer a comparative analysis and longitudinal view of student academic achievement nationally and internationally within, but not between, TIMSS and PISA assessment data. NSB, NSF (2014, 2016) emphasizes increasing academic achievement in science and STEM because of its roles in deciding the economic prosperity of nations in the 21st century.

The President's Council of Advisors on Science and Technology (2011) proclaimed the United States regularly performed in the median of international comparisons of science academic achievement and STEM disciplines. In attention to science academic achievement in the United States, Provasnik et al. (2012, 2016) reported that between 1995 (542), 2007 (539), 2011 (544), and 2015 (546), no measurable statistically significant differences were noted between the average science scores at grade four. Provasnik et al. reported between 1995 (513) and 2011 (525), a 12-point difference in average science scores at grade 8 was noted, but that between 2007 (520) and 2011 (525), no measurable statistically significant differences between the average science scores at grade 8 were noted. Provasnik et al. also reported that between 2011 (525) and 2015 (530), no measurable statistically significant differences were noted between the average science scores at grade 8. These data support the assertions and concerns of researchers and policy makers regarding the issue of stagnant science academic achievement in the United States (Conley, 2014; Holdren et al., 2013; Miller, 2010; Obama, 2009; Pub. L. 89-10).

Regarding the PISA assessments, The Organization for Economic Cooperation and Development (2016) reported that the average science academic achievement scale score for science literacy among 15-year-old students in 2015 was 496. Kelly et al. (2013) reported the average science academic achievement scale score for science literacy among 15-year-old students in 2012 was 497. However, Fleischman, Hopstock, Pelczar, and Shelley (2010) reported the average science academic achievement scale score for science literacy among 15-year-old students was 502. These data show the average science academic achievement scale score fell by 5 points between 2009 and 2012, which further supports the assertions and concerns of researchers and policy makers about the issue of stagnant science academic achievement in the United States (Conley, 2014; Holdren et al., 2013; Miller, 2010; Obama, 2009; Pub. L. 89-10).

In addition, NSB, NSF (2014) analyzed data from the 2011 TIMSS assessment program, and NSB, NSF (2016) analyzed data from the 2012 PISA. The NSB, NSF (2014) provided results that validated the findings from the independent TIMSS and PISA assessments. The NSB, NSF reported that United States fourth-grade science performance between 1995 and 2011 had not changed, and their international rankings had declined. The NSB, NSF also reported that, although United States eighth-grade science performance international rankings did not change, eighth-grade science performance between 1995 and 2011 had improved. Henceforth, the NSB, NSF (2016) also validated the findings from the independent 2012 PISA assessments and reported between 2006 (489), 2009 (502), and 2012 (497), which showed no significant differences science literacy scores of 15-year-old students.

In a state, such as Georgia within the United States, GMEOGA are part of a complete summative assessment program spanning grades 3-12. The GaDOE (2015a) Assessment Guide reported GMEOGA's main purpose was to yield important indicators about the quality of educational services and opportunities in schools and advise intentions to increase student achievement by evaluating the performance of students on the learning standards distinct to every discipline, class, or grade assessed. The program informs educators with formal results pertaining to instructional practice and guides local boards of education in recognizing positives and negatives geared toward creating precedence in planning instructional programs (GaDOE, 2015a, 2015b). The GMEOGA measures the proficiency of students' acquisition of knowledge and skills outlined by state-adopted content standards in science (GaDOE, 2015a, 2015b).

According to GaDOE (2015c, 2016d), the average science academic achievement scale score for fourth-grade students in 2015 was 505, and was 505 in 2016. GaDOE (2015c, 2016d) reported the average science academic achievement scale score for eight grade students in 2015 was 499 and 494 in 2016. GaDOE (2015c, 2016d) provided data comparable to Provasnik et al. (2012), TIMSS, Kelly et al. (2013), and PISA assessments and markedly support the assertions and concerns of researchers and policy makers about the issue of stagnant science academic achievement in the United States (Conley, 2014; Holdren et al., 2013; Miller, 2010; Obama, 2009; Pub. L. 89-10).

Based on the science academic achievement data for students in the United States, it could be assumed that the lack of focus on science education in elementary schools is connected to longitudinally stagnant science academic achievement from elementary to secondary schools and has an impact on long-term success or failure through post-secondary STEM fields of study and jobs (Blank, 2013; Lakshmanan et al., 2011). Blank argued that students' performances on science assessments were exceptionally better in schools where equity in time for science instruction exist in comparison to those schools where equity did not exist. Blank linked decreased time and mindshare for science education to continuous gaps in science academic achievement and inconsistencies in student performance in STEM fields of study. Sustained gaps in fourth-grade academic achievement in science remain a momentous concern as elementary schools nationally give narrowing attention to the instruction of science (Blank, 2013). National trend data during the 1980s, 1990s, and 2000s indicated that elementary classrooms gave extended amounts of time and mindshare in the instructional schedule for English language arts and mathematics education and progressively less of those factors to science education (Blank, 2013).

Supplemental Instructional Intervention

Issues and trends in student academic achievement in science have garnered the attention of educators and instructional leaders (Conley, 2014; Obama, 2009; Pub. L. 89-10). Policies related to NCLB, which include high stakes testing and inconsistent accountability measures, have dictated the diminished importance of instructional time, resources, and capacity allotted toward science education, particularly at the elementary school level (Banilower et al., 2013; Judson, 2013; Pub. L. 107-110; Sandholtz & Ringstaff, 2011; Sikma & Osborne, 2014). With the focus on performance accountability for reading and mathematics, elementary school teachers, whether conscientiously or unconscientiously, continually decrease efforts toward science instruction (Griffith & Scharmann, 2008; Johnson, 2007; Milner et al., 2012). With so much focus on reading and math academic achievement, science plausibly does not get the attention it needs to develop a course of action to synchronize the deployment of an intervention strategy or program (The President's Council of Advisors on Science and Technology, 2011).

Instructional intervention is necessary to create a positive learning environment, which fosters motivation, enthusiasm, and academic achievement in schools (Ramsey et al., 2013). Science curriculum could sustain beneficial improvements regarding its effectiveness by the prompt implementation of interventions (Tyler-Wood et al., 2012). Students who struggle with reading and math receive support with strategies such as Response to Intervention and Early Intervention Programs (Hoover & Love, 2011).

DeJarnette (2012) suggested increasing elementary students' motivation initially to study STEM in post-secondary schools and careers requires adequate and fair learning practices in corresponding content areas in elementary schools. However, interventions are not governmentally mandated to support students who are struggling with science (Martinez & Young, 2011). The inclusion of interventions for science at the elementary school level could be pivotal to increase student enthusiasm, motivation, and achievement in science and encourage them to pursue STEM fields of study in post-secondary education and jobs in STEM fields (Krajcik & Sutherland, 2010; Riegle-Crumb et al., 2011; Romance & Vitale, 1992, 2012; Vitale & Romance, 2012; Webb & Rule, 2012).

Major challenges to developing, mass adopting, implementing, and the upward mobility of valid science interventions and revolutionizing the teaching and learning of STEM in K-12 schools have been strict planning requirements and lack of opportunities for innovative uses of funding from the federal government (The President's Council of Advisors on Science and Technology, 2011). School districts adopt instructional resources for educators to use in planning lessons and instructional activities for students in content areas. Instructional resources include, but are not limited to, basil textbooks (traditional hardback subject specific books), instructional and assessment blackline masters (worksheets), and electronic instructional resources (digital media) to meet the needs of a diverse population of students. Lesson plans and instructional activities, which use instructional materials, are vital in a subject area, such as science, where resources and time are already strained (Bursal, 2013).

DeJarnette (2012) urged elementary educators to implement hands-on, inquiry-based activities by finding innovative ways to guide the instruction of abstract science concepts. However, Bursal (2013) believed science instructional materials already supported the learning of abstract ideas found in science curriculum, but also discovered that infield and preservice teachers' self-assessments indicated shortfalls in efficacy with incorporating science instructional resources in science lessons. The President's Council of Advisors on Science and Technology (2011) report suggested that support for teachers was insufficient, curriculum was uninspiring, and professional development was inopportune for science education. Bursal's (2013) findings depicted the importance of instructional materials in content areas where teachers lack instructional capacity, students lack background knowledge, and time is constrained in the classroom. Implementing inquiry-based science instructional interventions may cause teachers to feel increased self-confidence in science curriculum and instruction and increase science academic achievement (DeJarnette, 2012).

Contemporary Science and English Language Arts Education Reform

During the first part of the 21st century in the United States, education reform and support for teachers in traditional-based English language arts and science education have been focused on developing the Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS) (Common Core State Standard Initiative, 2010a, 2010b; Conley, 2012, 2014;

NGSS Lead States, 2013; NSB, NSF, 2016). In K-12 schools, learning standards guide academic curriculum to establish targets for student learning and academic achievement. For decades, each state independently designed, adopted, and implemented their own educational content learning standards for reading, math, science, and social studies academic content areas taught in K-12 schools (Conley, 2012, 2014).

In 2009, state school superintendents and education policy advisors began the work to unify learning targets across states in the United States (Conley, 2014; Peterson, Barrows, & Gift, 2016). The result of the work concluded with the creation of a consortium of 51 states and territories and the Common Core State Standards Initiative (2010a, 2010b). CCSS are universal, concise statements that inform students of the knowledge and skills required for mastery in programs of study in K-12 schools (Common Core State Standard Initiative, 2010a, 2010b). Although as many as 51 states and territories agreed to participate in developing the CCSS, the number choosing to adopt CCSS fell to as low as 43 states and 4 territories by 2016 (Common Core State Standards Initiative, 2016; Conley, 2014; Peterson et al., 2016).

Similarly, in 2010, 26 states formed a consortium working in conjunction with the National Science Teachers Association, American Association for the Advancement of Science, and Achieve, Inc. to compose the NGSS (NGSS Lead States, 2013). The National Research Council led the 26 states and professional organizations in a multi-year operation that was preceded by the work, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NGSS Lead States, 2013; Quinn et al., 2012). NGSS are performance expectations based on concepts and skills in which students need to demonstrate an understanding for proficiency in science (NGSS Lead States, 2013). In 2013, after review from the National Research Council, NGSS were presented to professional education associations in the United States to be considered for adoption into science education practices in K-12 schools (NGSS Lead States, 2013). Later in 2013, 12 states adopted NGSS, and by 2016, the total had grown to 17 states (Academic Benchmarks, n.d.; NGSS Lead States, 2013; NSB, NSF, 2016).

The state of Georgia was a participating member of the Common Core State Standards Initiative, and the English language arts CCSS were in practice throughout K-12 schools in the state. On February 19, 2015, The Georgia State Board of Education voted and renamed the English language arts CCSS to the English language arts Georgia Standards of Excellence (GSE) while retaining the content and structure of the standards (GaDOE, 2015f). The state of Georgia was not a participating state in adopting the NGSS, and, therefore, was continuing the use of the in-place Georgia Performance Standards (GPS) for science in K-12 schools during the development of this study (GaDOE, 2006). However, On June 9, 2016, The Georgia State Board of Education voted and adopted the K-12 Science GSE to be implemented beginning with the 2017-2018 school year (GaDOE, 2015d). The Georgia State Board of Education (2016d) explained that the Science GSE (SGSE) were developed to foster student proficiency in science through foundational knowledge and skills. The Georgia State Board of Education professed that The Project 2061's Benchmarks for Science Literacy and the follow up work, A Framework for K-12 Science Education was used to center the standards on deciding proper content knowledge and process skills for K-12 students. Considering the SGSE are not the NGSS, future research studies should recognize they are directly aligned with the work, A Framework for K-12 Science Education, and reflect the practices, crosscutting concepts, and core ideas for constructing knowledge and advancing proficiency in science (GaDOE, 2016d; Quinn et al., 2013; NGSS Lead States; 2013). Furthermore, (see Table D1 in Appendices) the in-place GPS for Science and the incoming SGSE are nearly identical with adjustments being made to reflect the practices, crosscutting concepts, and core ideas set forth by the work, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (GaDOE, 2006, 2016d; Quinn et al., 2012). Moreover, the in-place GPS, while being adjusted to become the SGSE, also added connections to interdisciplinary literacy expectations set forth by the English language arts CCSS and the GaDOE's shift in focus towards literacy in science (Common Core State Standards Initiative, 2010a, 2010b, 2016; GaDOE, 2006, 2015e, 2016d). Therefore, to provide greater significance for the study, it would be appropriate to include background information for NGSS and CCSS.

The SGSE and NGSS were written as performance expectations with the foundation on the three dimensions of learning science described in Quinn et al.'s (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (GaDOE, 2016d; NGSS Lead States, 2013). Regarding the integration of literacy and science, the NGSS Lead States (2013) declared an alignment by grade bands to the critical thinking skills and knowledge within the English Language Arts and Mathematics CCSS for the progression of learning across the curriculum. Similarly, GaDOE (2015e) affirmed the English Language Arts CCSS integration of literacy and science with shifts toward literacy in science focused on (a) *constructing* knowledge through reading informational, nonfiction text; (b) *identifying* text evidence to support reading, writing, and oral presentations; and (c) *practicing* literacy skills attentively amidst text with extended complexity and content area vocabulary (Conley, 2014). The GaDOE's (2015e) focus on literacy in science is supported through the implemented English language arts GSE and incoming SGSE in K-12 schools (GaDOE, 2015g; GaDOE, 2016d).

Integrated Instruction

SGSE and NGSS are deeply rooted in integrative practices within K-12 education (GaDOE, 2016d; NGSS Lead States, 2013). SGSE and NGSS engage students in developing proficiency in science by applying scientific inquiry and content knowledge through demonstrating understanding with literacy skills (GaDOE, 2016d; NGSS Lead States, 2013). K-12 educators can scaffold science instruction with integrated instructional strategies based on literacy as CCSS and NGSS and related standards such as SGSE all have a focus on literacy across all content areas (Common Core State Standard Initiative, 2010a, 2010b; Conley, 2014; GaDOE, 2016d; NGSS Lead States, 2013). Recognizing how critical literacy skills are to constructing knowledge in science, the NGSS and CCSS development and writing teams collaborated to label critical literacy connections definite content demands drafted in the NGGS (NGSS Lead States, 2013). CCSS asserts that admiration for practices and criteria in the discipline of science is a requirement for reading in science (Common Core State Standards Initiative, 2010a; NGSS Lead States; 2013). States that adopt CCSS can plan to integrate the instruction of science content and STEM with literacy, English language arts, and social studies (Blank, 2013). Literacy instruction is nonnegotiable under contemporary educational policy and science education, and STEM could benefit from integrated instructional strategies as CCSS focuses on literacy across the curriculum (Boyd, Sullivan, & Hughes, 2012).

Literacy instruction, when integrated with science and STEM subjects, should cultivate student learning by teaching comprehension skills and strategies, content specific vocabulary, and the purpose and structure of text while increasing students' participation and desire to learning in both content areas (Friedland, McMillen, & Hill, 2011). Considering Dewey's (1938) experiential learning theory and the integration of science and literacy during instruction, NGSS (2013) reported that information literacy skills are a critical means to declaring and justifying scientific claims, communicating knowledge of concepts, and describing learning experiences.

Elementary school science instruction provides the opportunity to merge science content with literacy skills through an integrated instruction approach to encourage success and academic achievement in science. Integrated instruction is defined as the use of a combination of content area and instructional strategies to teach a certain standard or skill (Sanders, 2008). STEM integrated learning activities involve merging STEM with literacy, English language arts, or social studies (Sander, 2008). Science and English language arts integrated learning activities have been shown to improve students' performances on science academic achievement assessments and positively impact their dispositions toward science when compared to those students who receive separate literacy and science instruction (Cervetti et al., 2012; Fang & Wei, 2010; Guthrie et al., 2004; Jackson & Ash, 2012; Romance & Vitale, 1992, 2012; Vitale & Romance, 2012).

As early as the 1990s, Romance and Vitale (1992) found that integrated instruction between science and English language arts literacy skills during instructional time increased science academic achievement to a recognizably higher level versus when they were segregated. Casteel and Isom (1994) found that focusing on the aspects of English language arts literacy skills during the instruction of science content would reduce factors, which lead students toward disliking science. Correspondingly, Ødegaard et al. (2014) determined that science inquiry benefited science and literacy learning through integrated instructional activities. Identically, Cervetti et al. (2012) concluded that integrated instructional activities positively impacted students 'science academic achievement and guided literacy development.

Researchers have also found that female students see growth in their science academic achievement, attitudes, enthusiasm, motivation, and self-esteem in STEM with the implementation of integrated science and English language arts literacy skill instruction (Deemer et al., 2014; O'Reilly & McNamara, 2007; Ramsey et al., 2013; Stout et al., 2011; Tyler-Wood et al., 2012). Thus, the use of integrated science and English language arts learning activities may advance students' reading, writing, and communication skills in scientific inquiry and increase their enthusiasm, motivation, and attitudes toward science education and STEM fields of study as they progress through K-12 and post-secondary school (Carney & Indrisano, 2013; Casteel & Isom, 1994; Fang & Wei, 2010; Krajcik & Sutherland, 2010; Ødegaard et al., 2014; Palincsar, Magnusson, Collins, & Cutter, 2001; Pearson et al., 2010; Riegle-Crumb et al., 2011; Robertson et al., 2014; Webb & Rule, 2012).

Regarding science instruction, Blank (2013) suggested an intervention strategy for teachers to prerelease science content standards to be learned each week as micro-managing time and learning targets for science may be too ambitious for elementary classrooms because of a focus on performance accountability in reading and math. In that case, teachers can provide a checklist of supplemental learning activities for students to complete to meet the standards during additional instructional time (Blank, 2013). In fact, many of the research studies reviewed deployed a variety of instructional delivery models (e.g., supplemental, replacement, augmented) for implementing integrated science and English language arts literacy instruction and traditional-based (e.g., business-as-usual, conventional, customary) science instruction across K-12 grade bands proved to be effective in increasing student academic achievement in science (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 1992, 2012; Spear-Swerling & Zibulsky, 2014; Vitale & Romance, 2012). Blank (2013) asserted that achievement in science during the era of unprecedented STEM field growth was fundamental, but that time allocations for the instruction of science in elementary schools were diminishing, and that time must be spent on science instruction if students' performance was expected to demonstrate growth.

Summary

In the United States, the transition to an information and service-based global economy from a manufacturing-based economy indicated a critical need for a well-trained workforce with STEM skills (Conley, 2014; Holdren et al., 2013; Pinnell et al., 2013). Science is recognized as a component of STEM. Researchers reported that the lack of focus on science education, particularly at the elementary school level, caused science academic achievement in the United States to remain stagnant as compared to the rest of the world based on national and international comparisons of longitudinal assessment data (Conley, 2014; Holdren et al., 2013; Kelly et al., 2013; Miller, 2010; NSB, NSF, 2016; The President's Council of Advisors on Science and Technology, 2011; Provasnik et al., 2012, 2016). Researchers in the United States linked concerns of stagnant K-12 science academic achievement to a dwindling workforce prepared to participate in STEM fields of study and jobs (Conley, 2014; Holdren et al., 2013; Miller, 2010). Researcher determined the challenges with instructional time, resources, and capacity impacted elementary science academic achievement and potentially further accentuated a dwindling workforce prepared to participate in STEM fields of study and jobs in the future (Miller, 2010; Obama, 2009; Pub. L. 89-10). Researchers noted that focusing on science education at the elementary school level was critical for long-term success in STEM fields of study and jobs in the future (Judson, 2013; Shanahan & Shanahan, 2012).

Science is recognized as a component of STEM, as well as a core content area within the larger framework of traditional K-12 education. In comparison to reading and math education, however, researchers reported that a focus on science education at the elementary school level was insubstantial as compared to other subjects such as reading and math (Banilower et al., 2013; Century et al., 2008; Chen, 2009; Eidietis & Jewkes, 2011; Griffith & Scharmann, 2008; Johnson, 2007; Judson, 2013; Levy et al., 2008; Miller, 2010; Obama, 2009; Pearson et al., 2010; Sandholtz & Ringstaff, 2011; Sikma & Osborne, 2014). Sandholtz and Ringstaff (2014) purported that despite national standards for science instruction, science education at the elementary school level remained inequitable as compared to reading and math instruction. The lack of focus on science education at the elementary school level, due broadly in-part to policies from the NCLB era, influences challenges with instructional time, resources, and capacity in schools particularly at the elementary level of the K-12 education continuum (Eidietis & Jewkes, 2011; Judson, 2013). Policy provisions and campaigns, however, including NCLB and The Educate to Innovate Campaign, affirm the importance of science education in the K-12 education continuum (Johnson, 2007; Obama, 2009).

Insubstantial education and stagnant academic achievement within an academic subject area are directly related to diminishing enthusiasm, participation, and total loss of interest or purpose toward a field of study (Archer et al., 2010; Beede et al., 2011; Cheryan et al., 2011, 2013; Diekman et al., 2016; Falk et al., 2016; Leaper et al., 2012; Robnett & Leaper, 2013; Wyss et al., 2012). The research emphasizes a problem with the female subgroup of the population choosing not to participate in STEM fields of study and jobs in comparison the male subgroup (Leaper et al., 2012; Sadler et al., 2012). Gender bias in science education between male and female students is apparent in the literature (Nnachi, & Okpube, 2015; Stout et al., 2011; Tyler-

Wood et al., 2012; Walters & McNeely, 2010). Male students dominate STEM post-secondary fields of study in comparison to female students (Nnachi, & Okpube, 2015). Moreover, female students remain subjected to gender biases and gender inequity in science education at an age where dispositions toward the content area and field of study are determined (Kurz et al., 2015).

Researchers have found that longitudinal, empirical, and quantitative data support the claim that the instruction of science favors male students as female students historically perform better in English language arts and social studies subjects (Lane et al., 2012; Tyler-Wood et al., 2012). Researchers recognize the importance of science education at the elementary school level, while also a being a component of STEM, and call for more studies into interventions to support academic achievement and long-term success within the content area and STEM fields of study and jobs (Penuel & Fishman, 2012; Wyss et al., 2012).

Researchers have determined that integrated science and English language arts literacy instruction intervention notably raised academic achievement in science compared to when the content areas are taught independently (Cervetti et al., 2012; Fang & Wei, 2010; Krajcik & Sutherland, 2010, Romance & Vitale, 2012). Moreover, the literature affirms that integrated science and English language arts literacy instruction positively changes students' attitudes away from disliking science (Riegle-Crumb et al., 2015; Webb & Rule, 2012). Researchers have identified connections to inquiry-based learning for integrated science and English language arts literacy instruction through third degree (i.e., literacy skill) investigations (Fang, 2013; Pearson et al., 2010). In addition, researchers have found that integrated science and reading/language arts literacy instruction benefits science academic achievement and the development of literacy skills across the curriculum (Cervetti et al.,2012; Fang & Wei, 2010; Ødegaard et al., 2014). Finally, researchers have established that integrated science and reading/language arts literacy instruction positively impacts science academic achievement, and enthusiasm, motivation, and attitudes of female students toward STEM (Deemer et al., 2014; O'Reilly & McNamara, 2007; Ramsey et al., 2013; Stout et al., 2011; Tyler-Wood et al., 2012). Integrated science and English language arts skill instruction encompasses a progressive, constructive, experiential, inquiry-based approach to teaching and learning science (Conner & Bohan, 2014; Hildebrand et al., 2008; Kuhn et al., 2000; Wojcikiewicz, 2010). Various researchers studied the impact of implementing integrated science and English language arts skill instruction deployed through a variety of instructional delivery models (i.e., supplemental, replacement, augmented). Researchers have not, however, studied the impact of ISLES in conjunction with traditional-based (business-as-usual, conventional, customary) on science academic achievement of upper elementary level students.

CHAPTER THREE: METHODOLOGY

Overview

In this chapter, the researcher will provide a description of the components within the methodology for this study. The detailed information in this chapter will provide context related to how the study was conducted. The contents of this chapter include the research design, research questions and hypothesis, participants and setting, instrumentation, procedures, and data analysis.

Design

The researcher in this study used a quasi-experimental, nonequivalent control group design to analyze the difference in science academic achievement when students were instructed with an 8-week integrated science and English language arts literacy skill supplemental instructional intervention (ISLES) in conjunction with traditional science classroom instruction as compared to when instructed using solely traditional science classroom instruction. Science academic achievement was measured by archived Spring 2015, and archived Spring 2016 GMEOGA for Science. Gall, Gall, and Borg (2007) explained that a quasi-experimental, nonequivalent control group should be used when the design consist of participants assigned to nonrandomized treatment and control groups with the inclusion of a pretest and posttest administered to those groups. Because of the use of a convenience sample for this study, equivalence did not exist between groups; therefore, analysis of covariance (ANCOVA) controlled for group differences other than the treatment, statistically. The independent variables were types of instruction. The dependent variable was academic achievement on the Spring 2016 fourth-grade GMEOGA for Science. A nonequivalent control group design was used for this study, and there was no GMEOGA pretest on any grade level. Therefore, the statistical control variable, prior science achievement academic, from the third-grade, Spring 2015 GMEOGA for Science was used as a pretest for ANCOVA for this study.

Research Questions

RQ1: Does the addition of an 8-week supplemental curricular intervention to traditional instruction make a difference in fourth-grade student achievement scores?

Null Hypothesis

H_{o1}: There is no significant difference among the student achievement scores in science of fourth-grade students who are provided either traditional curricular instruction plus an 8-week supplemental curricular intervention or solely traditional curricular instruction while controlling for prior achievement.

Participants and Setting

The participants for the study were drawn from a convenience sample of previously intact fourth-grade classes at an elementary school located in the southeastern region of the United States. The target elementary school is part of a large, urban metro school district, which, at the time of data collection, serviced approximately 109,000 students (GaDOE, 2016c). In all, 83 elementary schools are in the target school district. At the time of data collection, the total number of students in the target population of participants within the target school district was 8,021. The targeted elementary school is labeled as a Title I school that serves a student population, which is greater than 96% eligible for the free or reduced lunch program. At the time of data collection, this study's target elementary school's population was approximately 650 students. The number of sample participants in this study consisted of 115 students in fourth-grade classes within the targeted elementary school. According to Gall et al. (2007), 81 students is the required minimum for a medium effect size with a statistical power of .7 and alpha level at 0.05.

The entire sample participation was drawn from previously intact fourth-grade homeroom classes within the targeted elementary school. The demographics for the sample participants were 67 males (58.3%) and 48 females (41.7%). There were 105 African American students (91.3%), 2 Asian students (1.7%), 3 European American students (2.6%), 2 Mixed-Racial students (1.7%), and 3 Hispanic students (2.6%). The treatment group consisted of 35 male and 23 female students. The control group consisted of 32 male and 25 female students. The age range of the sample participants in this study was from 9 to 11 years old.

The setting for this study occurred within four previously intact fourth-grade homeroom science classes at an urban elementary school located in the southeastern region of the United States. Both the treatment and control teachers had taught traditional science classroom instruction; however, the treatment group homeroom teachers had instructed their homeroom students with ISLES activities based on the elementary school's Instructional Intervention Activities Planning Checklist, as shown in Table 3.1. The ISLES treatment was implemented 5 days a week, 25 minutes per sessions, for 8-weeks during pre-class, nonmaster scheduled, morning-work instructional skills-block periods. The treatment phase lasted from February to April 2016, and the Spring 2016 GMEOGA for Science posttest had been administered immediately post treatment during the month of April 2016 based on the targeted school districts testing calendar.

Table 3.1

Participants and Setting

		Treatment Group		
Teacher	Type of Instruction	Male Students	Female Students	Total
1	TSCI and ISLES	19	09	28
2	TSCI and ISLES	16	14	30
		Control Group		
3	TSCI	16	11	27
4	TSCI	16	14	30
Total		67	48	115

Note. ISLES = Integrated science and English language arts literacy supplemental instructional intervention; TSCI = traditional science classroom instruction

Table 3.2, Table 3.3, and Table 3.4 display the frequency distribution of students by race, gender, and age within the convenience sample of participants included within this study. The frequency distribution of students by race, gender, and age are categorized as within treatment and control groups. The frequency distribution of students' race is shown in Table 3.2. The frequency distribution of students race within the treatment group consisted of 94.8% (n = 55) Black students, 3.4% (n = 2) mixed students, 1.7% (n = 1) White students. The control group consisted of 87.7% (n = 50) Black students, 5.3% (n = 3) Hispanic students, 3.5% (n = 2) Native American students, 3.5% (n = 2) White students.

Table 3.2

Frequency Distribution of Student Race

Group		Race				
		Black	Hispanic	Mixed	Native American	White
Treatment	N	55	0	2	0	1
	% within TSCI and ISLES	94.8%	0.0%	3.4%	0.0%	1.7%
Control	N	50	3	0	2	2
	% within TSCI	87.7%	5.3%	0.0%	3.5%	3.5%
Total	N	105	3	2	2	3
	% within Total	91.3%	2.6%	1.7%	1.7%	2.6%

Note. N = number of students; ISLES = Integrated science and English language arts literacy supplemental instructional intervention; TSCI = traditional science classroom instruction

The frequency distribution of student gender is shown in Table 3.3. The frequency distribution of student gender within the treatment group consisted of 39.7% (n = 23) female students and 60.3% (n = 35) male students. The control group consisted of 43.9% (n = 25) female students and 56.1% (n = 32) male students.

Table 3.3

Frequency Distribution of Student Gender

Group		Gender	
		F	*M*
Treatment	N	23	35
	% within TSCI and ISLES	39.70%	60.30%
Control	N	25	32
	% within TSCI	43.90%	56.10%
Total	N	48	67
	% within Total	41.70%	58.30%

Note. N = number of students; ISLES = Integrated science and English language arts literacy supplemental instructional intervention; TSCI = traditional science classroom instruction

The frequency distribution of student age is shown in Table 3.4. The frequency distribution of (age) within the treatment group consisted of 32.1% (*n* = 18) 9-years' old students, 57.1% (*n* = 32) 10-years' old students, 8.9% (*n* = 5) 11-years' old students, and 1.8% (*n* = 1) 12-years' old students. The control group consisted of 26.8% (*n* = 15) 9-years' old students, 64.3% (*n* = 36) 10-years' old students, 8.9% 11-years' old students (*n* = 5), and 0% (*n* = 0) 12-year-old students.

Table 3.4

Frequency Distribution of Student Age

Group		Age			
		9	10	11	12
Treatment	N	18	32	5	1
	% within TSCI and ISLES	32.10%	57.10%	8.90%	1.80%
Control	N	15	36	5	0
	% within TSCI	26.80%	64.30%	8.90%	0.00%
Total	N	33	68	10	1
	% within Total	29.50%	60.70%	8.90%	0.90%

Note. N = number of students; ISLES = Integrated science and English language arts literacy supplemental instructional intervention; TSCI = traditional science classroom instruction

Instrumentation

The instrument used to measure science academic achievement in this study was the GMEOGA for Science. The GaDOE Assessment Guide (2015a, 2015b) describes the origin of the GMEOGA as an assessment that meets the requirements of Georgia law by the State Board of Education. The law determined that in the state of Georgia, an assessment must exist that connects state-adopted content standards and the knowledge and skills within to a measure of student academic achievement. GMEOGA intends to apprise efforts to enhance instruction and learning of state-adopted content standards and quantify academic achievement (GaDOE, 2015a, 2015b). GMEOGA's appropriateness for this study to measure the impact of ISLES on science academic achievement gains support by the program's rationale. GaDOE (2015a, 2015b) rationale describes the outcomes of the assessment program helps to discover students unsuccessful with accomplishing mastery of content.

Georgia Milestones End-of-Grade Assessments

Students in the targeted school district took the Spring 2016 fourth-grade GMEOGA for Science in April during the 2015-2016 school year. The GMEOGA for Science was administered to students by certified educators, other than the homeroom students' teachers. The GMEOGA was administered in two sections with a maximum of 70 minutes per section allowed to complete the assessment, unless there were special education modifications, which are required by law. The same rules applied to the previously administered Spring 2015 GMEOGA for Science during the 2014-2015 school year. The Spring 2015, and Spring 2016 GMEOGA for Science were administered using online, and paper/pencil modes of administration with a scheduled progression to a fully online assessment within a 5-year period. Students with special needs and accommodations continued to be offered the paper/pencils test materials as needed (GaDOE, 2015a).

The GMEOGA for Science is a criterion-referenced test, which was designed to provide information about student mastery of state-adopted content standards in science (GaDOE, 2015a, 2015b). The Spring 2015, and Spring 2016 GMEOGA for Science test three content domains. The GaDOE (2015a, 2015b) assessment guide defines a content domain as a nominal section that universally outlines the content of a course, as measured by End-of-Grade Assessments (GaDOE, 2015a, 2015b). GMEOGA content domains were Earth Science, Life Science, and Physical Science. The Spring 2015 third-grade GMEOGA for Science content domain weight proportions equaled (34%) Earth Science, (33%) Life Science, and (33%) Physical Science

(GaDOE, 2015b). The Spring 2016 fourth-grade GMEOGA for Science content domain weights proportions equaled (40%) Earth Science, (30%) Life Science, and (30%) Physical Science (GaDOE, 2015a).

The GMEOGA for Science contains 75 selected response items, which are machine scored for accuracy by GaDOE (GaDOE, 2015a, 2015b). Ten of the total selected response items were designated for field testing to be considered for future versions of the GMEOGA for science and were not included in determining students' scale scores (GaDOE, 2015a, 2015b). Furthermore, 10 of the total selected response items are norm-referenced items that are not included in determining students' scale scores, but only for comparison nationally (GaDOE, 2015a, 2015b). Finally, 10 of the total selected response items are norm-referenced questions aligned by Georgia Educators with curriculum content standards and included in determining students' criterion-referenced, scale scores (GaDOE, 2015a, 2015b). The remaining total of 45 selected response items are used by GaDOE to determine students' criterion-referenced, scale scores (GaDOE, 2015a, 2015b). Therefore, criterion-referenced, scale scores are based on 55 selected response items and equally as many points (GaDOE, 2015a, 2015b).

Validity and Reliability

Validity for the GMEOGA is instituted through the procedure of developing the test. Validity is not related to the test instrument, but rather if test scores can be appropriately used to measure the intended purpose of the test (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 2014; Fan, 2013). Development of GMEOGA includes following a rigorous development process that conforms to the Standards for Educational and Psychological Testing set forth by the APA, NCME, and AERA (AERA, APA, & NCME, 2014, GaDOE, 2016a).

Committees of Georgia educators participate in a content standards review that determines which and how concepts, knowledge, and skills are tested in GMEOGA for Science (GaDOE, 2016a). Qualified professional assessment specialist draft test items that are reviewed by committees of Georgia educators for calibration with curriculum, propriety, and possible bias and sensitivity issues (GaDOE, 2016a). The committees of Georgia educators have the right to reject or revise test item; however, if items are accepted, they are planted on operational test forms for field testing by the GaDOE (2016a).

While giving mandatory attention to content and statistical data, selected field-tested items are used to create multiple test forms that are equated to be certain that test forms are equal in difficulty (GaDOE, 2016a). Test forms are created to assess identical ranges of content and statistical attributes (GaDOE, 2016a). Once final test forms are administered to students, the results are processed to determine scale scores, and result are distributed to stakeholders (GaDOE, 2016a). Reliability indicators support the distinction of GMEOGA as having a high degree of validity by meeting the expectations for its intentioned purpose (AERA, APA, & NCME, 2014; Cronbach, 1951; Fan, 2013; GaDOE, 2016a).

Reliability is related to the level of consistency amid answers to items on an instrument with the intentions to measure identical dimensions (Cronbach, 1951; Nolan, Beran, & Hecker, 2012). The GaDOE uses Cronbach's alpha reliability coefficient to measure the reliability of GMEOGA (GaDOE, 2016a). Cronbach's alpha measures internal regularity throughout the answers to a group of items measuring a latent one-dimensional attribute (Cronbach, 1951). The GaDOE (2016a) reports Cronbach's alpha reliability coefficients for the third-grade, Spring 2015 GMEOGA for Science range from 0.89 to 0.92 for online and paper/pencil modes of administration that demonstrate reliabilities across all forms and administrations of the test

(Cronbach, 1951; GaDOE, 2016a). The GaDOE (2016b) reports Cronbach's alpha reliability coefficients for the fourth-grade, Spring 2016 GMEOGA for Science range from 0.89 to 0.90. The GMEOGA for Science's Cronbach's alpha reliability coefficients imply that the assessments are adequately reliable in their intended purpose and present a reliable report of student academic achievement (GaDOE, 2016a).

Procedures

The following paragraphs detail the systematic procedures used to conduct this study. The researcher applied for Internal Review Board approval from Liberty University and approval was granted (See Appendix A). The researcher sought approval from the targeted school district's Research Review Board to conduct research using archived demographic, Spring 2015, and Spring 2016 GMEOGA for Science student data. Upon approval, the researcher contacted the targeted elementary school's principal for permission to access archival data sets for the targeted grade level. The targeted elementary school's principal, instructional leaders, and teachers, who understand empirical research and school-wide academic data, previously made the decision independently to adopt and implement *research-based* integrated science and English language arts literacy instruction into school-wide instructional practices. Furthermore, the targeted elementary school's principal, instructional leaders, and teachers on the targeted grade level decided to implement an 8-week ISLES on the targeted grade level and randomly to assign teachers to participation and nonparticipation groups. Therefore, the targeted elementary school had two teachers on the targeted grade level who instructed students using an 8-week ISLES in conjunction with traditional science classroom instruction, and two teachers who instructed students using solely traditional science classroom instruction during the 2015-2016 school year.

The traditional science classroom instruction, which were provided to both treatment and control homeroom groups, was based on state-adopted science content standards and the school district's adopted science curriculum, adopted commercial textbook series, pacing charts, and planning guides. The state-adopted science standards and school district's adopted science curriculum were based on either earth, life, or physical science content domains. The treatment and control group teachers developed and implemented traditional instructional lesson plans for science to all their assigned homeroom students on their assigned grade level for the 2015-2016 school year. Mandated traditional science classroom instruction periods were built into the elementary school's master schedule to occur Monday through Friday each week for approximately 60-minutes per day.

Treatment group teachers provided ISLES activities to students, 5 days a week for 25 minutes per session during morning, nonmaster scheduled, pre-class, instructional skills-block work periods for a duration of 8 weeks from February through April 2016. The ISLES activities were based on either earth, life, or physical science content domains that aligned to state adopted science content standards and district's adopted science curriculum. The ISLES activities for each session, as shown in Table C1, included, but were not limited to, leveled nonfiction books, differentiated word work activities (e.g., matching, unscramble, crossword, fill in the blank, word search, analogies), comprehension graphic organizer activities (e.g., cause and effect, main idea and details, compare and contrast, sequence of events), vocabulary-building activities (e.g., definition, picture, sentence), and information summarizing activities (e.g., multiple choice, tables, short answer, extended response).

All weekly-determined ISLES activities were provided to students on Monday through Friday based on the targeted elementary school's implementation checklist, see Table C1 in

Appendices. Treatment group teachers provided foundational whole-group guided practice instruction and displayed written directions and anchor charts to support students in completing learning activities during the morning, nonmaster scheduled, preclass, instructional skills-block work periods. Treatment group teachers were not required to write supplemental lesson plans or record and report any data for the ISLES instructional skills-block work periods as the activities were not included in traditional science classroom instruction grading practices and did not in any capacity affect, impact, or alter traditional science classroom instruction grading procedures. The ISLES activities were supplemental to the teacher-developed traditional science classroom instruction lesson plans and aligned to state-adopted science content standards and school district's curriculum planning guides. The ISLES were provided using pre-developed, research-based supplemental instructional materials adopted by the school's principal into school-wide instructional practices. Treatment group teachers crosschecked fidelity for the provision of learning activities on the activity checklist, as shown in C1, designed by the school's instructional leaders and teachers for the implementation of the ISLES activities.

The data manager for the targeted elementary school within the participating school district provided the researcher with Excel spreadsheets data files containing the archived student demographic, Spring 2015, and Spring 2016 GMEOGA for Science student scores by class for both the treatment and control groups without any identifiable information of the students or teachers present in the data files. The data manager identified teachers' homeroom groups for data analysis based on participation and nonparticipation during the implementation phase of the Integrated Science and Literacy SII for the 2015-2016 school year. The researcher required that teachers be identified as number 1, 2, 3, or 4, and students be identified by a district provided identification number designed only for identifying treatment and control grouping for data analysis in this study. The researcher did not collect or report any names or record any data directly from teachers or students from within any classroom during this study. This process protected the privacy of students and teachers. Once finalized scores for the 2015-2016 GMEOGA for Science were verified, the data manager sent the researcher the data files. At this point, the researcher uploaded the archived scale scores from the third-grade Spring 2015 GMEOGA for Science to control for prior achievement, and the archived scale scores from the Spring 2016 fourth-grade GMEOGA for Science to measure academic achievement from the excel spreadsheets into SPSS and run the appropriate analyses.

Data Analysis

An ANCOVA was used to analyze RQ1 to determine any difference among science academic achievement on the GMEOGA for Science of students who were instructed with an 8-week ISLES in conjunction with traditional science classroom instruction as compared to when instructed using solely traditional science classroom instruction. An ANCOVA is used when the researcher wants to control the variable of predetermined differences between treatment and control groups with two independent variables and a dependent variable (Gall et al., 2007). This study's independent variables at the nominal level were types of instruction. The dependent variable at the ratio level were academic achievement scale scores on the fourth-grade, Spring 2016 GMEOGA for Science. The statistical control variable, prior achievement, consisted of academic achievement scale scores from the third-grade Spring 2015 GMEOGA for Science. Gall et al. (2007) determined that for an ANCOVA, statistical procedure the power will be set to 0.7, covariate r set to 0.5, and the alpha will be set to $p < 0.05$.

The researcher used SPSS for assumption testing. The sample population was greater than 50 ($N = 115$) so the Kolmogorov-Smirnov test for assumption of normality was used to determine if distributions were normal for the ANCOVA. The assumption tests for the ANCOVA included a box and whisker plot to look for extreme outliers and Levene's test for equality of error variance with tests for assumption of linearity. The assumption tests for the ANCOVA also included a scatter plot to test the assumption of bivariate normal distribution and assumption of homogeneity of slopes. Partial eta squared η_p^2 determined effect size because the study's statistical analysis was ANCOVA (Gall et al., 2007). The level of measure for the dependent variable was at the ratio level and was tested at the 95% confidence level.

CHAPTER FOUR: FINDINGS

Overview

In this chapter, the researcher will provide a description of the components within the data analysis for this study. The detailed information in this chapter will provide context related to the findings of this study. The contents of this chapter include the research questions, null hypothesis, descriptive statistics, results, and assumption tests.

Research Questions

RQ1: Does the addition of an 8-week supplemental curricular intervention to traditional instruction make a difference in fourth-grade student achievement scores?

Null Hypothesis

H_{o1}: There is no significant difference among the student achievement scores in science of fourth-grade students who are provided either traditional curricular instruction plus an 8-week supplemental curricular intervention or solely traditional curricular instruction while controlling for prior achievement.

Descriptive Statistics

An archival data file was presented to the researcher containing third grade Spring 2015, and fourth grade Spring 2016 GMEOGA for Science scale scores. The archival data file consisted of a convenience sample of 115 students from within previously intact fourth-grade classes at an elementary school located in the southeastern region of the United States. During initial analysis of the data, the researcher discovered an extreme outlier within the control (TSCI) group. The extreme outlier can be seen in Figure 4.2. The extreme outlier's pretest scale score was the highest within either group, but had an average posttest scale score (463). Because a convenience sample was used for this study, the extreme outlier was removed and an ANCOVA was reexecuted with a convenience sample of 114 students with results presented in Table 4.5.

Summary statistics for student assessment scores are shown in Table 4.4. The treatment group had a mean pretest score of 465.21 (*SD* = 30.72) and mean posttest score of 454.34 (*SD* = 36.06). The control group had a mean pretest score of 475.72 (*SD* = 37.46) and a mean posttest score of 464.33 (*SD* = 45.73). The mean of the treatment group in comparison to the control group *across* the pretest and posttest showed an approximate 10-point difference between the groups. The mean of the treatment group in comparison to the control group *within* the pretest, and posttest showed an approximate 10-point difference between the groups. The treatment group had a median pretest score of 460.5 (Min = 410) (Max = 545) and a median posttest score of 447 (Min = 406) (Max = 589). The control group had a median pretest score of 470 (Min = 415) (Max = 594) and a median posttest score of 463 (Min = 369) (Max = 627). The treatment group's median had a 13-point difference and the control group's median score had a 7-point difference. The pre-existing differences between the treatment and control group was not contingent upon the intervention in the study and based on unadjusted descriptive statistical analysis.

Table 4.4

Summary Statistics for Student Assessment Scores

Time	Group	Mean	Median	Std. Deviation	Minimum	Maximum
Pre-Assessment	Intervention	465.21	460.5	30.72	410	545
	No Intervention	475.72	470	37.46	415	594
Post-Assessment	Intervention	454.34	447	36.06	406	589
	No Intervention	464.33	463	45.73	369	627

Note. Std. = standard

Results

Assumption Test

Following the standard procedure for Analysis of Variance, SPSS was used to perform the requisite assumption test for an ANCOVA. An ANCOVA allowed the researcher to control the variable of predetermined differences between treatment and control groups with two independent variables and a dependent variable (Gall et al., 2007). Initial assumptions for an ANCOVA were met as observations were independent, as the convenience sample of participants were assigned to a treatment or control group based on the random selection of teachers by the school's principal. The convenience sample of participants was previously grouped into classes prior to the study being conducted therefore the random assignment of teachers to treatment and control groups ensured observations were independent. Because of the use of a convenience sample, prior academic achievement was not evenly distributed across treatment and control groups, so the variable of prior academic achievement was controlled for in the statistical ANCOVA. This study's independent variables were at the nominal level, and the dependent and statistical control variables were at the ratio level.

The sample was greater than 50 ($N = 115$) so the Kolmogorov-Smirnov test for assumption of normality, and histograms of residuals by group (a. Treatment group, $N = 58$) (b. Control group, $N = 57$) were used to determine if distributions were normal for the ANCOVA. Results of the histograms (See Figure 4.1) in general display a bell-shaped pattern designating that each group's residuals are approximately normally distributed. The results of the Kolmogorov-Smirnov test for assumption of normality showed $p > .200$ for the treatment group, and $p > .200$ for the control group. Results of the Kolmogorov-Smirnov test for assumption of normality (See Table 4.5) within each group indicated normal distribution within each group.

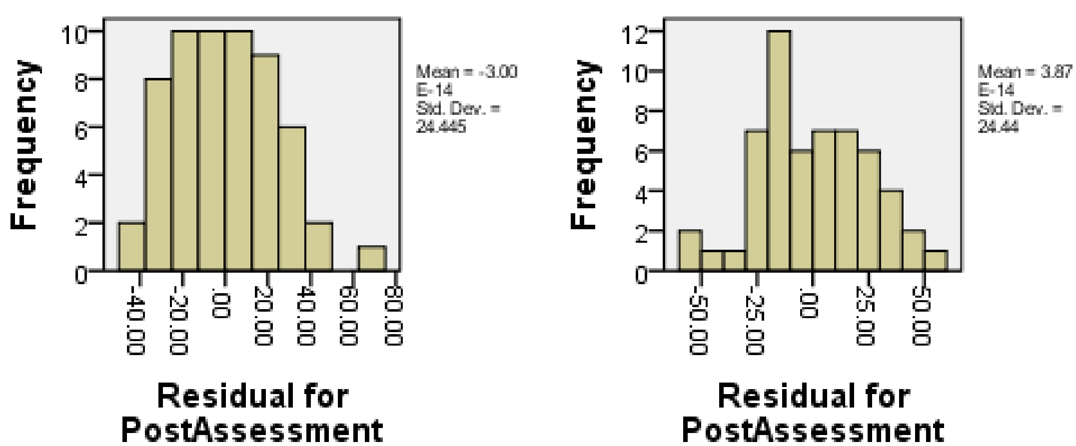
The assumption tests for the ANCOVA also included Levene's test for equality of error variance. The results of Levene's test for equality of error variance showed $F(1,112) = 0.094$, $p = 0.76$. The $p = 0.76$ statistic is relatively high concluding that the treatment, and control groups do not show evidence of having different variability in the residuals. The assumption of linearity for the ANCOVA included a scatter plot to test the assumption of bivariate normal distribution. The scatterplot (See Figure 4.3) did not show a distinct pattern to the residuals which provided evidence for the linearity of the model. The assumption test for homogeneity of slopes showed $F(1,110) = 3.814$, $p = 0.053$. The statistics showed $p > 0.05$, which indicated the effect of the pretest scores was the same for the treatment and control groups.

Table 4.5

Results of Kolmogorov-Smirnov Tests for Normality

Group	Statistic	*df*	*p*-value
Treatment	0.074	58	.200*
Control	0.074	56	.200*

* This is a lower bound of the true significance.



a) Intervention Group

b) No Intervention Group

Figure 4.1. Histograms of residuals by group

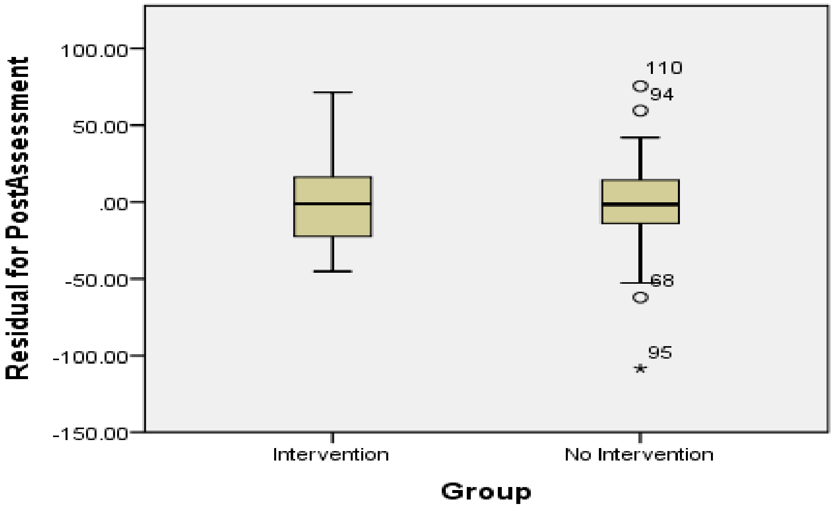


Figure 4.2. Box plots of residuals by group

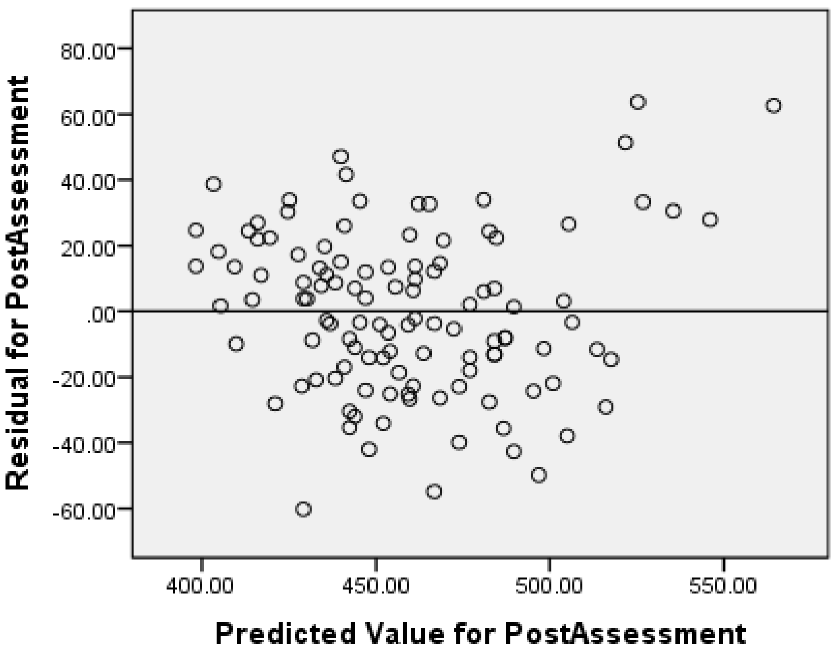


Figure 4.3. Scatterplot of residuals v. predicted values

Null Hypothesis One

Null Hypothesis One stated, "There is no significant difference among the student achievement scores in science of fourth-grade students who are provided either traditional curricular instruction plus an 8-week supplemental curricular intervention or solely traditional curricular instruction while controlling for prior achievement."

An ANCOVA was conducted in SPSS to analyze Null Hypothesis One. An ANCOVA is appropriate when there is a need to control predetermined differences between treatment and control groups with two independent variables and a dependent variable (Gall et al., 2007). The researcher failed to reject Null Hypothesis One, which indicated there was no significant difference between the adjusted posttest science academic achievement scores of the treatment, and control groups $F(1, 111) = 0.098$, $p = 0.755$, Partial eta squared $\eta_p^2 = 0.001$ (See Table 4.6). Thus, there was no difference in the adjusted mean scores between the treatment group (M_{adj} = 458.538, SE = 3.293) and the control group (M_{adj} = 460.015, SE = 3.35).

Table 4.6

ANCOVA Results – ANOVA Table

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*p*-value	Partial Eta Squared
Intercept	165.17	1	165.17	0.265	0.608	0.002
Group	61.13	1	61.131	0.098	0.755	0.001
Pre-Assessment	121967.02	1	121967.019	195.548	<0.001	0.638
Error	69232.94	111	623.72			

Table 4.7

Model-Adjusted Post-Assessment Average Scores

			95% Confidence Interval	
Group	Mean	Std. Error	Lower Bound	Upper Bound
Intervention	458.538	3.293	452.012	465.063
No Intervention	460.015	3.352	453.373	466.656

CHAPTER FIVE: CONCLUSION

Overview

In this chapter, the researcher will provide a description of the components within the conclusion for this study. The detailed information in this chapter will provide context related to significance of this study. The contents of this chapter include the research questions, hypothesis, participants and setting, discussion, implications, and limitations, data analysis.

Discussion

The purpose of this quantitative quasi-experimental pretest-posttest control group design study was to analyze the impact of instruction using integrated science and English language arts literacy supplemental instructional intervention (ISLES) in conjunction with traditional science classroom instruction, while controlling for prior academic achievement, on 4th-grade student science academic achievement. The convenience sample of participants was comprised of a population of students from within previously intact 4th-grade homeroom classes at an urban elementary school located in the southeastern region of the United States. The instrument used to measure science academic achievement was the archived Spring 2016 GMEOGA for science (GaDOE, 2015a). The instrument used as the statistical control variable, prior academic achievement, was the archived Spring 2015 GMEOGA for Science (GaDOE, 2015b).

The United States was rapidly transitioning toward an information and service-based STEM global economy (Conley, 2014). The transition signaled a crucial need to focus on workforce development with STEM skills (Conley, 2014; Holdren et al., 2013; Pinnell et al., 2013). Science is recognized as a component of STEM (Chen, 2009). Science is also recognized as a traditional K-12 education core content area of instruction (Chen, 2009).

Science education, however, at the elementary school level has generally struggled to be viewed as a nonnegotiable part of a traditional K-12 education (Judson, 2013).

Several educational researchers have recognized the science education deficiency at the elementary school level (Banilower et al., 2013; Fang, 2013; Sandholtz & Ringstaff, 2011). Numerous educational researchers have found that instructional time, resources, and capacity are barriers to increasing equity for science education in elementary schools (Carney & Indrisano, 2013; Krajcik & Sutherland, 2010; Riegle-Crumb et al., 2015; Robertson et al., 2014; Spear-Swerling & Zibulsky, 2014; Webb & Rule, 2012). Some researchers have found that integrated science and English language arts literacy instruction addresses challenges with equity for science education in elementary schools and improves science academic achievement (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 2012; Vitale & Romance, 2012). This research study contributes to the existing body of literature in science education by determining the impact of integrated science and English language arts literacy instruction as a supplemental instructional intervention on science academic achievement of upper elementary students.

Research Questions One

Research Question One inquired, "Does the addition of an 8-week supplemental curricular intervention to traditional instruction make a difference in fourth-grade student achievement scores?" The null hypothesis was as follows: There is no significant difference among the student achievement scores in science of fourth-grade students who are provided either traditional curricular instruction plus an 8-week supplemental curricular intervention or solely traditional curricular instruction while controlling for prior achievement. For this study, student achievement is described as academic achievement, which is defined as the attainment of facts or skills through cognitive processing as quantified by formative, summative, or standardized assessments (Ferrara et al., 2011).

An ANCOVA of the posttest scores on the Spring 2016 GMEOGA for science, while controlling for prior achievement, showed that the treatment group and control group did not have a statistically significant difference among the student achievement scores in science $F(1, 111) = 0.098$, $p = 0.755$, Partial eta squared $\eta_p^2 = 0.001$ (See Table 4.6). The results show the effect of group was not significant and therefore did not influence posttest.

The results of this study do not support research, which concluded that integrated science and English language arts literacy instruction increased science academic achievement (Cervetti et al., 2012; Fang & Wei, 2010; Krajcik & Sutherland, 2010, Romance & Vitale, 2012). The research studies that are not supported by the results of this study replaced traditional science classroom instruction with integrated science and English language arts literacy instruction (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 2012; Vitale & Romance, 2012). Cervetti et al.'s (2012) study replaced 4th-grade traditional classroom science instruction and traditional literacy instruction through district-adopted instructional materials with integrated science and English language arts literacy instruction. Romance and Vitale's (2012) study replaced 3rd -5th grade traditional reading and English language arts instruction with integrated science and English language arts literacy instruction. Alternatively, Vitale and Romance's (2012) study included supplemental integrated science and English language arts literacy instructional activities with traditional reading and language arts instruction in K-second grade. This study, however, used integrated science and English language arts literacy instruction as a supplemental instructional intervention to traditional science classroom instruction in 4th grade.

Inquiry-based learning is a direct descendant of experiential learning theory (Spronken-Smith & Walker, 2010). Inquiry-based learning through integrated science and English language arts literacy encompasses the third degree of investigations (literacy skills) (Cervetti et al., 2012; Fang & Wei, 2010). Inquiry-based learning by integrated science and English language arts literacy through the third degree of investigations (literacy skills) allow students to display knowledge of content by communicating learning through reading, writing, and speaking. The results of this study do not support the experiential learning theory through inquiry-based learning that by integrated science and English language arts literacy instruction that student achievement in science will be significantly different. Experiential learning theory states that knowledge is gained through various experiences and directed social responsibility (Conner & Bohan, 2014). Experiential learning theory is the foundation of progressive education (Conner & Bohan, 2014). Progressive education principles insist that purposeful learning and academic achievement can produce positive outcomes with the presence of both principles (George, 2011). The results of this study however, did not produce statistically significant differences with the presence of both principles (ISLES and science academic achievement). Therefore, the results of this study do not support the basis of experiential learning theory.

Implications

Between the years of 2010-2020, STEM job growth was expected to grow by a minimum of 20% (Lockard & Wolf, 2012). Researchers, however, argued the United States had been surpassed as leaders in innovative science and technology research and development (Milner et al., 2012; NSB, NSF, 2016). Research and development efforts focusing on STEM education had become aimed at K-12 students. Science is a component of STEM, as well as a core content area of instruction within the K-12 education continuum. Focusing on STEM education at the elementary level of the K-12 education continuum will continue to be a challenge if science education is not recognized as a nonnegotiable core content area of instruction.

One strategy for educational reform in the K-12 education continuum for science has been focused on shifting educational standards and practices to increase student achievement, literacy skills, and success in science and STEM. Quinn et al.'s (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* provided a foundation for reforming and improving educational standards and practices. NGSS Lead States (2013) Next Generation Science Standards are performance expectations based on concepts and skills needed to proficiency in science that incorporate science and engineering practices, crosscutting concepts, and core ideas. Science GSE were developed by the Georgia State Board of Education (GaDOE, 2016d). The Science GSE are learning standards based on foundational knowledge and skills designed to grow student proficiency in science through incorporate science and engineering practices, crosscutting concepts, and core ideas (GaDOE, 2016d).

In contrast, another strategy for educational reform in the K-12 education continuum for science has been focused on shifting instructional strategies to increase student achievement, literacy skills, and success in science and STEM. English Language Arts CCSS focus on literacy in science by constructing knowledge, identifying text evidence, and practicing literacy skills through reading informational nonfiction text (Conley, 2014). Several researchers have focused on integrated science and English language arts literacy instruction and found that student achievement increased with the use of the integrated instructional strategy (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 2012; Vitale & Romance, 2012). Integrated science and English language arts literacy instruction are methods that may help alleviate the challenges of science education not being recognized as a nonnegotiable core content area of instruction.

K-12 schools must recognize science education as a nonnegotiable core content area of instruction. K-12 schools must also commit to finding interventions that address challenges with instructional time, resources, and capacity if science education will not be viewed as a nonnegotiable core content area of instruction. This research study was based on previous research findings and a hypothesis that integrated science and English language arts literacy instruction would increase science academic achievement in upper elementary students (Cervetti et al., 2012; Ødegaard et al., 2014; Romance & Vitale, 2012; Vitale & Romance, 2012).

This study proposed an intervention that alleviated challenges with instructional time, resources, and capacity while attempting to increase science academic achievement, but the study did not yield results that supported the hypothesis. This study did not show a difference in science academic achievement with supplemental integrated science and English language arts literacy instruction in conjunction with traditional science classroom instruction; however, because of the use of a convenience sample for this study, the results cannot be generalized and may yield different results different sample populations. Regardless of the results, this study provided insight to the body of literature on integrated science and English language arts literacy instruction interventions.

Limitations

The researcher was unable to participate in designing the intervention or provide professional development related to the intervention in this study. The review of literature pertaining to this study accentuated that gaining access to instructional time, settings, and resources in educational settings is a challenge without being recognized as a reputable researcher within the educational research community. The researcher, however, identified an integrated science and English language arts instructional intervention activities checklist developed by the targeted school that guided the implementation of the intervention (See Table C1). A review of the integrated science and English language arts instructional intervention activities checklist determined that the ISLES intervention lasted for 8 weeks (See Table C1). As a result, time and treatment interaction was a limitation that can affect internal validity. The researcher recognized that findings in study could be different if ISLES were implemented for a duration longer than 8 weeks.

Instrumentation was a limitation that can affect internal validity as the researcher was unable to observe test items and test forms for the GMEOGA for science. GMEOGA test items and test forms are developed by the Georgia Department of Education and remain in confidentiality until test administrations occur, based on testing calendars adopted by local boards of education. The researcher successfully secured validity and reliability statistics for Spring 2015, and Spring 2016 GMEOGA science test forms that were administered during testing calendars to sample participants (GaDOE, 2016a, 2016b; Gall et al., 2007).

Implementation bias was another limitation that could affect internal validity as the researcher was unable to guide the implementation of the intervention or the traditional science classroom instruction provided to sample participants (Gall et al., 2007). Teachers, however, in the targeted school were required independently to develop science lesson plans for their individual homeroom classes to deliver traditional science classroom instruction. Science lesson plans were based on state-adopted science content standards, and district-adopted pacing charts, curriculum guides, and instructional resources. Instructional resources implemented during the intervention were not included in grading practices or reporting and eliminated from use during traditional science classroom instruction.

A convenience sample was used for this study. As a result, another limitation that can affect internal validity was sample selection bias. Over 90% of the sample population was African American, which may not accurately represent the entire population of students within fourth-grade classes in elementary schools located in the southeastern region of the United States. This means that the results of the study cannot be generalized, and future researchers need to focus on a more diverse demographic of students, which may allow for generalization of the results (Gall et al., 2007).

Recommendations for Future Research

Recommendations for future researchers are needed to advance the body of literature regarding integrated science and English language arts literacy instruction and academic achievement. The researcher recommends the following for future research:

- Conduct research on teachers with science endorsements and their abilities and attitudes toward integrated science and English language arts instruction.
- Conduct research on teachers with reading endorsements and their abilities and attitudes toward integrated science and English language arts instruction.
- Conduct research on Lexile reading levels and integrated science and English language arts instructions in homogenous reading ability class settings.
- Conduct research on blended learning environments and integrated science and English language arts instruction.
- Conduct research on STEM certified schools and integrated science and English language arts instructions.
- Conduct research on single-gender class settings and integrated science and English language arts instructions

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Appendix A. IRB Exemption Letter

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

April 28, 2017

Jamar Marks
IRB Exemption 2857.042817: Impact of Integrated Science and English Language Arts Literacy Supplemental Instructional Curricular Intervention on Science Student Achievement of Elementary Students

Dear Jamar Marks,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(4), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

> (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Please note that this exemption only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether possible changes to your protocol would change your exemption status, please email us at irb@liberty.edu.

Appendix B. School District Research Review Board Approval Letter

Reference: Impact of Integrated Science and English Language Arts Literacy Supplemental Instructional Intervention on Science Academic Achievement of Upper Elementary Students (File # 2016-025)

Dear Mr. J. Marks:

This letter is to inform you that your research proposal has been approved by the Department of Research, Assessments, and Grants for implementation in the DeKalb County School District (DCSD).

When you begin your research you must secure the approval of the principal/chief site administrator(s) for all schools named in the proposal. You should provide the application with all required attachments and this district approval letter to the principal(s) in order to inform their decision. **Please remember the principal/chief site administrator has the final right of approval or denial of the research proposal at that site. In addition, note that teachers and others may elect not to participate in your research study, even though the district has granted permission.**

The last day to collect data in schools in DCSD for the 2016-2017 school year is Friday, March 31, 2017. The deadline is to protect instructional time during the assessment season and end of the year activities scheduled at individual schools. This approval is valid for one year from the date on this approval letter. Should there be any changes, addenda, design changes, or adverse events to the approved protocol, a request for these changes must also be submitted in writing/email to the DCSD Department of Research, Assessments, and Grants during this one year approval period. Changes should not be initiated until written approval is received. Further, should there be a need to extend the time requested for the project; the researcher must submit a written request for approval at least one month prior to the anniversary date of the most recent approval. If the time for which approval is given expires, it will be necessary to resubmit the proposal for another review by the DCSD Research Review Board.

Completed results are required to be submitted to the Department of Research, Assessments, and Grants.

Appendix C. Instructional Intervention Activities Planning Checklist

Table C1

Integrated Science and English Language Arts Instructional Intervention Activities Checklist

Science Integrated Curricular Intervention Instructional Activities Checklist	Day 1 Nonfiction Books (Low, Mid, High)	Day 2 Word Work Activities (Matching, Fill-in-the-Blank, etc.)	Day 3 Graphic Organizers (Main Idea and Details, Cause and Effect, etc.)	Day 4 Vocabulary Study Activities (Draw, Define, Sentence, etc.)	Day 5 Summarizing Activities (Multiple Choice, Short Answer, etc.)
Week 1 Physical Science: Forces and Motion					
Week 2 Physical Science: Simple Machines					
Week 3 Physical Science: Sound and Light					
Week 4 Life Science: Food Energy in Ecosystems					

Table C1 Continued

Table C1

Integrated Science and English Language Arts Instructional Intervention Activities Checklist

Science Integrated Curricular Intervention Instructional Activities Checklist	Day 1 Nonfiction Books (Low, Mid, High)	Day 2 Word Work Activities (Matching, Fill-in-the-Blank, etc.)	Day 3 Graphic Organizers (Main Idea and Details, Cause and Effect, etc.)	Day 4 Vocabulary Study Activities (Draw, Define, Sentence, etc.)	Day 5 Summarizing Activities (Multiple Choice, Short Answer, etc.)
Week 5 Life Science: Adaptations for Survival					
Week 6 Earth Science: Weather					
Week 7 Earth Science: Water Cycle					
Week 8 Earth Science: Planets and Stars					

Note. Reproduced from targeted school's instructional resources

Appendix D. Science GPS and GSE Standards Comparison

Table D1

A Comparison of Fourth-Grade Science Georgia Performance Standards and Science Georgia Standards of Excellence

	Science Georgia Performance Standards	Science Georgia Standards of Excellence
Earth Science	S4E1. Students will compare and contrast the physical attributes of stars, star patterns, and planets.	S4E1. Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets
	S4E2. Students will model the position and motion of the earth in the solar system and will explain the role of relative position and motion in determining sequence of the phases of the moon.	S4E2. Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.
	S4E3. Students will differentiate between the states of water and how they relate to the water cycle and weather.	S4E3. Obtain, evaluate, and communicate information to demonstrate the water cycle.
	S4E4. Students will analyze weather charts/maps and collect weather data to predict weather events and infer patterns and seasonal changes.	S4E4. Obtain, evaluate, and communicate information to predict weather events and infer weather patterns using weather charts/maps and collected weather data.
Life Science	S4L1. Students will describe the roles of organisms and the flow of energy within an ecosystem.	S4L1. Obtain, evaluate, and communicate information about the roles of organisms and the flow of energy within an ecosystem.
	S4L2. Students will identify factors that affect the survival or extinction of organisms such as adaptation, variation of behaviors (hibernation), and external features (camouflage and protection).	

Table D1

A Comparison of Fourth-Grade Science Georgia Performance Standards and Science Georgia Standards of Excellence

	Science Georgia Performance Standards	Science Georgia Standards of Excellence
Physical Science	S4P1. Students will investigate the nature of light using tools such as mirrors, lenses, and prisms.	S4P1. Obtain, evaluate, and communicate information about the nature of light and how light interacts with objects.
	S4P2. Students will demonstrate how sound is produced by vibrating objects and how sound can be varied by changing the rate of vibration.	S4P2. Obtain, evaluate, and communicate information about how sound is produced and changed and how sound and/or light can be used to communicate.
	S4P3. Students will demonstrate the relationship between the application of a force and the resulting change in position and motion on an object	S4P3. Obtain, evaluate, and communicate information about the relationship between balanced and unbalanced forces

Note. Source (GaDOE, 2006, 2016d,)

Appendix E. Recruitment Email

(Emailed to targeted school's principal and academic data manger)

Date

Permission to conduct research

Greetings,

My name is Jamar Marks and I am a doctoral candidate in the school of education at Liberty University. In partial fulfillment of the requirements for my degree, I am conducting a research study to determine the impact of integrated science and English language arts literacy instruction on science academic achievement of upper elementary students. I am requesting permission to access archival data sets (Spring 2015, and Spring 2016 GMEOGA for Science) to analyze science student achievement within targeted populations of students (3rd and 4th grade) within your school. I would like to inform you that my research does not involve directly contacting any teachers or students in the school setting. Furthermore, if the results of the research are published, I want to ensure you that the names and identities of the school setting, teachers, and students will not have been recorded and will not be identifiable. I appreciate any consideration on your behalf, and I look forward to hearing back from you with a decision.

Please do not hesitate to contact me with any questions or concerns regarding this request.

Thanks a million,

Jamar Marks

Doctoral Candidate, Liberty University