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Science Scores in Title I Elementary Schools in North Georgia: A Project Study

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Ramon Frias

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Walden University
2013

Abstract

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Ramon Frias

M.S., Nova Southeastern University, 1997

B.A., Florida International University, 1989

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

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The No Child Left Behind Act (NCLB)'s emphasis of reading, language arts, and mathematics (RLA&M) and its de-emphasis of science has been a source of great concern among educators. Through an objectivist and constructionist framework, this study explored the unforeseen effects of the NCLB on public science education among Title I (TI) and non-Title I (NTI) students. The research questions focused on the effects of NCLB on Criterion Referenced Competency Test (CRCT) scores in the high-stakes subjects of reading, language arts, mathematics and the low stakes subject of science among TI and NTI 3rd, 4th, and 5th grade students in a north Georgia County during the 2010/2011 school year. This study also compared instructional time TI and NTI teachers dedicated to science. A causal-comparative quantitative methodology was used to analyze Georgia's public domain CRCT scores. Three independent-samples *t* tests showed that TI schools exhibited significantly lower Science CRCT scores than did NTI students at all grade levels ($p < 0.0001$). The data also showed CRCT scores in high-stakes subjects between TI and NTI students converging but science CRCT scores between TI and NTI students diverging. The self-report survey indicated no significant differences between TI and NTI teachers' instructional science time ($t\ (107) = 1.49$, $p = 0.137$). A teacher development project was designed to focus on improving teacher science content knowledge and pedagogical content knowledge through a formal introduction to the nature of science. With increasing global science competition, science is more relevant than ever, and communities need students with strong science foundations. Further study is recommended to analyze the factors associated with this science gap between TI and NTI students.

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Dedication

I wish to dedicate this page to Lourdes my wife of 21 years. She has been unwavering and invaluable in helping me finish this goal of mine to achieve my doctorate. There is no way I would've been able to accomplish this without her. I love you more today than when I married you, thank you for helping me and allowing me this quest.

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I would like to thank my parents Ramon and Gladys Frias for instilling in me the drive to better myself through education. My mom told me if you focus on something you can obtain in my dad’s words of wisdom were why not do it the time will pass by anyway make the most of it. To my two sons Marcus and Matthew I leave these words of wisdom while you are in the middle of something you can’t always see or feel that what you are doing means anything but at the end of the trip you can look back and realize then that the journey was worth it and that the road in front of you will be more fulfilling because of it. I would also like to thank Dr. Beth for her commitment in helping me achieve this goal.

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Section 1: The Problem

Introduction

The No Child Left Behind (NCLB) Act of 2001 requires that schools make adequate yearly progress (AYP) on a number of variables. NCLB has had a profound effect on the amount of time elementary schools spend on certain subjects, which has led to the emphasis of high-stakes subjects like mathematics and reading/language arts, but the curtailing, and in some cases elimination, of instruction in low-stakes subjects like science, social studies, art, and music (Greene, Trivitt, & Winters, 2008). This trend may exacerbate the tendency of fewer minority students, who also tend to be of lower socioeconomic status (SES), to be represented in science and engineering fields (Kohlhass, Lin, & Chu, 2010). The purposes of this project are to explore (a) how the standardized science scores of Title I students, who tend to be majority minority and of lower SES, compare to those of non-Title I students in this North Georgia County, and (b) compare the time a short time spent on science curriculum in Title I elementary schools to that of non-Title I elementary schools in this North Georgia County.

Definition of the Problem

This North Georgia County is like so many large school districts in the country, has a large population of minority and lower SES students attending Title I schools. In this North Georgia County, the minority and lower SES populations in Title I schools are as high as 93%, with an average of 85% of students in Title I schools being either minority students, lower SES students, or both (National Center For Educational Statistics, 2010; U.S. Department Of Education, 2007). For a variety of reasons, these students tend to score lower on standardized tests (Tate & Hogrebe, 2010). In these Title I elementary schools, AYP is based in part on mathematics and reading/language arts scores from a state generated standardized test. This process greatly diminished the amount of time spent on science, in an effort to increase the chances of making AYP (Griffith & Scharmann, 2008). Causing many Title I schools to diminish or eliminate science and other low stakes subjects in order to focus on bringing their students up to state test standards in mathematics and reading/language arts. This creates a situation in which students in Title I schools are exposed to substantially less science instructional time than their non-Title I counterparts (Queenan, 2011). Leading to diminished science proficiency, content knowledge, and interest as they enter the secondary school level (Gorard, 2009). These effects are at the core of my theoretical framework, which places NCLB as the catalyst for this shift toward high-stakes, AYP-determining subjects.

Rationale

Evidence of the Problem at the Local Level

Science in this North Georgia County has been under much political scrutiny, reaching an apex in 2002 when all high school biology textbooks were stickered on the front cover with a disclaimer, "This textbook contains material on evolution. Evolution is a theory, not a fact, regarding the origin of living things. This material should be approached with an open mind, studied carefully and critically considered" (National Science Board, 2004, p 1). The county was forced later to remove all the stickers from the textbooks but only after the courts got involved. This incident indicates not just that this North Georgia County views of science but how science is viewed by a large segment of the population (National Science Board, 2004).

This North Georgia County School District only requires proficiency in the subjects of mathematics and reading/language arts for elementary schools to make AYP. Although science is tested beginning in third grade, it is not a necessary component of AYP until students reach high school (Georgia Department of Education, 2010). This devaluation of science at the elementary level can lead to students assigning the subject matter a less important and critical role in their lives (Cole & Osterlind, 2008; Wise, 2009). Of this North Georgia County's elementary schools, 48% are designated Title I. The student population that make up Title I schools has well documented and show significantly depressed scores in mathematics and reading/language arts (Duncan & Sandy, 2010). It was expected that mathematics and reading/language arts, the driving disciplines for AYP are emphasized in Title I schools over subjects like science because science scores are not used in measuring AYP for schools. Title I schools are overwhelmingly Black, Hispanic and lower SES in their demographic makeup (Cobb County School District, 2011). For a variety of complex social and political reasons, this population of students also tends to have lower graduation rates and fewer admissions into universities (Flores & Kaylor, 2007).

The state of Georgia in accordance with the A+ Educational Reform Act of 2000,O.C.G.A. §20-2-281, mandates that the State Board of Education adopt end-of-course assessments in some core high school subjects (e.g., algebra, U.S. history, biology literature) to be determined by the State Board of Education (Georgia Department of Education, 2010). In this North Georgia County, the percent of Black, Hispanic, and White students that pass the end of course test (EOCT) in science are 62.5%, 63.5%, and 93%, respectively (Georgia Department of Education, 2011). These numbers show a large disparity between Black and Hispanic students whose passing rate is in the low 60% range, while white students demonstrate a passing rate above 90%. For many of these students, this disparity could possibly be traced back to mathematics, and reading/language arts having been emphasized over science, such that science instruction has become a rarity for the students of many Title I schools (Burton, 2010).

With this as my backdrop, an independent-samples *t* test was chosen because as stated by Green & Salkind (2011, p. 175) an independent-samples *t*-test is used to "evaluate the difference between the means of two independent variables". One is the grouping variable, Title I students and non-Title I students. The other is the test variable, being the student scores on the Georgia CRCT in the different subject matters (i.e. science, mathematics, reading/language arts) and grade levels (i.e., third, fourth, and fifth). The purpose of the *t*-test is to evaluate whether the test variable mean value of one group differs significantly from the test variable mean value of the other group.

Evidence of the Problem from the Professional Literature

In 1983, *A Nation at Risk* (National Commission on Excellence in Education) foretold of an educational system in decline, especially in areas of U.S. supremacy like commerce, industry, science, and technological innovation. The United States has been trying to combat this apparent decline ever since, culminating in the 2001 NCLB Act that was expected to strengthen and reestablish the United States' supremacy in commerce, industry, science, and technological innovation.

Yet, in the 2009 Programme for International Student Assessment (PISA), the United States came in 22nd in the world in science proficiency, behind Norway, Japan, and surprisingly, Hungary, and Slovenia (Center on Educational Policy, 2008). Low science proficiency in the United States is bound to continue as long as the educational system continues to reward schools that do well on standardized state-mandated tests that focus almost exclusively on mathematics and reading/language arts (Miller, 2010). This narrowing of curriculum is forcing many underperforming elementary schools, which are many times Title I schools, to spend a disproportionate and increasing amount of instructional time on mathematics and reading/language arts, and little or no time on science (Perry & McConney, 2010).

Griffith and Scharmann (2008) find that the greatly restricted and diminished amount of the structural time spent on science can have a profound effect on students' attitudes toward science, ultimately manifesting diminished numbers of students entering science related fields at higher levels of education (Barmby, Jones, & Kind, 2007). The issue of low student interest in the sciences is more predominant among minority and lower SES students (Williams, 2010). With many Title I schools diminishing or eliminating science in order to try to bring the students in those schools up to state standards, this creates a situation where students in Title I schools are exposed to substantially less science, which may lead to diminished science proficiency, content knowledge, and interest as they enter the secondary school level (Gorard, 2009).

Definitions

Adequate yearly progress (AYP): Monitoring tool to determine if schools are complying with NCLB. Factors used for determining AYP are (e.g. graduation rates, standardized test scores and attendance).

High-stakes test: any exam that has a meaningful consequence to the test taker.

Low-stakes test: any exam that has no meaningful consequence to the test taker.

Nature of science: has seven aspects and "refers to understanding science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Akerson, Hanuscin, & Lee, 2010).

No Child Left Behind (NCLB): 2001 landmark federal mandate to improve accountability in United States public school systems.

Socioeconomic status (SES): “An individual's or group's position within a hierarchical social structure. Socioeconomic status depends on a combination of variables, including occupation, education, income, wealth, and place of residence (Houghton Mifflin Company, 2012).

STEM: (science, technology, engineering, and mathematics) national programs established to support teachers and students in the areas of science, technology, engineering, and mathematics.

Title I: “the largest federal education-funding program. It provides funding for high poverty schools to help students who are behind academically or at risk of falling behind” (Education.com, 2012). Established in the Elementary and Secondary Education Act (ESEA).

Transiency rate: the percentage of students who do not complete a complete school calendar year in the same system in which they started.

Significance

Keeping the United States technological and scientific advantage is so important that the White House stated that “Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been before” (The White House Office of the Press Secretary, 2009, p. 1). The irony of this statement is that the United States’ world standing in science is diminishing and should be an area of great concern, but this trend will continue if mathematics and reading/language arts continue to be emphasized over science (Perry & McConney, 2010).

Since the inception of NCLB, the importance of science and the role it plays in our society has been a source of great debate (Judson, 2010). Part of the contention lies with the idea of the importance and relevance of science at the elementary school level. With science untested until the middle and high school levels (Mentz, 2010), students are not getting a foundation for science. However, students who get this foundation as early as kindergarten are better at developing and accepting scientific processes more readily (Akerson, Buck, Donnelly, Nargund-Joshi, & Weiland, 2011).

Much of the discussion has been focused around the perceived inability of younger elementary school students to do complex science. For this reason, there has been a steady erosion and oversimplification of science taught at the elementary school level, when it is taught at all (Mentz, 2010). However, Koedinger, Pavlik, McLaren, and Aleven (2008) found that it is not only important but also cognitively appropriate to introduce science at the elementary school level. Much of today's science misconceptions, anxieties, and lack of interest are a manifestation of a diminished early science exposure (Mallow, Kastrup, Bryant, Hislop, Shefner, & Udo, 2010).

Research shows that standards and subjects that are not included in assessment programs are more likely to be ignored, leaving students with less favorable attitudes toward science (Barmby et al., 2007). Just as science in society is becoming increasingly important for our ability to progress, maintain, and "meet economic, environmental and technological challenges" (International Journal of Science Education, 2010, p. 2), interest in science is being suppressed. Not only are fewer people pursuing science related fields, but also the number of women and minorities entering the sciences and engineering programs is of major concern in the United States (Wagner, 2010). This trend will continue if science is deemphasized at the elementary school level, particularly for students in Title I schools, who are more likely to be representative of minority groups and low SES.

Guiding/Research Questions

The purpose of NCLB was to improve America's educational system and address its diminishing status on the world stage as stated in the report, *A Nation at Risk* (National Commission on Excellence in Education, 1983). To bring the United States out of the perceived educational crisis it was in NCLB emphasized three core essentials of education mathematics, reading, and language arts. NCLB allowed states to design their own methods for demonstrating that mathematics and reading/language arts skills were improving in their students. This caused a quantum shift in how school systems viewed their curricula and the importance of certain subjects (Aram, Freed, Higgins, & Powell, 2009). The lack of emphasis and diminished instructional time on low-stakes subjects like science has been commonplace since NCLB implementation (Griffith & Scharmann, 2008; Miller, 2010). Other barriers that have contributed to diminish science emphasis at the elementary school level include (a) elementary school teacher anxieties about teaching science due to minimal content knowledge (Howard Hughes Medical Institute, 2009) and (b) the inherent complexity of science and its relatedness to a number of other disciplines (Fyneweverb & Gulacara, 2010; The Royal Society, 2008).

Science is much too important a concept in today's world to be placed on the fringes of our educational system; it is vital that we bring science back into the classroom to ensure the success of our students (Feller, 2011). The proposed self-report, descriptive comparative study will address the issue of whether or not NCLB has caused Title I elementary schools in Cobb County to spend less instructional time on science than non-Title I elementary schools, presumably in order to meet AYP and avoid further scrutiny and penalties for not meeting the desired state goals (Foley & Nelson, 2010; Blewett & Kaufman, 2010).

For the purposes of this study, my research questions are:

1. Has the decreased emphasis in science due to NCLB affected science scores of Title I students more than non-Title I students?
2. How have mathematics and reading/language arts scores between Title I students and non-Title I students been affected due to the increase emphasis of these subjects in order to obtain AYP?
3. Do teachers in Title I schools spend less instructional time on science than non-title I teachers?

To address these questions, I will perform a quantitative causal-comparative study using (a) public domain data of elementary school results on the Georgia Criterion-Referenced Competency Test (CRCT) in the subjects of mathematics, reading/language arts, and science, and (b) self-reports survey of teachers' instructional time spent on science.

I assert these hypothesis for the study:

1. Title I students should have science scores that differ significantly when compared to non-Title I students.
2. Title I students should have mathematics and reading/language arts scores that do not differ significantly when compared to non-Title I students.
3. The total instructional time spent on science on average per week by teachers in Title I schools should be less than that of teachers in non-Title I schools.

Review of the Literature

In this proposal, I address three barriers to elementary school science education and the ways in which Title I elementary schools may be affected more profoundly than non-Title I elementary schools due to (a) the overemphasizing of high-stakes subjects (i.e., mathematics and reading/language arts) in Title I schools, (b) elementary school teacher anxieties about teaching science (Buxton & Provenzo, 2011), and (c) the inherent complexity of science and its relatedness to a number of other disciplines (Fyneweverb & Gulacara, 2010; The Royal Society, 2008). The identification of these three barriers to elementary school science came about by determining and asking:

- How has NCLB affected curriculum subject distribution and if so what subjects have been affected the most;
- How do Title I and non-Title I schools compare to each other;
- Are high-stakes subjects and low stakes subjects receiving the same instructional time in elementary schools;
- Are science and non-science classes different in their level of difficulty and complexity;
- Do elementary school teachers have the same anxiety levels toward science and non-science curriculum subjects;

Once the categories had been established, data base research strategies using search parameters (e.g., author, title, keywords) were used along with Boolean search operations (e.g., and, or, not) in between the search parameters. Other database expanding Boolean strategies were initiated by the use of (a) parentheses, and quotes around groups of words, and (b) Question mark (?) and asterisk (*) in keywords (Penn State University, 2002). This would allow for a more thorough and robust exploration of the categories in the research for this proposal is based on.

Theoretical Framework: Organized Anarchies Between the Federal And State Governments

During the 1960s, the United States space race emphasized science and technology in order to beat the Soviets to the moon. The United States produced engineers and scientists at impressive rates to fulfill this goal, and science permeated all aspects of life (e.g., television, movies, industry). In the past few decades, however, the United States has not produced enough graduates in science, technology, engineering, and mathematics (STEM) to keep the country on the vanguard of scientific innovation (Hossain & Michael, 2011).

The lack of science emphasis at the elementary school level has persisted for several decades (Burton, 2010). With the enactment of NCLB in 2001, many elementary schools (e.g., Title I elementary schools with majority minority populations and lower SES), science became a low-stakes subject with minimal or no instructional time dedicated to it (National Science Teachers Association, 2009). The unintentional consequences of NCLB causing a decreased emphasis in science and technology in our schools was central in focusing my attention for this project which explored the organized anarchies between the federal government's ability to affect state's educational processes through federal programs (Cohen, March, & Olsen, 1972). This lack of emphasis on science may further affect the number of people entering STEM fields of study (The White House: Office of the Press Secretary, 2009). More specifically, the lack of science emphasis in Title I schools may further diminish science content knowledge and science interest in the students attending those schools, which continue to add to the already existing low representation of minorities and lower SES students in STEM careers (Feller, 2011). By definition, Title I schools serve lower SES students who tend to be minority Black or Hispanic. These populations have been notoriously underserved, underfunded, and politically and geographically segregated (Joyner & Marsh, 2011). Many of these students also face other systemic problems associated with being poor and/or ethnic minorities. These students, because of their lower SES, are at greater risk of being exposed to (a) drugs, before and after birth; (b) abuse, mental and physical; and (c) neglect, which has long been connected with low cognitive abilities (Ornoy & Ergaz, 2010).

By concentrating in Title I schools such high numbers of minority and lower SES students, whose exposure to middle-class and upper-class reasoning, future outlooks, political clout, and technological advances are limited, many students experience educational deficits that are difficult to escape (Farnen, 2007). An additional level of instability is that many of these Title I schools usually hire less experienced or newly graduated teachers, who may not be fully-qualified for the areas they teach, and fewer teachers with advanced degrees (Joyner & Marsh, 2011). This adds discontinuity to an already fractured system that has extremely high teacher turnover rates (Joyner & Marsh, 2011). Lleras (2009) stated that any increases in classroom disruptions could seriously affect students' ability to learn and economic factors used in determining Title I status (e.g., percent of students receiving free or reduced-price lunch) can be linked to classroom behavior. There is also evidence to suggest that lower SES students have a greater risk potential for developing behavioral and cognitive problems (Burns, Nelson, & Parker, 2010). Title I schools with high poverty rates in early grades show an increased likelihood of school-level aggression in subsequent grades. This aggression sometimes creates a negative environment because of increased disruptions, which can be extremely detrimental to the learning environment of the students in those schools (Bierman, Thomas, Thompson, &

Powers, 2008). Many of the social inequalities culminate in minority students who are both poor and English language learners (ELLs). Solorzano (2008) stated that for these students, persistent problems in education can be connected to inconsistent and ill-conceived educational strategies that have been instituted and continue to be used even though their effectiveness is highly disputed.

To negate these inequalities, NCLB focused schools' curricula around three core essentials: mathematics, reading, and language arts. It also mandated that students be tested annually in mathematics and reading/language arts in all elementary school grades to quantify educational progress. If a school does not score within a certain parameter (i.e., it does not make AYP), it is sanctioned as a result (Miller, 2010). To try to ensure AYP, schools emphasize mathematics and reading/language arts and reduce the amount of time dedicated to other subjects like science (Queenan, 2011). Specifically, the amount of time spent on science has fallen on average nationwide over 200% in elementary schools since a national survey conducted in 2000, and many less privileged elementary schools (e.g., Title I) have completely eliminated science instruction (Lawrence Hall of Science, 2007).

Massey and Rothwell (2010) stated that the concentration of minority and lower SES populations has increased substantially in U.S. cities over the past two decades. This packing of high risk students with little to no science content knowledge and a perceived lack of importance placed on science, many times pushes Title I elementary schools to reach critical mass in terms of producing students with lower science proficiency. This process can then manifest in an increasing number of Title I students dropping out at the secondary level due to their inability to pass science content classes at the high school level of rigor (Tate & Hogrebe, 2010). Due to Title I students' lower SES and lack of access to middle- and upper-class privileges, the students tend to have lower “metacognitive skills and epistemological beliefs” (Yilmaz-Tuzun & Topcu, 2009, p. 680) in science, many of which stems from their parents’ metacognitive skills and epistemological beliefs about science (Yilmaz-Tuzun & Topcu, 2009). This makes the introduction of science more imperative at the elementary school level, not less, and by addressing this deficiency early, its effects on the students could be minimized as they progress through their educational careers. Unfortunately, what is transpiring currently is the opposite. The amount of science that students are exposed to in Title I schools is dwindling. To achieve “robust learning” (Koedinger, Pavlik, McLaren, & Aleven, 2008, p. 2155), it is imperative to allow adequate instructional time to assimilate the science learned (Koedinger et al., 2008). Under the current conditions, it is not beneficial to schools to devote instructional time to science. This harms students’ ability to achieve the cognitive levels needed to succeed later in the sciences (Furtado, 2010).

Elementary Teachers’ Anxieties About Science

Teaching science can also be a daunting task, now add that to the statement “Many elementary school teachers have little to no science background, and some are even fearful of science. It is easy for a teacher to say, ‘I don’t want to teach that’ (Howard Hughes Medical Institute, 2009, p. 1) and this can facilitate the lack of science in the classroom. Key factors to this hindrance are a lack of teacher content knowledge and pedagogical content knowledge in science. Without science content knowledge or pedagogical content knowledge, it is difficult for a teacher to teach science effectively or in an inquiry-based fashion (Tairab, 2010). Ball, Hoover, and Phelps (2008) found that this lack of content knowledge and pedagogical content knowledge produced severe anxiety and a phobia of science in many elementary school teachers. Unlike secondary level science teachers, whose focus of study is more central, much of this anxiety and fear comes from the fact that elementary school teachers have a broad-spectrum specialty (California Council on Science and Technology, 2010). The fear and anxiety that a teacher faces when he or she teaches science is magnified in many Title I schools because school administrators find the teaching of science as counterproductive to the overall effectiveness of the school because it takes time away from the high-stakes tested subjects important for AYP (Upadhyay, 2009).

Content knowledge is key in teaching science at any level: "Science is separated from other intellectual activity because it is cumulative in nature, requiring individuals to build knowledge layer by layer" (Griffith & Scharmann, 2008, p. 44). If elementary school teachers have never built up these layers of knowledge, it is exceedingly difficult, then, to put this knowledge into a pedagogical format to teach students (Ball, Hoover, & Phelps, 2008). Elementary school teachers participate in a wide variety of science in-service professional development activities to improve their ability to teach science. However, these in-services, while useful, do not support the basic problem that is lack of teacher content knowledge (Gupta, Saxman, & Steinberg, 2010).

There is minimal resistance to the notion that students learn best when instructed by effective teachers. What is it that makes a teacher effective? Teachers must not only understand the subject matter and pedagogy but also be able to transform such understandings within their teaching practice so the students can conceptualize new ideas (Akerson, Hanuscin, & Lee, 2010). Emphasizing the requirement that a teacher thoroughly understand the nature of science NOS critical to a student's ability to comprehend the relevance of science. Creating a dilemma where many elementary school teachers do not have an adequate conception of the NOS and could increase a teacher's anxiety about teaching science (Posnanski, 2009).

A teacher's ability to teach student's content and understanding of the NOS relies on the teacher's own content knowledge and understanding of the NOS. The recurring theme that consistently appears in the research is that teachers and students often have an overly simplistic and incomplete perspective of the NOS (Anagun & Yalcinoglu, 2012). Key to overcoming teacher anxiety about science, teaching science, and the simplistic and incomplete perspectives of the NOS are to better prepare the elementary school teachers through training of the NOS (Akerson & Adb-El-Khalick, 2009; see also (Hestness, Marbach-Ad, McGinnis, Pease, & Riedinger, 2011). Today's teachers are not just required to teach science concepts, integrate skills to better understand scientific knowledge, and use scientific inquiries to connect with students, but also to help the students assimilate and comprehend the NOS (Akerson & Adb-El-Khalick, 2009). Several methods have been used to improve a teacher's ability to accomplish the before mentioned requirements for teaching science effectively. One of the most successful methods is one that first has the teacher recognize metacognitively where his or her scientific abilities lie (Akerson & Adb-El-Khalick, 2009). This process establishes a starting point from which a teacher can start to strengthen his or her core knowledge of the NOS and from that point, improve his or her pedagogical skills for teaching the NOS.

The Complexities of Learning Science

The understanding of the world around us begins at infancy as we start to perceive the world by the use of our senses. These initial perspectives are at the core of most science misconceptions (Bloom & Weisberg, 2007). The problem is that this core knowledge "give[s] students a head start when it comes to understanding and learning about objects and people… but also clash[es] with scientific discoveries about the nature of the world, making certain scientific facts difficult to learn" (Bloom & Weisberg, 2007, p. 996) this statement shows the difficult balance that is necessary to teach and learn science.

In conversations, when I am asked what I do for a living, and I respond, "I am a teacher," I am acknowledged with a nod of acceptance, but when I say, "I teach AP chemistry," the responses are more celebratory and congratulatory. These responses are more indicative of perceptions and experiences people have had in trying to learn science. Schreiner (2010) found that learning science could be hampered and made more difficult by:

- Misconceptions that students carry from previous learning that, if seated deeply, can interfere with the learning of new material;
- Compound learning: because science builds on prior knowledge, if there is little to no prior knowledge, the topic becomes increasingly difficult to learn, especially with teachers who are pressed for time and do not have the luxury of reviewing basic concepts; and
- Abstract and unobservable concepts: many times the ideas and concepts being taught are outside the physical reality of people because what one is studying is too small to see or quantities are too large to conceive.

These factors are contributors in making science difficult to learn (The Royal Society, 2008). Another aspect of science rendering it more difficult to learn is that science requires not just a firm foundation in science but also many times full integration of mathematics and reading skills that must be equally developed if a student is to succeed. The integration of science with other subjects is necessary for a full and in-depth comprehension of the material (Graeber, McGinnis, & Roth McDuffie, 2006).

The effects of the difficulties in learning science can be seen in today's educational push in science, technology, engineering, and mathematics (STEM) curriculum. For the past few decades STEM curricula and subject matter have been stressed to meet an ever-expanding need for individuals to fill STEM careers fields (Shelley & Whalen, 2010). But even with this increased emphasis in STEM, the U.S. was had little to no success in filling those needs. This leads to the question of, "Why?" Bevins, Brodie, Byrne, and Price (2011) elaborated on how many students, while they enjoy school science, would not consider a STEM career. Even those who do pursue a STEM career path opt out very early in their college career. The problem is not that we are not having enough students consider STEM careers but that we cannot keep them from opting out and pursuing a different career path. The current retention rate for incoming freshmen to senior year STEM candidates is a mere 60% (Shelley & Whalen, 2010). Understanding the dilemma begins with accepting the realization that many core science concepts are very difficult to learn because students have no foundation to relate the subject matter to what they already know (Diehl & Reese, 2010). The current educational philosophy involves the idea that all students are capable of going into and succeeding in STEM classes and careers, but this negates the reality that to succeed in STEM classes and careers requires bright and innovative students that can persevere (Atkinson, 2012). Shelley and Whalen (2010) found three main student perceived factors to this lack of retention in STEM classes and careers:

- The pedagogical style of teacher led transmittance of information is uninspiring and detached;
- STEM lacks relevance to students' lives, and the subject matter has no interplay with their interest and aspirations; and

- Science is perceived as difficult because it is intellectually challenging and works with unfamiliar terminology and concepts.

Two of these student perceptions of the difficulties with STEM material can be addressed by modifying how teachers introduce and teach science material, but the third perception that science is difficult is part of the reality of STEM classes and must be accepted and realized by the students.

Implications

If I find that students in Title I elementary schools have significantly lower science test scores when compared to the non-Title I elementary students in this North Georgia County, and that they are receiving less instructional time in science (i.e., a low-stakes subject), the implication will be that Title I students are left lacking in a field of study that is becoming more crucial for success. One potential project direction would be professional development sessions for teachers. Professional development programs to instruct and review the core science curriculum topics can be used to instill confidence and content knowledge in elementary school teachers so that they would be more willing and able to dedicate instructional time to science. The program must be designed to impress upon the teachers the importance and relevance of science education early in the students of these Title I schools to strengthen the students' chances for success in science.

Summary

The teaching of science is problematic in many Title I schools. The students these schools serve are being deprived of the science instruction they need to be productive in a society where science and technology are increasingly paramount to success. Due to the requirements of NCLB and the mandate that all schools make AYP by testing students in only math and reading/language arts, the amount of time allotted for science has been curtailed. This reduction of allotted science time has been even more significant in Title I schools (Carlone, Huan-Frank, & Kimmal, 2010), whose unique demographic makeup requires teachers to incorporate large blocks of time in order to remediate students whose mathematics and reading/language arts proficiency levels are below state standards. This creates schools full of students that usually get little to no science exposure, leaving them with science deficits that will continue throughout their academic careers. Many of these Title I schools' overriding goal is to ensure AYP, which is gauged in part by math and reading/language arts scores on a state generated standardized test, in order to avoid scrutiny and punitive measures.

Elementary school teachers also tend to be more leery of science than their secondary school counterparts due to (a) personal anxieties about science, produced by previous science class exposure and lack of success, and (b) a deficient level of science content knowledge, due to a limited amount of science content requirements for elementary generalists at the university level (Buxton & Provenzo, 2011; Howard Hughes Medical Institute, 2009). These factors and the pressure that Title I school administrators place on Title I teachers to not teach science makes it easy for these teachers, whom many times are young and inexperienced, to eliminate science instruction (Griffith & Scharmann, 2008; Johnson, 2007).

The effects on elementary school science can be divided into two sources: external influences and internal influences. First, the external influences are (a) NCLB and the unexpected consequences of its implementation on science, (b) the overemphasizing of high-stakes testing subjects (e.g., mathematics and reading/language arts) over low stakes testing subjects (e.g., science), and (c) the lack of elementary school teacher content knowledge in science and the increased level of anxiety is produced in elementary school teachers when trying to teach science. Second, the internal influence is the noted reasoning that science is more difficult to learn than other subject matter, due to the stratification and complexity of the NOS. With the knowledge that United States are as a nation producing fewer STEM prepared students, it is irresponsible that a subject matter as cognitively important as science is being left out at a such a crucial developmental time (i.e., elementary school), when a student's ability to reason and accept new ideas is pliable. My project study will examine the marginalizing of science in Title I schools and explore how that affects students' science content knowledge and proficiency with these hypothesis:

1. Title I students should have science scores that differ significantly when compared to non-Title I students.
2. Title I students should have mathematics and reading/language arts scores that do not differ significantly when compared to non-Title I students.
3. The total instructional time spent on science on average per week by teachers in Title I schools should be less than that of teachers in non-Title I schools.

This will be done by analyzing this North Georgia County School District elementary school students' CRCT scores in the different subject areas they take in elementary school starting with second grade. Trying to determining if science scores are being affected more than other subject matter scores that are used in determining AYP as mandated by NCLB.

The purpose of this study was to attain information about the potential impact of NCLB on the instructional time elementary school teachers are dedicating to science, with special emphasis on Title I schools and the unique dilemma they have in assuring they make AYP. The methodology for this proposal was to obtain public domain information about this North Georgia County Title I and non-Title I elementary schools and compared their science, mathematics, and reading/language arts scores. The scores were then analyzed by using an inferential statistical test (i.e., *t* tests) to determine if the science scores mean value are significantly different between the Title I and non-Title I students. A *t* test was used to determine if mathematics and reading language arts scores showed the same significant mean value difference between the Title I and non-Title I students. I ascertained how much instructional time was being given to students in the subject area of science, and determined at Title I students were being exposed to less science content knowledge than non-Title I students. A self reports survey encompassed 15 of this North Georgia County 63 school teachers were conducted and ascertained that students in this North Georgia County Title I schools were spending less instructional time per week in science than this North Georgia County non-Title I school students. In the next section, I review the methodology for the study.

Section 2: The Methodology

Introduction

A divergence in science proficiency and content knowledge is occurring between Title I elementary students (i.e., primarily lower SES and minority students) and non-Title I students in this North Georgia County. This division of science proficiency and content knowledge is leaving Title I elementary students in a vulnerable position from which many will not recover (Brenneman, 2011). Creswell (2008) stated that quantitative research design best suits studies that:

- Collect data from questions and responses from established instruments;
- Accumulate and sort numerical data;
- Analyze a large population;

To quantify the problem, a quantitative study was conducted to analyze (a) students' scores on the Georgia reading/language arts, mathematics and science CRCTs and (b) teachers' self-reports of science instructional time.

I hypothesized that:

1. Title I students should have science scores that differ significantly when compared to non-Title I students.
2. Title I students should have mathematics and reading/language arts scores that do not differ significantly when compared to non-Title I students.
3. The total instructional time spent on science on average per week by teachers in Title I schools should be less than that of teachers in non-Title I schools.

Study Design

Due to factors associated with lower SES, Title I students tend to score lower on standardized tests than non-Title I students (Kearns, 2011). This doctoral project study addressed the question: Do students who attended Title I elementary schools have science scores that are significantly lower than their mathematics and reading/language arts scores when compared to the scores of non-Title I elementary school students? If science is being de-emphasized in Title I schools, then these students should have science scores that are significantly lower than their mathematics and reading/language arts scores when compared to the scores of non-Title I students. Which implied that if mathematics and reading/language arts were being overemphasized in order to make AYP, Then mathematics and reading language arts scores between Title I and non-Title I students would not be as significantly different than non-Title I students. In this project study, I analyzed Title I elementary schools student scores from the 2010-2011 school year on the Georgia Criterion-Reference Competency Test (CRCT) to determine if (a) Title I students had science scores that differ significantly when compared to non-Title I students, (b) Title I students had mathematics and reading/language arts scores that do not differ significantly when compared to non-Title I students and (c) the instructional time Title I teachers spent in science is less when compared to the instructional time non-Title I teachers spent in science instructional time using a self-report data. The scores were analyzed by using inferential statistical tests (i.e., mean, standard deviation, and *t* test) (Lodico, Spalding, & Voegtle, 2006, p. 214) that determined if the mean values between the Title I and non-Title I test variables differ significantly. Results of the self-reports descriptive comparative data analysis were used to determine if there is a significant difference in the instructional time spent on science curriculum between teachers in Title I elementary schools and teachers in non-Title I elementary schools.

The Georgia CRCT in science is administered to all Georgia elementary students starting in the 3rd grade and annually thereafter until the 8th grade (Georgia Department of Education, 2010). Because of pressure to make AYP, schools are cutting out completely or greatly diminishing the amount of time spent on science in order to reinforce high-stakes subjects (i.e., math and reading/language arts); this was even more prevalent in Title I schools (Miller, 2010).

In order to ascertain just how widespread this problem (i.e., the over emphasizing of high-stakes tested subjects over low stakes subjects in order to make AYP) was, I selected a quantitative design. Because the groups were already separated and had been exposed to the dynamics that exist in their schools (i.e., Title I vs. non-Title I), a causal-comparative study is best suited to analyze the potential disparities among high-stakes subjects (i.e., math and reading/language arts) and low-stakes subjects (i.e., science) in these schools.

Setting and Sample: Cobb County Schools Demographics

This North Georgia County Schools enrolled 106,509 students as of September 2011. The 69 elementary schools enrolled 50,127 students. There are 33 Title I elementary schools, which make up 48% of the elementary schools in the county and 42% of the total elementary school population of the county. The ethnic and racial breakdown of students in this North Georgia County Title I schools as of March 2011 was 44.5% White, 31.2% Black, 16.5% Hispanic, 4.8% Asian, 2.7% multi-racial, and less than 0.1% American Indian. The free and reduced lunch rate for the county was 43% for the 2010-2011 school year. The transiency rate for the 2009/2010 school year was 24.2 % (Cobb County School District, 2011). I used the population of the entire county's 69 elementary schools' 3rd (8,093 students) 4th (8,044 students) and 5th (8,159 students) grade student scores for this research study. Any student who took the CRCT science in 2010-2011 was eligible for inclusion in the archival data set I analyzed. For the purposes of this study, Title I schools were schools serving a school attendance area in which not less than 40 percent of the students were from low-income families determined by the percentage of students qualifying for free and reduced–price meals, census, Aid for Dependent Children [AFDC] or Medicaid (Georgia Department of Education, 2010).

Instrumentation and Materials: Georgia's CRCT

The Georgia CRCT was designed to measure "how well a person had learned a specific body of knowledge and skills, which helps to identify a student's strengths and weaknesses in specific subject areas. In education, CRCTs were made to determine whether a student had learned the material taught in a specific grade or course" (The National Center for Fair & Open Testing, 2007, p. 1). The state of Georgia also continuously monitors any changes made to the standards to ensure that the CRCT meet requirements. Changes to the CRCT requires about two years of development before they were implemented (Georgia Department of Education, 2010). Before test questions were allowed to be incorporated into the CRCT, Georgia educators scrutinized the test questions multiple times to determine if questions properly assess the curriculum topics being tested and were appropriate for the grade level and cognitive abilities of the students being tested. After the test was administered, Georgia educators evaluated test items (i.e., standardized), this determined how many questions needed to be answered correctly to meet the different levels of proficiency and their corresponding scores. For the purposes of this study, CRCT scores are defined as follows (Georgia Department of Education, 2010):

- Exceeds standards: math and science (850-990), reading (850-920), and language arts (850-930);

- Meets standards: math and science (800-849), reading (800-849), and language arts (800-849);
- Does not meet standards: math and science (650-799), reading (650-799), and language arts (650-799);

These are the scale range scores that are translated from raw scores (i.e., the number of correctly answered questions compared to the total number of questions) (Georgia Department of Education, 2010). The translating of raw scores to scale scores is necessary in order to try to ensure that from year to year different exams on the same subject matter, which may have had different difficulty levels, generated a comparable score. On the Georgia CRCT, this was done each year by establishing a committee made up of teachers, state administrators, and content area specialists that established the raw cut score, which is the minimum number of correct responses necessary to pass the test or excel on the test (i.e., meets or exceeds standards) for that particular test cycle. This raw score was then converted to the scale score, which is a pre-established score that does not change from year to year. In Georgia, that translated to a scale score of 800 for mathematics, science, reading, and language arts. The scale range scores for the CRCT is 650-910 and above and is arranged to match students of comparable abilities (Georgia Department Of Education, 2011).

Reliability of the CRCT came from the use of the Cronbach's alpha reliability coefficient and the standard error of measurement (*SEM*). The Cronbach's alpha reliability coefficient scores were calculated by using the Crocker and Algina's formula that expresses the consistency of test scores, while the *SEM* scores are used to indicate the random variability in the test scores (Georgia Department of Education, 2011). The scores for the CRCTs given in 2011 ranged from .85 (Grade 8 Reading) to .94 (Grade 7 Science; Grades 6 and 7 Social Studies); these were acceptable score indices (an ideal test would score close to ± 1) (Lodico, Spalding, & Voegtle, 2006). The *SEM* for the 2011 CRCTs ranged from 2.36 (Grade 4 Reading) to 3.31 (Grade 8 Science). This band of error is reported together with the student's scale score (Georgia Department of Education, 2010). This error band represents the score the student should have achieved each successive time the same exam is taken (Georgia Department of Education, 2010).

The Georgia CRCTs are administered in April or May of the academic year as determined by the local school district. The testing is conducted over a one-week period where a specific subject area test with two sections is administered each day of the week (e.g., Monday-reading/language arts, Tuesday-math). Students have a maximum of 70 minutes per section to complete the test. Extra time and accommodations are made for students with documented Individualized Education Programs (Georgia Department of Education, 2010). Sample questions and tests are available on the Georgia Department of Education website (viz., http://www.doe.k12.ga.us/). All of the data (i.e., schools' CRCT scores) for analysis are public domain. Any person with Internet access can retrieve and view all schools' scores from the Georgia Department of Education website.

Instrumentation and Materials: Teachers' Self-Reports

The population for the self-reports survey included elementary school teachers from this North Georgia County School District. This North Georgia County School District has 65 elementary schools with approximately 2,000 elementary school teachers. Permission for a cross-sectional descriptive self-report questionnaire was obtained from this North Georgia County School District. The district instituted some procedural guidelines on how to conduct the survey, including that (a) principals must be contacted by phone to get confirmation they are willing to participate in a survey, and (b) principals must provide signatures if they are willing to have their schools participate in the study. With these guidelines in place, I was able to obtain only 15 school principals willing to have their schools participate in the study, from six Title I and nine non-Title I schools. It was a random sampling of the elementary school teachers in this North Georgia County. The approved survey questions and consent forms were sent by mail to each of the participating elementary schools in the county, with instructions to the principal of each school that asked them to let the teachers at that school complete the questionnaire on the Scantrons provided. The teachers were allotted 5 days to complete the questionnaire on the Scantrons; at that point, all the documents were returned back to me in a self-addressed stamped envelope that was provided in the package. The survey itself should not have required more than 5 minutes to complete. My self-reports questionnaire was designed to compare how much instructional time is spent on science by Title I and non-Title I elementary school teachers. According to the Social Science Research Council (2009), self-report questionnaires should be (a) given to participants that are pertinent to the study (i.e., have an interest in the subject matter they are being asked to participate in) to ensure adequate participation by the participants, and (b) developed to ensure minimal bias is injected into the questions being asked of the participants. To improve accuracy and response rates to self-reports questionnaires, some crucial principles were used: (a) questions were clear and easy to understand; (b) participants were given a strong sense of anonymity with little fear of reprisal (Center for Health and Safety Culture, 2011). My self-report questionnaire was designed to collect data, on the average amount of instructional time in minutes per week spent on science by the teacher from the Title I schools and non-Title I schools. To review questions on a self-report questionnaire that could be used in this study (see appendix A).

The returned questionnaires were analyzed using a non-paired independent sample *t*-test to determine the difference between the instructional time Title I teachers spent on science versus the instructional time non-Title I teachers spent on science. To maximize face validity of a self-report questionnaire, the participants were informed of the true nature of the study and were assured anonymity by not asking any personal questions or asked to divulge any personal information. This process helped to establish trust in the participants and bolstered established high face validity in order to ensure that the participant's answers to the self-report questions were truthful (Lodico, Spalding, & Voegtle, 2006).

I used a self-report methodology because, for the purpose of this project, the data obtained from self-report questionnaires denote behavior exhibited by the participants without inferring relationship or causality (Lodico, Spalding, & Voegtle, 2006). A self-reports questionnaire was used to compare and describe the behavior of two groups (i.e., Title I and non-Title I teachers) and not intended to change their behavior.

Data Collection

Data collection and analysis of the students' CRCT scores were conducted by using this North Georgia County webpage (http://www.cobbk12.org/centraloffice/title1/index.aspx), which identifies the Title I schools in the county, and the webpage (http://www.cobbk12.org/schools/elementary_schools.aspx) which lists all this North Georgia County schools to identify the remaining non-Title I schools (i.e., independent variables). These two independent variables are two distinct categorical groups that are separated and will be measured as nominal scales. I attained this North Georgia County's schools' third, fourth, and fifth grade CRCT scores on the science, math, and reading/language arts components for the 2010-2011 school year (i.e., dependent variables) from this North Georgia County School

District homepage (http://www.cobbk12.org/). I clicked on "Test Scores" that provided a PDF file with all schools' scores and the county mean scores. These dependent variables were interval scale measurements of the students' CRCT scores and were categorized, ranked and had equal spacing by virtue of the CRCT being scale scored and translated from raw scores.

Descriptive statistics are an essential part in establishing patterns and describing overall performance of the item(s) in most quantitative studies (Lodico, Spalding, & Voegtle, 2006). In this study, an inferential statistical test (i.e., independent samples *t*-tests) using SPSS software was performed, in order to determine if the Title I schools' weighted mean value scores (*WMS*) by grade level and subject area were significantly different from the county's non-Title I school's *WMS*. An independent-samples *t*-test was chosen because as stated by Green and Salkind (2011), participant groups (i.e., Title I and non-Title I schools) can be compared and evaluated to determine if the *WMS* difference between the test variables is significant. The data files were constructed of 12 data scores each, consisting of a grade level and subject component (e.g., 3rd science, 3rd reading, 4th mathematics, 4th reading, and 5th language arts), with each data score generated by both a Title I and non-Title I schools. The collected data were used to determine a WMS between the group variables, the Title I and non-Title I. The data are displayed in tables, two for each grade level (see Tables 1-8). From these data tables, two line graphs were constructed: (a) a line graph displaying the confidence interval which contains the *WMS* on the y-axis and grade level Title I and non-Title I on the x-axis (see Figure 1) and (b) a line graph displaying the standard error difference by grade level on the y-axis and the subject matter on the x-axis.

Self-Report Survey

An unpaired independent-samples *t*-test also was administered to self-reports survey data to ascertain the difference in the amount of instructional time devoted to science in minutes, on average, per week (i.e., the test variable) between Title I and non-Title I teachers (i.e., the group variable). The questionnaire first established if the teacher belonged to a Title I or non-Title I school this allowed for the first separation of the data to form my group variable. The following questions had the teachers determine how many minutes per week on average were spent on science curriculum. The last question on the survey had the teachers approximate the total time they spent on science curriculum per week. There were six possible answers to the estimated time dedicated to science (see appendix A). Each of the possible answers was assigned a number (e.g., response A, 0 minutes, was 0; response B, 1-20 minutes, was 1; etc.). These corresponding numbers were used in the unpaired independent-samples t-test to determine results.

The results from the self-reports descriptive survey are displayed in a box plot graph (see figure 3). The box plot graph was designed to show the teachers' status, designated as Title I or non-Title I on the X axis, and the average time in minutes per week dedicated to science instruction on the Y axis. This allowed a direct comparison of the time spent on science and allowed me to ascertain if Title I teachers were spending less instructional time on science content than their non-Title I peers. The use of these parametric tests and statistical tools were an essential component to reject the null hypotheses:

1. There will be no significant difference in students' science scores between Title I and non-Title I schools.
2. There will be significant differences in students' mathematics, reading/language arts scores between Title I and non-Title I schools.

3. Title I elementary schools teachers do not spend significantly less instructional time on science curriculum when compared to non-Title I schools.

Data Analysis and Results

Through a framework of objectivism and constructionism, the focus of this study was to explore organized anarchies (Cohen, March, & Olsen, 1972) between the federal government's ability to affect Georgia's educational processes through federal programs and the unforeseen consequences that may be produced by those federal programs. The data obtained showed how the district's reality and decisions making process toward education (i.e., constructionist framework of this North Georgia County School District) was directly influenced by NCLB. From this point is where I established the parameters of this study.

CRCT Scores

Twelve independent-samples *t*-tests were conducted. All the tests indicated statistically significant differences in terms of their result scores this allowed me to reject my null hypothesis (see Tables 1 to 8).

Table 1

Independent Samples Statistics of Science t test scores: Descriptive Statistics

	TI-Schools					NTI-Schools			
Grade	*SEM*	*WM*	*SD*	*n*	Grade	*SEM*	*WM*	*SD*	*n*
3	1.66	817	8.80	28	3	2.17	847	13.2	37
4	2.03	817	10.7	28	4	2.41	858	14.7	37
5	2.09	814	11.1	28	5	2.71	853	16.5	37

Note. TI = title one; NTI = non-title I; *SEM* = standard error of mean; *WM* = weighted mean; *SD* = standard deviation; Grade = grade level; *n* = sample size.

Table 2

Science t test scores: Independent Samples t test (IS t test)

Grade	*t* Statistic	*DF*	*WMD*	95% Confidence Interval	*SED*	*p* values
3	-10.4	63	30	[24.24, 35.76]	2.88	< 0.0001
4	-12.5	63	41	[34.42, 49.77]	3.29	< 0.0001
5	-10.8	63	39	[31.78, 46.22]	3.61	< 0.0001

Note. DF = degree of freedom; *WMD* = weighted mean difference; *SED* = standard error of difference.

Table 3

Independent Samples Statistics of Reading t test scores: Descriptive Statistics

	TI-Schools					NTI-Schools			
Grade	*SEM*	*WM*	*SD*	*n*	Grade	*SEM*	*WM*	*SD*	*n*
3	1.39	830	7.37	28	3	1.61	855	9.81	37
4	1.14	824	6.02	28	4	1.30	850	7.93	37
5	1.23	827	6.50	28	5	1.22	847	7.43	37

Note. TI = title one; NTI = non-title I; *SEM* = standard error of mean; *WM* = weighted mean; *SD* = standard deviation; Grade = grade level; *n* = sample size.

Table 4

Reading t test scores: Independent Unpaired Samples t Test (IS t test)

Grade	*t* Statistic	*DF*	*WMD*	95% Confidence Interval	*SED*	*p* values
3	-11.3	63	25	[20.57, 29.43]	2.19	< 0.0001
4	-14.5	63	26	[22.41, 29.59]	1.80	< 0.0001
5	-11.3	63	20	[16.47, 23.52]	1.77	< 0.0001

Note. DF = degree of freedom; *WMD* = weighted mean difference; *SED* = standard error of difference.

Table 5

Independent-Samples Statistics of Language Arts t test scores: Descriptive Statistics

TI-Schools					NTI-Schools				
Grade	*SEM*	*WM*	*SD*	*n*	Grade	*SEM*	*WM*	*SD*	*n*
3	1.50	828	7.95	28	3	1.52	846	9.22	37
4	1.35	825	7.15	28	4	1.44	848	8.76	37
5	1.13	832	5.98	28	5	1.37	850	8.36	37

Note. TI = title one; NTI = non-title I; *SEM* = standard error of mean; *WM* = weighted mean; *SD* = standard deviation; Grade = grade level; *n* = sample size.

Table 6

Language Arts t test scores: Independent Samples t Test (IS t test)

Grade	*t* Statistic	*DF*	*WMD*	95% Confidence Interval	*SED*	*p* value
3	-8.26	63	18	[13.64, 22.36]	2.18	< 0.0001
4	-11.3	63	23	[18.84, 27.06]	2.03	< 0.0001
5	-9.67	63	18	[14.28, 21.72]	1.86	< 0.0001

Note. DF = degree of freedom; *WMD* = weighted mean difference; *SED* = standard error of difference.

Table 7

Independent Samples Statistics of Mathematics t test scores: Descriptive Statistics

TI-Schools					NTI-Schools				
Grade	*SEM*	*WM*	*SD*	*n*	Grade	*SEM*	*WM*	*SD*	*n*
3	1.71	827	9.07	28	3	2.30	853	14.0	37
4	1.74	821	9.23	28	4	1.86	850	11.3	37
5	2.04	836	10.8	28	5	2.19	860	13.3	37

Note. TI = title one; NTI = non-title I; *SEM* = standard error of mean; *WM* = weighted mean; *SD* = standard deviation; Grade = grade level; *n* = sample size.

Table 8

Mathematics t test scores: Independent Samples t test (IS t test)

Grade	*t* Statistic	*DF*	*WMD*	95% Confidence Interval	*SED*	*p* value
3	-8.55	63	26	[19.92, 32.08]	3.04	< 0.0001
4	-11.0	63	29	[23.75, 34.25]	2.63	< 0.0001
5	-7.79	63	24	[17.84, 30.16]	3.08	< 0.0001

Note. DF = degree of freedom; *WMD* = weighted mean difference; *SED* = standard error of difference.

For each grade level (i.e., third, fourth, and fifth), there were 4 subject areas (i.e., mathematics, reading, language arts, and science). The scores on the Georgia CRCT for the 2010-11 school year showed a significant deviation from the *WMS* between Title I and non-Title I students, but science scores showed a greater deviation from the mean than any of the other subject areas for all grade levels. Title I scores were designated as Group 1 and non-Title I scores designated as Group 2 in the SPSS defined groups. A negative *t* value for all grade levels and subject matter indicates that the *WMS* for the non-Title I students is significantly greater than that for the Title I students. The difference was anticipated and expected due to national trends and SES standings. What the data also show is that as Title I students progress from the third, fourth, and fifth grades, the *WMS* in reading converge or remain flat when compared to non-Title I students (cf., *MD* = 25, 26, and 20 respectively), language arts (cf., *MD* = 18, 23, and 18 respectively) and mathematics (cf., *MD* = 26, 29, and 24 respectively). Showing a narrowing of the *WMS* by +5 for reading scores, 0 for language arts scores, and +2 points for mathematics scores. At the same time science scores diverged for the same three grade levels; (cf., *MD* = 30, 41, and 39 respectively), which reflects an overall disparity of -9 points between Title I and non-Title I students as they progress from third grade to fifth grade (see Figure 1).

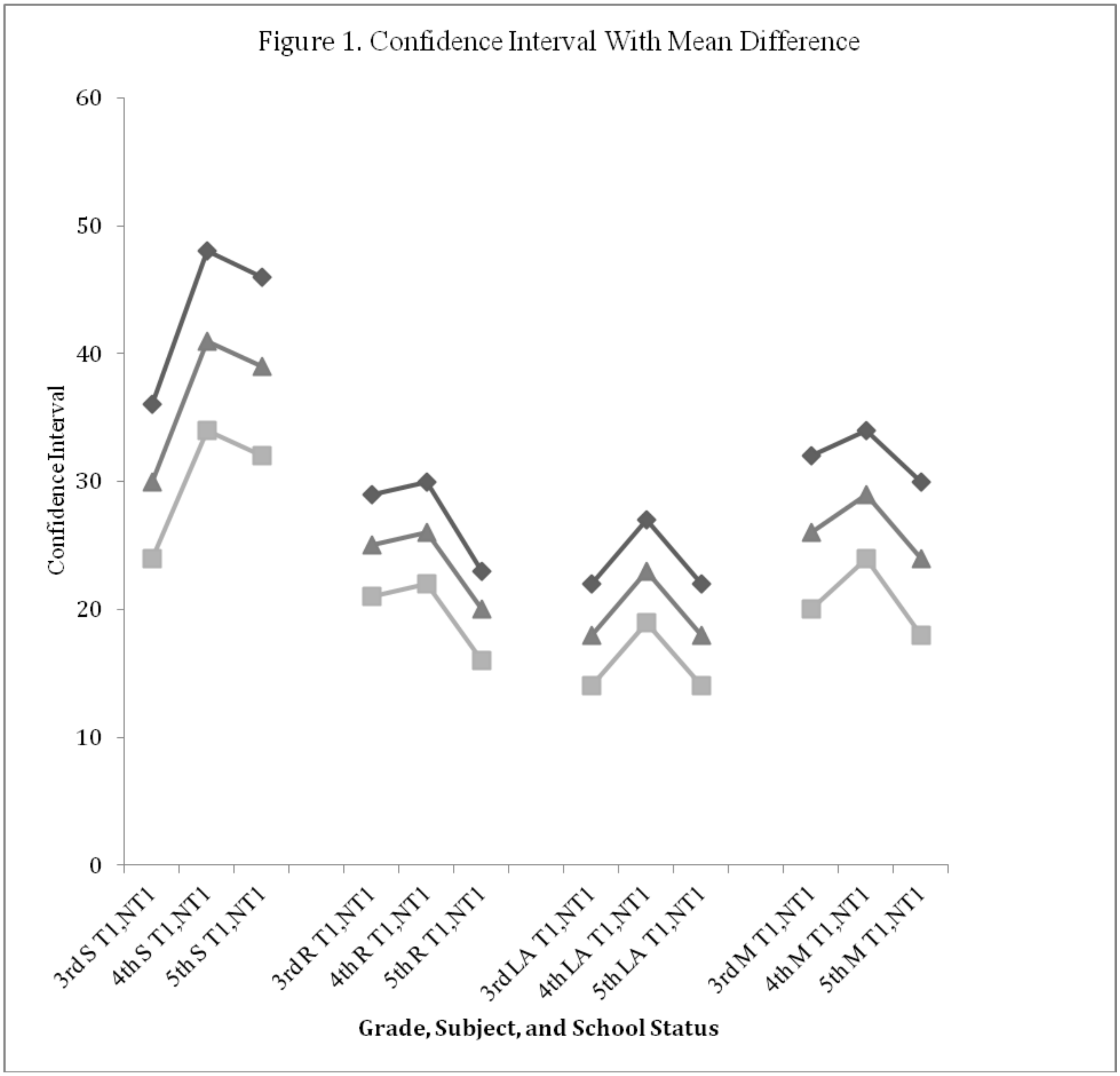

Figure 1. The darker top line with squares represents the high-end score of the confidence interval between the Title I (T1) and non-Title I (NT1) for each subject in increasing grade order. The lighter middle line with triangles represents the *WMD* between the T1 and NT1 for each subject matter in increasing grade order, and the lightest bottom line with squares represents the low-end score of the confidence interval between the T1 and NT1 for the subject matter in increasing grade order.

The conceptual framework at play here was the unforeseen effects and consequences of NCLB on public science education and the dynamic interplay between students of different socioeconomic status (SES). The data affirmed that while the extra focus on mathematics and reading/language arts at the elementary grade levels between 3rd, and 5th grade has helped in narrowing the achievement gap between Title I and non-Title I students, the extended focus on these three subject areas has been at the expense of science exposure and content knowledge for the students in these Title I schools. This pattern was also seen after looking at the standard deviation between the Title I and non-Title I students in the subject areas of mathematics, reading/language arts, and science (see tables 1.2, 1.4, 1.6, and 1.8). These 3 subject areas also showed a narrowing fluctuation in the *SED* between the Title I and non-Title I students from 3rd, 4th, and 5th grade reading, language arts, and mathematics (e.g., 2.22, 1.80, 1.77; 2.18, 2.03, 1.86; and 3.04, 2.63, 3.08 respectively), this fluctuation in the *SED* was not seen in a science course (e.g., 2.88, 3.29, and 3.61 respectively) as shown in Figure 2. Illustrating the average distance between the sample difference and the population difference was growing, affirming a widening gap in science scores.

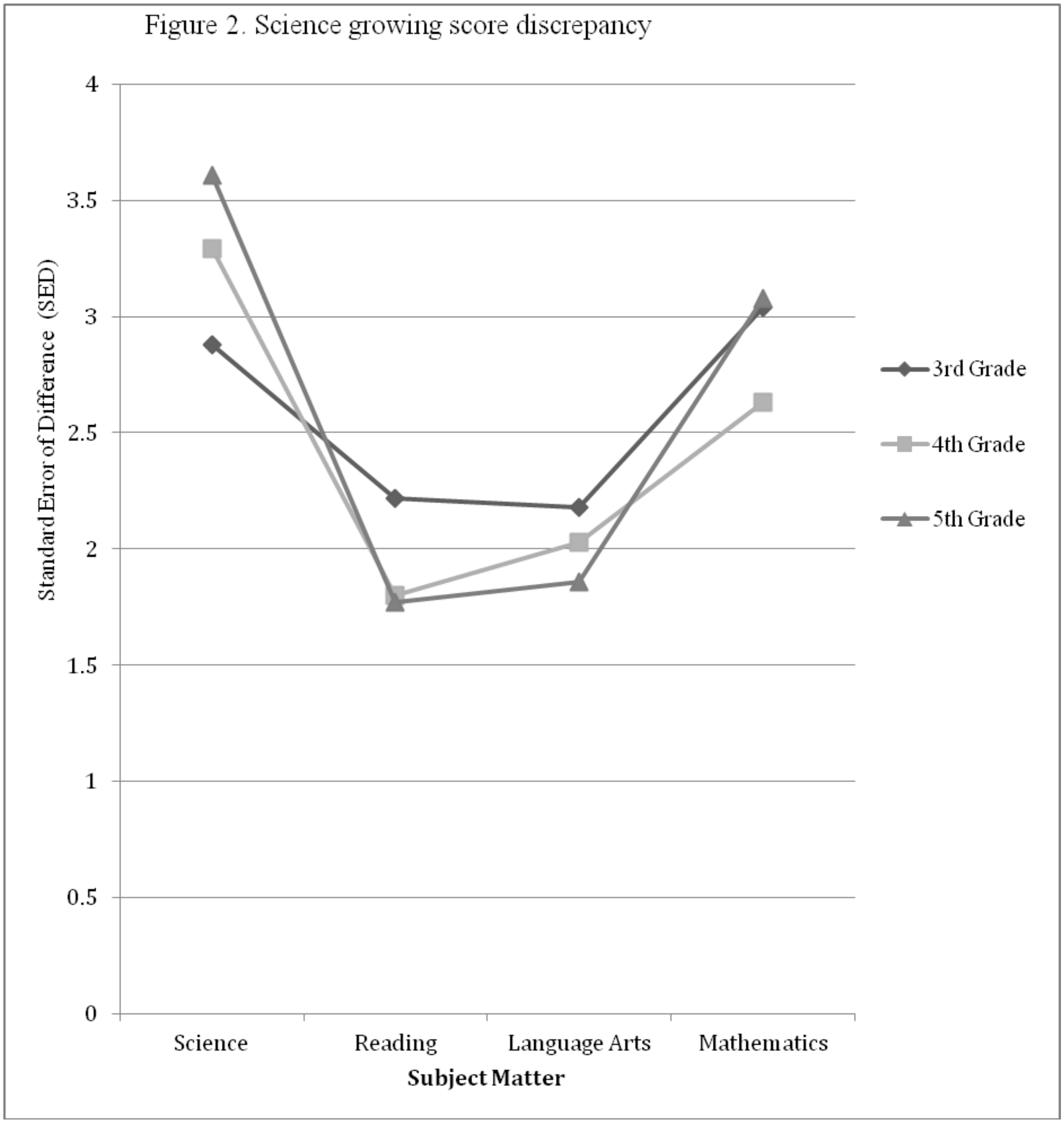

Figure 2. The *SED* for each subject matter and grade level between Title I and non-Title I students. The 3rd grade *SED* is depicted by the darker line with diamonds, the 4th grade *SED* is depicted by the lightest line with squares, and the 5th grade *SED* is depicted by a moderate line with triangles.

Self-Report Survey

An independent samples *t* test was conducted on the self-report survey to evaluate the hypothesis that Title I elementary school teachers spent less instructional time on science then non-Title I teachers. The test was not significant, $t(239) = 1.49$, $p = 0.14$, so I must accept the null hypothesis that Title I elementary schools teachers did not spend significantly less instructional time on science curriculum when compared to non-Title I schools (see table 9 and 10).

Table 9

Independent Samples Statistics of Survey t test scores: Descriptive Statistics

TI-Teachers				NTI-Teachers			
SEM	*M*	*SD*	*n*	*SEM*	*M*	*SD*	*n*
0.12	4.81	1.20	107	0.08	5.02	0.98	132

Note. TI = title one; NTI = non-title I; *SEM* = standard error of mean; *M* = mean; *SD* = standard deviation; n = sample size.

Table 10

Survey t test scores: Independent Samples t test (IS t test)

t Statistic	*DF*	*MD*	95% Confidence Interval	*SED*	*p* value
1.49	239	-0.21	[-0.49, 0.07]	0.14	0.137

Note. DF = degree of freedom; *MD* = mean difference; *SED* = standard error of difference

The results were unexpected due to the results obtained from the analysis of the CRCTs scores. Teachers in the Title I schools ($M = 4.81$, $SD = 1.20$) on the average taught between 41-60 minutes per week, just slightly less than the non-Title I teachers ($M = 5.02$, $SD = 0.98$) on average taught 61- 80 minutes per week. The 95% confidence interval for the difference in the means was quite narrow, ranging from – 0.49 to 0.07. Figure 3 shows the distribution of the two groups.

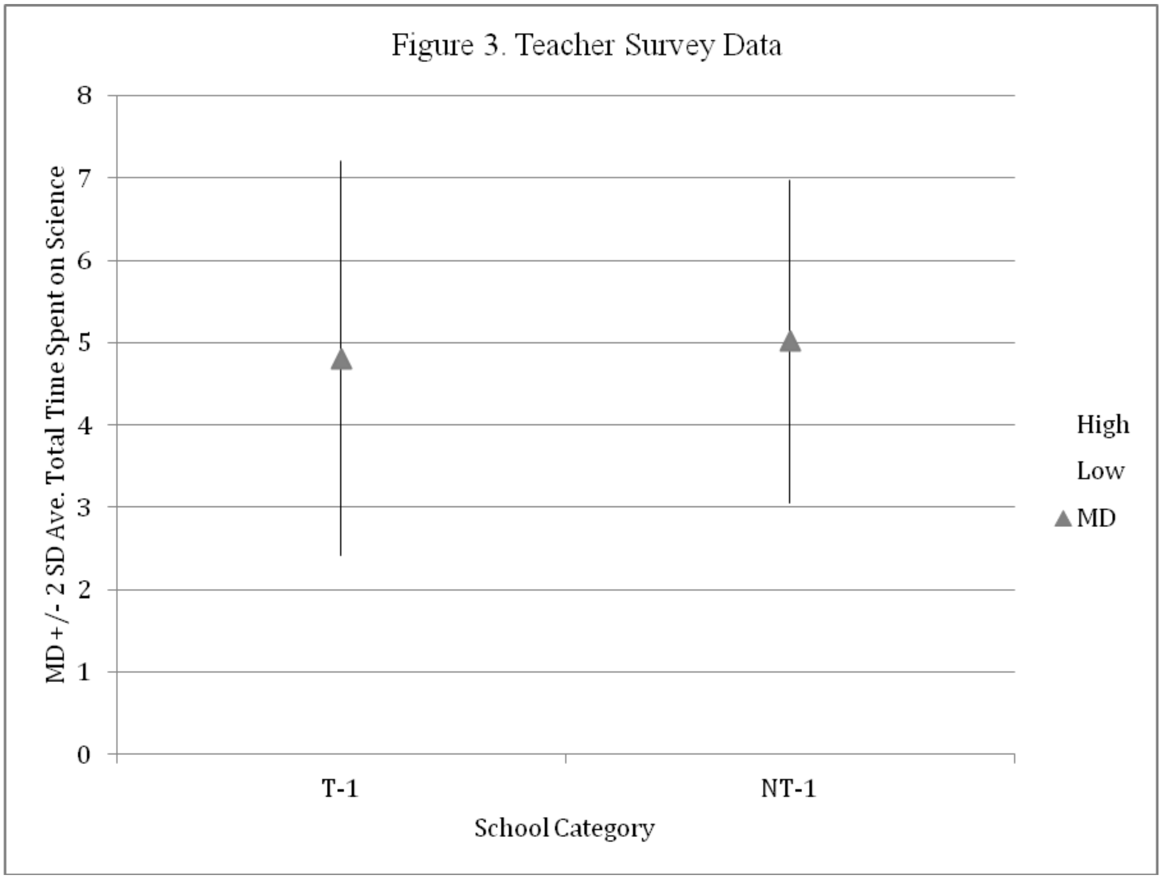

Figure 3. Error bars (showing two *SD*'s above and below the *MD*) for the average amount of time spent on science curriculum per week by Title I (T-1) and non-Title I (NT-1) teachers.

Project Reasoning

The results from the data analysis indicate a disturbing trend where Title I students' science content knowledge is steadily decreasing even though their exposure to science curriculum is virtually the same as those of non-Title I students. I hypothesized that the best way to address the problem was to improve the Title I students' exposure to science by developing a 4 day professional development program in the fundamentals of NOS for Title I elementary school teachers. Research has shown that many elementary school teachers do not have a comfortable relationship with science (Cotadish, Dailey, & Hughes, 2011). My project's main premise is to give teachers in Title I schools a more solid science foundation that can help these teachers become more willing and able to address science in their classrooms. The project is designed to address 3 facets: (a) the lack of content knowledge many elementary school teachers have about the nature of science (NOS), (b) some of the anxiety that elementary school teachers have toward teaching science in the classroom due to their lack of content knowledge in the NOS, and (c) the relevance and benefits of science education in early childhood education (i.e., elementary school). By addressing these key issues, the project is expected to mitigate the apparent widening gap in science content knowledge between Title I and non-Title I students. It would be negligent to not try to somehow diminish this disturbing trend that exists between Title I and non-Title I students concerning science education. Science is becoming a more integral part of our lives and if Title I students are allowed to continue on this deteriorating path it can possibly have far more reaching consequences later in terms of job possibilities. Therefore, I believe this project is an essential component to begin to address this problem.

Assumptions, Limitations, Scope, and Delimitations

There are limitations and extraneous variables that cannot be controlled or accounted for in any study (Creswell, 2008). A weakness of this study is that I surmised that the reasoning for the diminished science scores was variations in science instructional time in particular schools, due mainly to the lower SES population that the school served. I countered these effects by identifying the scope of this study using two distinctive independent variables (i.e., Title I status) and using large population samples to measure actual effects. These two distinctive independent variables had unique circumstances that can be inferred for each, creating two general homogeneous subdivisions of the overall population. The assumed variables that make up these two distinctive groups are not absolute but are well documented in current research literature (National Center For Educational Statistics, 2010; see also Bempechat, Li, Neier, Gillis, & Holloway, 2011; Bartel, 2010):

- Title I elementary schools, whose demographic makeup is primarily lower SES and whose population tends to be more minority Black and Hispanic;
- Non-Title I elementary schools, whose demographic makeup is primarily middle to upper SES and whose population tends to be whiter;

In this study, I also assumed that reduced time spent on science instruction created discrepancies in science scores, rather than other extraneous variables. I did, however, limit the effects of this assumption by addressing that the extraneous variables should affect all subject matter scores somewhat equally. While this study looked at a national problem of less instructional time given to science inadvertently due to the implementation of NCLB, my results could only reflect the dynamics at play within the boundaries of this North Georgia County School District. My results were limited to this North Georgia County School District. A further limitation of the study is that out of the 65 elementary schools in the county, 27 Title I and 38 non-Title I, only 15 schools, 6 Title I and 9 non-Title I, showed a willingness to participated in the study. Diminishing my self-reports questionnaire sample population, in terms of schools, by 77%.

Protection of Participants' Rights

The data obtained for the comparison of scores on the CRCT in the different subjects and between Title I and non-Title I schools were aggregate archival data, which are available in the public domain. Therefore, this portion of my data collection represented a minimal risk. Participants that took part in the self-report portion of the study only identified themselves as teachers from either a Title I school or non-Title I school; no other personal information was necessary or required as part of the self-report questionnaire. This format ensured anonymity and posed minimal risk to the participants. The participants were informed prior to beginning the questionnaire that completion was voluntary and submission of the survey constituted consent of the study.

Conclusion

The independent-samples *t* test compared Title I to non-Title I students as they progress from 3rd, 4th to 5th. It carried a two-tailed *p*-values that were less than 0.0001, and this difference was considered statistically significant in all the subjects (i.e., science, reading, language arts and mathematics). With all of the *t* test values falling in this category, it was important to analyze other aspects of the data results. There were two data results (viz., the MD and SED) that were relevant and indicative of the problem of this study. The analysis of the WMD and SED between the Title I and non-Title I students both indicated that scores in reading, language arts, and mathematics had converging patterns signifying gains in these subject matters by the Title I students. The WMD and SED between the Title I and non-Title I students in science showed a diverging pattern, signifying a probable loss of ground in science by Title I students. This illustrated that while the application and implementation of NCLB and its use of measuring gains in terms of AYP has had a possible positive effect on high-stakes testing subjects like reading, language arts, and mathematics, scores on the Georgia CRCT converged as students in Title I schools progressed from 3rd, 4th, to 5th grade. Their implementation for the low-stakes testing subject of science has shown a possible negative effect by showing diverging science scores on the Georgia CRCT as a student in the title I schools progress from 3rd, 4th, to 5th grade. As a result, I propose a project (i.e., a 4 day professional development to establish a fundamental foundation in NOS) that will address this problem of an apparent widening gap in science scores on the Georgia CRCT between Title I and non-Title I students. The results from the self-report survey did not support the hypothesis that Title I students were being exposed to less science instructional time than non-Title I students. With a $t(239) = 1.49$, $p = 0.14$, and a SEM almost the same, the amount of science exposure for Title I and non-Title I students was virtually the same. These results leave an interesting quandary if the students are all being exposed to virtually the same amount of time to science curriculum. What is causing the discrepancy in the scores being obtained by these two subgroups of students?

Section 3: The Project

Introduction

Students in Title I schools in this North Georgia County are at a distinct disadvantage over non-Title I students when it comes to science. I was able to come to this conclusion after having first obtained permission from Walden University Institutional Review Board (IRB) and given the approval code 01-31-13-0173370 which allowed me to perform my study. The data analysis of the study has shown that students in Title I schools exhibit scores in reading, language arts, and mathematics that converge with that of non-Title I students, but scores in science that diverge from their non-Title I peers. My project will address some key issues that may be impeding the teachers' ability to implement science curricula in the classroom and illuminate the importance of science in the elementary school curriculum. The project will focus on Title I elementary school teachers to curtail the diverging science Criterion-Referenced Competency Test CRCT scores. The project will be guided by the literature to address (a) the lack of content knowledge many elementary school teachers have about the nature of science (NOS), (b) some of the anxiety that elementary school teachers have toward teaching science in the classroom, and (c) the relevance and benefits of science education in early childhood education (i.e., elementary school). By addressing these three barriers to science education at the elementary school level, it is possible to correct the widening science proficiency gap that exists between Title I and non-Title I student performance as shown in the data analysis of this study.

Description of Goals

This project is designed to address hindrances to science education in Title I elementary schools as denoted in Section 1 of the study. The elementary school teacher's level of anxiety and attitudes toward teaching science, due primarily to the lack of content knowledge (CK), pedagogical content knowledge (PCK), and poor experiences in previous classes dealing with the NOS.

The project can be best described as a formal professional development introduction to the NOS for elementary school teachers or as a foundations course designed to reinforce the fundamental components of science that are critical in establishing a more adequate content knowledge base, alleviating science anxiety, and negating possible negative attitudes toward NOS. The project will first bring attention to the widening gap between Title I and nontitle I students by showing the teachers what is happening to their students' science scores relative to high-stakes subject scores and re-emphasizing with current research the importance of science education at the elementary school level. The second and more critical section of the project will address the anxieties and negative attitudes that the teachers may have toward science. This will be achieved in two stages. The first stage will be to establish the teacher's current level of science content knowledge and attitudes toward the NOS by administering a pretest to establish a starting point for each teacher in terms of NOS content knowledge and attitudes. From that starting point, teachers will begin to build up and/or stratify their individual science content knowledge and attitudes by the use of lecture notes, computer graphic demonstrations to help visualize abstract concepts, and hands-on laboratory exercises that correspond and reinforce the didactic content and visual graphic presentation.

The goals I wish to accomplish with this project are that teachers will:

- Discover, accept, and improve their current content knowledge and attitudes toward the NOS.
- Have reduced anxiety levels when they are teaching science topics due to the newfound confidence that comes with improved content knowledge in science.

- Acknowledge the importance of science at the elementary school level and start to apply their new CK and PCK to improve their students' science content knowledge and science scores.

Rationale

The introduction and implementation of documents and policies like Benchmarks for Science Literacy, National Science Education Standards, and No Child Left Behind (NCLB) have placed great pressure on what is to be taught in terms of science curriculum (National Center On Time and Learning, 2011). While some of these documents and policies try to improve and enhance science, often the implementation of these policies gives an "impoverished view of what makes science such a robust epistemology" (Buxton & Provenzo, 2011, p. 52) is a profound statement of what happens many times when trying to re-emphasize science. Add to this the lack of training, content knowledge, and discomfort that many elementary school teachers have in NOS, and you have a situation where science education at the elementary school level can be seriously hampered (Posnanski, 2009). To tackle these issues I propose a 4 day professional development project designed to address the lack of training that hampers a teacher's ability to actively teach science in a classroom setting by addressing (a) possible lack of content knowledge, and (b) discomfort in teaching science and NOS. Professional development workshops that are implemented appropriately and have set goals can be an effective conduit in improving both teacher and student performance (Forbes, 2011).

Review of the Literature

As stated by Jackson (2007) science has been in a "quiet crisis" in recent years with schools narrowing curriculum since the passage of NCLB and its requirements for schools to make AYP in the main subject areas of reading, language arts, and mathematics. Along with this is the precarious and many times uneasy relationship many elementary school teachers hold toward science and science curriculum (Posnanski, 2009). This paper will analyze the research to explain how a well-planned and orchestrated professional development workshop can be used to diminish the precarious and uneasy relationship elementary school teachers sometimes have toward science and reintroduce to elementary school teachers the importance of students having a solid foundation in the NOS. The goal of this professional development project is to address and improve three key issues that can help elementary school teachers reach their full potential in teaching the NOS:

- Discover, accept and improve their current content knowledge and their possible misconceptions of the NOS.
- Have reduced anxiety levels when they are teaching science topics due to the newfound confidence that comes with improved content knowledge in science.
- Acknowledge and accept the importance of science at the elementary school level and start to apply their new CK and PCK to improve their students' science content knowledge and science scores.

Teacher Professional Development

Recent research has shown that many of the professional development workshops for teachers have yielded little to no evidence of success in student achievement (Barufaldi & Cormas, 2011). The problem, however, was not the professional development workshops themselves but how they were implemented, with many of the workshops using anecdotal ideas, superficial learning, no clear objective, and below par evaluating techniques (Barufaldi & Cormas, 2011). To produce an effective professional development workshop the, above four mentioned misgivings must be addressed along with the workshop's ability to instill that professional development is (a) an ongoing process, (b) has the ability to improve communication skills, and (c) can lead to real world applications (Barufaldi & Cormas, 2011). Cotadish, Dailey, & Hughes (2011) state “in order to increase the quality and quantity of science instruction, elementary school teachers must receive professional development and science learning processes”. It is essential that teachers emphasize and engage students in science because of the critical role science plays in today’s world (Forbes, 2011). A professional development workshop in science should give a teacher a deeper understanding of the language of science and the process of science in order to give the teacher the ability to create lessons that not only teach science but gives the students the insight and knowledge so that the student can apply the concept to address real-life events (Cotadish et al., 2011). Just as ineffective professional development workshops have had little significant affects in addressing teacher or student performance, a high-quality and well-planned professional development workshop has shown to be quite effective in improving teacher and student abilities (Cotadish et al., 2011). The key issue driving the use of a professional development program in science is the principle that a better prepared, more content knowledge rich, and less fearful teacher can lead their students in a better science endeavor. Professional development programs, when properly implemented and continuing, can be the glue that fosters and holds together teachers that can then improve themselves and other colleagues to further collaboration of what was learned and how the material can be delivered for outcome results in student gains (Stansbury, 2012).

Discovering and Improving Content Knowledge

Key to how a teacher approaches a subject matter to be taught to their students is the teacher’s own content knowledge and comfort level held in that subject matter (Akerson, Hanuscin, & Lee, 2010; Akerson & Adb-El-Khalick, 2009; Posnanski, 2009). It is essential that a teacher feel well-versed and secure in a subject matter because there are indications that demonstrate a teacher's discomfort in presenting a subject matter translates into classroom dynamics that may limit the students ability to achieve in the classroom (Posnanski, 2009). It is important to clarify to elementary school teachers that science is not just a hodgepodge of "facts, laws and theories" (Anagun & Yalcinoglu, 2012, pp. 119). Explaining what is NOS can be a challenge because there is no set definition for NOS (Bryan, Butler, & Seung, 2009; Akerson & Adb-El-Khalick, 2009; Akerson, Hanuscin, & Lee, 2010). What we can stress is that NOS requires the consideration of epistemology, acceptance of ideas that leads to a way of understanding, and values that extend the knowledge of science (Akerson & Adb-El-Khalick, 2009). With this in mind we can target our teachers with five essentials strands for improving their content knowledge in NOS. The AAAS, 1993; National Research Council, 1996; National Science Teachers Association, 2000 all emphasize the importance of these five aspects to be crucial in developing the NOS content knowledge of elementary school teachers (Akerson & Adb-El-Khalick, 2009):

> These aspects include that scientific knowledge is empirical (i.e., to a significant extent, derived from and/or consistent with observations of the natural world); that scientific knowledge is both reliable and tentative (i.e., subject to change); that scientific investigation is theory-driven, which entails that, even through scientists strive for objectivity, their work is the less affected by their theoretical commitments and personal histories; that the inferential nature of scientific knowledge details the need to appreciate the crucial distinction between inferences (e.g., scientific claims) and observations (i.e., the evidence that provides support for the claims); and that human activity plays a role in developing the scientific knowledge (Akerson & Adb-El-Khalick, 2009, pp. 2163).

By clarifying these 5 essential ideas about NOS one can begin to rectify many of the misconceptions that still linger even after three decades of professional development and training of elementary school teachers in science curriculum (Burgoon, Heddle, & Duran, 2010). These 5 essential ideas are crucial if we are to help elementary school teachers be successful in transferring their content knowledge to the students because even with all the past focus on science training many teachers still feel inadequately prepared to conduct a science concept and even less prepared conducting an inquiry-based lesson (Hestness, Marbach-Ad, McGinnis, Pease, & Riedinger, 2011). So it is imperative that we first establish a baseline for the teacher in terms of content knowledge and attitudes (i.e., perspective views) on NOS because these two factors are key in developing a teacher's pedagogical content knowledge (PCK), best suited to enhance student performance (Bolus, Byers, Koba, Scheepke, & Sherman, 2011; Dunst & Raab, 2010). This process of establishing a baseline will be a fundamental first step in bringing teacher's views, which in many cases is not in-line with the most current scientific conceptual undertakings (Akerson & Adb-El-Khalick, 2009). The establishment of a baseline in terms of content knowledge and attitudes toward NOS will allow us then to address the teacher's strengths and weaknesses in these areas. This can be achieved by using survey questionnaires like The Views of Nature of Science Questionnaire-Form C, Metacognitive Awareness Inventory and the National Science Teachers Association (NSTA) recently released electronic professional development indexer (Akerson & Adb-El-Khalick, 2009; Bolus et al., 2011). From that point we can start aligning the teacher's content knowledge and attitude toward current scientific concepts. Once the teachers PCK is aligned with current scientific concepts this should strengthen a teacher's ability to teach NOS and play a more crucial role in the students' science acceptance and interest. This is a crucial component because current research indicates that teachers who lack a solid and more diverse understanding of science hold many of the same inaccurate concepts held by the students in their classes (Tairab, 2010; Burgoon et al., 2010).

Reducing Anxiety Levels

NOS can be a daunting and overwhelming concept. Particularly when the concept does not have a unifying definition in the literature and yet we want elementary school teachers that many times carry anxieties and negative attitudes about NOS that can hinder the teacher's ability to explore and teach science in the classroom (Bursal, 2012). Anxiety can affect many aspects of the person's ability to perform a task by internalizing an emotional state about a concept rather than confronting and acting upon it. It can manifest itself in self-doubt about one's ability to complete or adequately complete a task (Cheung & Hui, 2011; Mallow, 2010). Not only do elementary school teachers have this anxiety toward teaching science, there can also be an underlining negative attitude toward science which can come from the teachers own poor performance in science classes (e.g., elementary and secondary schools), a lack of a role model in science (i.e., for females whose gender stratification of science may have started as early as fourth grade) and societies modern perception of scientist (Bryant, Hislop, Kastrup, Mallow, & Udo, 2010). These two obstructions must be addressed with the teachers because if not the teacher's anxiety and negative attitudes toward science will eventually lead to the avoidance of science instruction in the classroom (Bryant et al., 2010). Key to overcoming the teacher's anxiety and negative attitudes toward science is to fortify their current content knowledge with a strong foundation in NOS. So by first establishing the teachers content knowledge, anxiety level and science attitude baseline it will allow us to address the components that can manifest itself into a classroom atmosphere that can hinder and/or reduce student motivation in science (Cheung

& Hui, 2011). This will give us a starting point to begin strengthening the teacher's content knowledge and attitude toward science, which then can translate into reduced level of anxiety and a more effective teacher of science curriculum. Anxiety toward a particular topic (i.e., statistics, mathematics and science) can exist across gender, race and ethnicities (Alfaro & Bui, 2011; Dorwood & Hadley, 2011). How it manifests itself in a teacher's ability to teach is quite systematic. The higher the anxiety toward the topic the greater the negativity toward a topic and the less effective that teacher is in presenting materials on that topic that can then lead to lower student performance in that topic (Sneider, 2011).

Acknowledging the Importance of Science at the Elementary School Level

One of President Obama's core ideas to strengthen our nation is to increase investment in the healthy development of young children. A worthy goal but one that runs in to the problem of finding and allocating the money's to the best programs, the problem is which programs brings in the best returns for the money invested in them (Shonkoff, 2009)? The advancements in Nero science, genetic mapping and molecular biology have been quite impressive and all reinforce the importance of positive and stimulating experiences in early childhood bring about a substantial synaptic brain development (Shonkoff, 2009). It is here that we must put our efforts and establish a framework to improve and enhance today and tomorrow's healthy young minds. With all the emphasis on improving science understanding it is still unclear if our students are truly developing a better understanding of the NOS.

Even with all of the science and technology surrounding our current society, today's early childhood educators try to avoid science in the classroom. The reasoning for avoiding science tends to be consistent (i.e., low self-efficacy, science anxiety, and the belief that language and literacy are more important as stated by Carlson, Dubosarsky, Mason, Murphy, and Roehrig

(2011). This problem also tends to be more prevalent in minority populations where the student's possible diminished exposure to science can lead to a limited career selection and limited financial rewards (Carlson et al., 2011). This pattern can be curtailed with the proper and early intervention of NOS in the early education of these students (Ackerson, Pongsanon, & Quigley, 2010). An important and critical aspect of teaching science early is to try to instill a "holistic sense" to science (i.e., to not just learn science concepts but to integrate them into their everyday lives and how they interact with all subjects) as stated by Arroio and Gillian (2012). The goal behind teaching and reaching our students in terms of science education early in their development is to establish not just science literacy but to instill in students an acceptance and realization that science is an integral part of their lives. This connection can be the most profound and essential part of becoming science aware, which can then lead to a more diverse field of career orientation. An alarming and disturbing trend has been occurring with America's students and the decreasing numbers of them entry and finishing science, technology, and mathematics (STEM) programs and degrees (DeJarnette, 2011). The United States has been at the forefront of science and technology for decades but this is not what is transpiring today, as fewer and fewer students pursue STEM careers. This lack of students pursuing STEM careers is a troubling pattern because much of the American economy is driven by innovations in these STEM fields. What makes this situation even more puzzling is the vast array of programs targeted at middle school and high school across the United States has not had much of an influence increasing these numbers (DeJarnette, 2011). One of the problems could be that we are simply waiting too long to expose our students to this realm of thinking concerning NOS. There has been substantial curriculum development toward encouraging and exposing middle school and high school students. There has been little done at the elementary level for both students and teachers where a proactive push toward STEM programs could have a more dramatic and long-lasting affect (DeJarnette, 2011).

Implementation

Proposal for Implementation and Timetable

My proposed professional development program for reestablishing science as a critical and essential part of early childhood education could possibly begin for the 2014/2015 school year. That would allow for the 2013/2014 school year to be the year where the project is proposed to the school district for implementation and if accepted for implementation. The remaining part of the year would go into establishing the logistical needs of the program to begin the 2014/2015 school year. To implement this project will require several steps, including (a) arranging a presentation of the data obtained in my dissertation to illustrate the need for science curriculum and teacher training in the NOS to meet the needs of the students in the classroom, (b) arranging a meeting with the district personnel in charge of science curriculum and professional development in order to explore funding possibilities, and (c) establishing a teacher professional development course incorporating the components of this project. If the county is unwilling or unable to fund the project and alternative could be to elicit funds and support from local universities and colleges.

Potential Resources and Existing Supports

The North Georgia School District for which I work has a strong support system for implementing professional development. There are professional development days built into the school calendar, which can be used to present and implement the project to the general education elementary school teachers. The project can be offered to elementary school teachers giving preference to those teachers who are in Title I schools. The teachers would commit to attending this professional development project for four days during the school year. This is the proposed timetable for the implementation of the teachers' professional development in the foundations of science and NOS (also see appendix B for different format).

Day 1- The 1st half of the day, about four hours, will be used in the establishment of the participants' baseline in terms of content knowledge and attitudes toward the NOS. This will allow me to address the teachers' specific strengths and challenges. The participants will be asked to complete these three assessment tools in order to establish a baseline:

1. The survey questionnaires The Views Of Nature Of Science Questionnaire (VNOS) Form C, available at (http://ret.fsu.edu/Files/Tools/VNOS(C)%5B1%5D.pdf).
2. Metacognitive Awareness Inventory (MAI), available at (http://fincommons.net/wp-content/uploads/2009/03/metacognitive-awareness-inventory.pdf).
3. The National Science Teachers Association (NSTA) electronic professional development indexer (EPDI), available at: (https://learningcenter.nsta.org/indexer/default).

Once on this website the participants will be instructed to choose these content areas for content knowledge evaluation. Under Earth and Space Science indexer participants will choose (a) ocean effect on weather and climate, (b) earth's changing surface, and (c) earth, sun and moon. Under Life Science Indexer participants will choose (a) cell structure and function, (b) cell division and differentiation, (c) flow of matter and energy, and (d) heredity and variation. Under a Physical Science Indexer participants will choose (a) nature of light, (b) electricity and magnetic forces, (c) atomic structure, (d) chemical reactions, and (e) force and motion.

The first two assessment tools will be used to establish the participants' attitudes and perceptions toward science. The 3rd will be used to determine that participants' content knowledge in different science topics that correspond to the science curriculum (i.e., Earth and space science, physical science, and life science).

Day 1- The 2nd half of the day, participants will break off into groups of 4 and discuss and analyze with each other each of their responses to the VNOS (see appendix C) and MAI (see appendix D) assessment tools. Once the analysis is complete, the participants will classify their own perceived attitudes toward science on a scale of 1 to 4, where 1 is classified as very poor and 4 is classified as very good. Two hours will be allotted for this process. The last two hours of the first day will be used to analyze the results from the NSTA EPDI and to discuss, analyze, and correct the incorrect responses with supporting information for each of the EPDI core topics (i.e., Earth and space science, physical science, and life science). Then, each participant will rank the 3 core topics starting with their weakest topic in terms of content knowledge to the strongest. This will be used as a starting point for Day 2.

Day 2- The 2nd day will begin with the creation of groups of 4 participants, each group will having a self evaluated participant who considers him or herself (a) high content knowledge and poor attitude, (b) low content knowledge and good attitude, (c) high content knowledge and good attitude, and (d) low content knowledge and poor attitude. If all 4 of the possible combinations cannot be fulfilled per group, the best heterogeneous combination of the 4 possible combinations will be established. This combining participants will happen 3 times, one for each of the core topics with 2-2.5 hours allotted per topic:

- The Earth and space science component will focus mainly on the driving forces behind weather and climate patterns and states of water in terms of kinetic molecular theory and energy changes. This will be a self-driven exploration of driving forces behind weather and climate patterns by exploring these websites that are interactive and visually dynamic in explaining the concepts. At this website (http://beyondweather.ehe.osu.edu/issue/the-sun-and-earths-climate/the-sun-earth's-primary-energy-source) there are five main concepts on how the primary driving force for the earth to whether is the Sun and they are labeled A-E. The participants are to read, described and analyzed each of the main topics and their influence on the Earth's weather (see appendix E). Participants will begin at this NASA website (http://science.nasa.gov/earth-science/focus-areas/) then click on the focus on link where they will read, described and analyzed for many areas of research by NASA (a) atmospheric composition, (b) whether, (c) climate variability and change, and (d) water and energy cycle (see appendix F). Participants will view the video at this website (http://www.youtube.com/watch?v=N9OL6AwyM5I) and evaluate its content in terms of its ability to clarify weather and weather patterns on Earth. Participants will read and watch the videos at this website (https://sites.google.com/a/maricopa.edu/obedchem/chemistry/09-30-2012-states-of-matter-and-the-kinetic-molecular-theory) in order to evaluate and describe the diagrams in the link in terms of the kinetic molecular theory of particles.

- The physical science component will focus on light and sound, electromagnetism, forces and motion (i.e., Newton's 3 laws of motion), and physical and chemical change. The participants will be using for this component the PhET interactive simulation website (http://phet.colorado.edu/en/simulations/category/physics) where the participants will explore and manipulating these 14 simulations (see appendix G) (a) bending of light, (b) color vision, (c) photoelectric effect, (d) sound, (e) energy forms and changes, (f) build an atom, (g) states that matter basic, (h) battery voltage, (i) magnets and electronegativity, (j) magnets and compasses, (k) force and motion basic, (l) motion in 2D, and (m) ramp force and motion (see appendix G). By manipulating and analyzing the effects manipulating the different variables on each simulation the participant will gain a unique, in-depth and more robust knowledge of those topics.

- The life science component will focus on classification of organisms, genetics, cell structure, and ecology. The participants will be using for this component the PhET interactive simulation website (http://phet.colorado.edu/en/simulations/category/biology) where the participants will explore and manipulating these 2 simulations (a) gene expression-the basics and (b) natural selection. By manipulating and analyzing the effects manipulating the different variables on each simulation the participant will gain a unique, in-depth and more robust knowledge of those topics. The participants will explore classification of organisms in this interactive website (http://www.emindweb.com/demo/classificationDemo.html), (http://www.youtube.com/watch?v=o1GQyciJaTA, http://www.johnkyrk.com/), and (http://www.wiley.com/college/boyer/0470003790/animations/cell_structure/cell_structure.htm).

Day 3- The 3rd day will begin with the pre-established participant groups, following up on the second day's immersion and learning of the main three core components of the science curriculum, with labs and activities that reinforce and enhance what was learned in Day 2. Two hours will be allotted to each of the following topics:

- For the Earth and space science component, there will be two lab activities. The first will be available via an interactive computer simulated weather website (http://weatherlabs.planet-science.com/home.aspx) this website walks participants through a series of steps or activities designed help gather a better understand of not just how weather works but to estimate and predict how accurate it is. The second lab will be a phase change water lab that focuses on energy, temperature, kinetic and potential energy, and the phase changes of water (see appendix H).
- For the physical science component, the participants will pick one lab from the PhET website that corresponds with each of the categories that comprise the physical science curriculum components (i.e., light and sound, electromagnetism, forces and motion, and physical and chemical change). All the simulations have a teacher idea section that contains activities that directly correspond and correlate to the selected simulation. The participants will be asked to choose the level of the lab they believe is best for them, in terms of their ability and the grade level they teach for example (see appendix I and J). These simulations are designed to walk participants through a series of steps or activities designed to help gather a better understand of not just how weather works but to estimate and predict how accurate it is.
- For the life science component, the participants will pick one lab from the PhET website that corresponds with each of the categories that comprise the life science curriculum components (classification of organisms, genetics, cell structure, and ecology). All the simulations have a teacher idea section that contains activities that directly correspond and correlate to the selected simulation. The participants will be asked to choose the level of the lab they believe is best for them, in terms of their ability and the grade level they

teach for example (see appendix J). These simulations are designed to walk participants through a series of steps or activities designed to help gather a better understand of not just how weather works but to estimate and predict how accurate it is. At the end of the third day's professional development the participants will be informed when the fourth professional development day will be meeting.

Day 4 – The 4th day will be scheduled to take place at the end of the school year the after the completion of the initial three day professional development took place. The participants will again take the VNOS, MAI, and the NSTA EPDI. Afterward, they will form the same four-person group that they were in during the first 3 days of the program. The participants will discuss, analyze, compare their current attitudes, and content knowledge toward science to their previous results to determine if there has been a change. Three to 4 hours will be allotted for this activity. The second half of the day will consist of participants sharing and presenting activities and/or lessons that they particularly enjoyed and had successful outcomes with their students. The participants will be informed by e-mail of this requirement (i.e., sharing and presenting activities and/or lessons) 3 weeks prior to the fourth professional development day in order to allow them adequate time to select the activity and/or lesson plan they wish to present. Three to 4 hours will be allotted for this final closing activity.

Potential Barriers

Funding needs for the project include:

- Establishing a location that can facilitate the needs of the 4 day professional development workshop.
- Allocating the funds for the materials and equipment that would be needed to run the day professional development workshop.

- Getting a sufficient number of Title I elementary school teachers to commit to a four day professional development in science.

The facility chosen would have to have computer and science lab stations able to accommodate about 50 teachers and be centrally located in the county not too overburdened or discourage some of the teachers with extremely long commute times. The allocation of funds must be established and set in the counties' budget by the end of the school year prior to the professional development planned date of implementation to ensure time for planning and recruiting of participants. Insuring sufficient numbers of teachers for the project ties in directly with the ensuring an allocation of funds. The earlier the facility and funds are allocated the more time there is to ensure adequate teacher recruitment and participation in the program.

Roles and Responsibilities of Students and Others

This professional development program for reestablishing science as a critical and essential part of early childhood education would be a voluntary program for elementary school teachers, but once started, the teachers would be required to fully commit to the program (i.e., complete all four days) within a calendar year after it was started. The participants must be made aware of the importance of implementing the content knowledge they have acquired in order to be more effective in the classroom in terms of transferring their newly developed sense of NOS to the students in their classrooms. Appling this method can ensure that the methods learned can become part of the teachers PCK. The program would also have to be funded for a minimum of two years by the school district in order to allow for at least one full cycle of the program to be completed by all the elementary school teachers that start the program. Without a full 2-year commitment to the program by the school district, the project will neither be completed nor fill the needs of the teachers. My responsibility would be to both the school district and the teachers that are entrusting me to properly implement the program as effectively and efficiently as possible. This means trying to make sure that the teachers after completing the program will have:

- Improved their current content knowledge and discovered their possible misconceptions of the NOS.
- Reduced their anxiety levels about teaching science topics.
- Acknowledged and accepted the importance of science at the elementary school level.

Project Evaluation

To determine how effective the project was in addressing the 3 major points of the 4 day professional development -- (a) improving teachers content knowledge of NOS, (b) reducing anxiety, and (c) having the teachers acknowledge and accept the importance of science at the elementary school level -- summative assessment approach will be taken. This outcomes-based evaluation will be accomplished by having the teachers take the same three evaluations (i.e., VNOS, MAI, and the NSTA EPDI) they completed in Day 1 of the project (i.e., professional development) and comparing their results after completing the professional development one year later. The use of a summative assessment approach will allow me to gauge how effective the project was in producing a teacher that is more capable to teach science elementary curriculum and to ascertain how the teachers' perspectives on the three main components addressed in this project have been affected. It would also be interesting to evaluate the teachers who completed the program five years after completing the program to determine if they had resorted back to their original orientation toward science or if they have maintained the new level perspective toward science.

Implications Including Social Change

Local Community

The main purpose of this project was to address a critical shortfall (i.e., the diverging science scores between Title I and non-Title I students on the Georgia CRCT in a North Georgia County) and the extraordinary pressures that are placed on all schools in order to prove that they are properly serving the students they are educating (Allen & Thompson, 2012). These external pressures (i.e., NCLB and AYP) have affected all schools, but Title I institutions, due to their demographics, are more acutely sensitive to these external pressures. Some of the effects have been:

- Students having deficient content knowledge in science and STEM.
- Increased student apathy toward science education.
- A much stricter and more punitive system.
- An educational system that looks good but may not be serving the true needs of the students within it (Allen & Thompson, 2012).

My project's main goal is to stimulate the social change needed to give all students the same possibilities of succeeding in STEM, which is such a vital component for success in today's job market. An important aspect for this social change to occur is to address the needs and weaknesses of the teachers which are so important to the bridging the gap that exist between Title I and non-Title I students could begin to erode away the discrepancy that exist (Kwan & Lee, 2012).

The importance of the project to the local stakeholders (i.e., school district and parents) is not just improved scores on a test but the creation of a more well-rounded and STEM savvy student able to succeed and progress as he/she continues his/her education. The most important stakeholders, however, are the students themselves. Much of the students' abilities to succeed in the courses they take come from their attitudes toward those courses (Alfaro & Bui, 2011) (Alfaro & Bui, 2011) (Alfaro & Bui, 2011). If we instill a sense of relevance and acceptance of STEM material can be instilled early in a student's educational exposure, it could manifest in more accepting attitudes toward STEM and increase the chances to succeed in those courses (Sneider, 2011). This should help produce students that are not just more accepting of STEM courses but more willing to enter and persevere in those courses therefore having the student fulfill an important niche in the modern job market essential for success.

Section 4: Reflections and Conclusions

Project Strengths and Limitations

The project's strength lies in directly addressing the teachers' needs (i.e., lack of content knowledge, anxiety). By mitigating these deficiencies in a teacher's abilities to teach science and nature of science (NOS), I am attempting to enhance an essential component critical to making science a key component in the development of those students (Bryan, Butler, & Seung, 2009). The premise of the project is sound and persuasive because it tries to strengthen a possible weakness in the teachers' background content knowledge (CK) and pedagogical content knowledge (PCK), which corresponds with the growing evidence that effective teachers hold an analytical understanding of the curriculum they are teaching (Beyer & Davis, 2012) A key aspect of this project was to reinforce the teachers' CK and PCK so that they can go beyond just teaching material and give the students more insightful information about the relevance and real world applications of the material that is more useful in terms of understanding the NOS (Alonzo & Furtak, 2010). The project's limitation lies in trying to impart something as complex and voluminous as science CK and PCK to participants in a mere 4 days. This limitation is mitigated, however, by focusing on key aspects of the science curriculum for which the teachers are responsible to teach the students. The project focused on enhancing and strengthening the core knowledge the teachers had in 3 of the main curriculum topics chemistry, physics, and earth science. In order to establish a working foundation and general core of knowledge to which the teacher would be able to draw from and expand upon as they begin to explore the topics with their students. The project's most important aspect was to give the teachers a strong sense of NOS so as to reduce the stress and anxiety levels that accompany and hinder many teachers when they teach science, making them more adept and willing to teach science in the classroom.

Recommendations for Addressing the Problem Differently

To address the problem of the diverging science scores in this North Georgia County from a different perspective, I could have focused on students' rather than teachers' barriers. Many of the problems and difficulties students have later in science classes may be reduced if diagnosed and treated early at the elementary school level (Barmby, Jones, & Kind, 2007). Early treatment and diagnoses could be done by designing a project to identify the current status of, some key fundamental science components within the student (i.e., content knowledge base, science anxiety, and possible negative attitudes toward NOS). The project could 1st try to reemphasize the importance of science education by showing students all the different jobs and activities of people who study science. The 2nd and more critical section of the project could address the anxieties and negative attitudes that students may have toward science. This could be achieved in two stages. The 1st stage could be to establish the students' current level of science content knowledge and attitudes toward the NOS by administering a pretest to establish a starting point for each student in terms of NOS content knowledge, anxiety, and attitudes toward science. With that information, it would be possible to begin to build up and/or stratify the students' individual science content knowledge and also address any negative attitudes and anxieties that the students may carry toward science (Bryant et al., 2010). By addressing the problem this way, it could be possible to stem and cut off early the possible seeds that can grow into larger hindrances in the students' abilities to perform in science as they progress through school (Sagir, 2012). Using this method to identify students who could later have trouble in science, by addressing these students' misgivings and limitations in science early (Sagir, 2012).

Scholarship

The attainment of scholarship has been truly life altering. I now see that information by itself is not enough, that the reasoning why and the goal of those behind the information are just as important as the information itself. The interpretation of the data or facts that the information is constructed around can be manipulated to express just about any point of view. What is most important about what I have learned about scholarship is that it should not be biased. It is critical that one should represent the data as accurately as possible, in order to explain the truth about what is being studied. Making this process the best way to express the reality of the world around us through unfiltered truths. I have also learned to be skeptical of scholarship, to analyze and dissect it in order to determine its true purpose by delving into the entity that produced it and trying to surmise its intended goals. A key technique used to ascertain sources of information was to reduce the URL addresses down to their core addresses (i.e., home pages) and learn about the sources' goals and objectives by reading their mission statement and other components of the home page. This activity gives vital information about the sources' sponsors and objectives along with any agenda or affiliations, thus allowing me to judge the credibility of my sources.

Project Development and Evaluation

I realized that proper project development begins with the correct interpretation of data from a study and then identifying how to address an identified gap or problem. To tackle any deficiencies, it is essential to study and analyze the deficiencies, so that the best techniques can be used to maximize the effectiveness and proper application of those techniques to combat the deficiencies. I chose to implement a teacher centered professional development project to enhance and reinforce the teachers' science CK and PCK in order to address the problem of low science scores in Title I elementary schools. I have taken from this experience that a project's goals and objectives should be uniquely tailored to the circumstances at hand without manipulating an existing project to fit a different set of parameters. I chose to evaluate my project by performing a standard pre- and post-test of the participants because it would give a quick and useful measure of the gains made by the participants in the short-term. Evaluating this way, while productive in illustrating the gains made by the participants, does not show how effective the project is in terms having a prolonged and sustained change in the teachers' behaviors in the classroom. It would be interesting if a study could be done to determine if teachers who went through this professional development project had students who outperformed other Title I students. Evaluating the professional development project this way would probably be most effective. Evaluations, while they are an important part of any project, many times can only provide a small view of the overall effects the project had on the participants. It is important, then, to acknowledge the limitations of any evaluation of any project study.

Leadership and Change

The concept of leadership cannot be separated from change. As one takes a leadership position, change is an inevitable because when one is placed or accepts a leadership position, the ideas one has to improve the system becomes a goal to be obtained in order to initiate a change. Leadership also requires not becoming so focused on the desired goal that other aspects of the system become neglected and start to impede the overall process, which is probably the true nature of leadership, the ability to affect change while making the improvements that are deemed as priorities. Leadership also stems from the willingness to trust others to achieve the goals set forth and not micromanage them to the point of reducing creativity and productivity. A principle aspect of leadership is to accept that while change may be inevitable, it is seldom swift. Every situation carries its own internal inertia to resist change. To initiate a change, leadership must apply influence and ideas in a constant and gradual manner in order to allow the entire situation to adjust to this external change. Abrupt and sudden changes can be shaken off and the situation returns back to its normal state, but a sustained and persistent application of an idea can render true change throughout a system.

Further, the application of leadership can be difficult to pursue and enforce without having a source of authority. As a teacher, this idea of leadership is the hardest to yield. Today's educational system is not designed to give teachers much freedom in which to take real leadership roles. An example of this that just played out in the North Georgia County in which I work is that the local school board overruled the recommendations made by a special elected committee of teachers for the new mathematics books that incorporate the latest Common Core curriculum standards. The committee was charged with selecting the best new mathematics books for adoption, and the School Board simply ignored the teachers' selection and designated their own. In another case, the School Board asked teachers to take part in the continued use of a balanced school calendar, which had been used the previous year with remarkable results like (a) reduced teacher and student absenteeism, (b) savings in spending on accounting, and (c) improved student performance. The teachers overwhelmingly approved its continued use because of the remarkable results shown by implementing the balanced calendar, but the School Board instead implemented a pre-established calendar with no input from teachers. Leaving many of the county's teachers bitter because it showed how little input and weight they are given in terms of affecting policy. Teacher leadership at the school level is also an issue, for example in many high school settings department heads, instead of being teachers with many years of experience dealing with administrators, parents, and students, are instead fairly new teachers who do not question administrative directives due to their lack of experience.

Scholar and Practitioner

I have grown and changed in four aspects as a person and a leader**.** First, when I began this journey, I was so ignorant of how education is shaped, molded, manipulated and governed that it has impressed upon me the notion that at no time should anyone be that unaware of what is truly going on around him or her. To expand on this idea, I believe there should be a core requirement course at the university level that delves into the dynamics and influences on education that starts with the local level and follows the hierarchical anarchy all the way up to the federal level. To illustrate this, I had no idea how No Child Left Behind (NCLB) worked. I knew about all the testing, but I had no idea that each state was allowed to make up its own rules for what was considered proficient. It seemed ridiculous to me that you could basically have 50 different parameters on what is considered proficient for students. The other NCLB rule that was illogical was that if you set your standards low and your students met those goals that the school system got money and looked great. If a district had set its standards high and did not meet those standards, money was taken away in that the system was somehow deficient for not meeting its goals.

Second, the quality of my CK and PCK has also gone through a profound metamorphosis because, while knowing material is a quintessential part of teaching, understanding how the material is being disseminated to the target group can be just as crucial. I understand now how it is important that I try in all the CK I know about chemistry and tie it into how it is tangible and usable in the real world. For example, when I teach electron configuration, I tie into the science of spectroscopy and analytical chemistry. This can then be tied into television shows that use forensics in their storylines.

Third, the activities I have gone through in the last four years, some of them enjoyable and relevant and others not so enjoyable and not so relevant to me are still a crucial part in expanding who I have become. If we only see and do in terms of our own narrow perspectives, we can be blind to other ideas and possibilities that exist. I believe this is where I have grown the most, by being more accepting and realizing that other people can be given the same information but come to a totally different conclusion to my own. One activity I did with my students that pushed the boundaries around me the most was the community and education connections project where I connected solution chemistry to how water treated and analyzed for our consumption to the use of chemical analysis and analytical techniques. It was a unique situation where I had a select group of Title I students in an AP chemistry class for an entire school year allowing me the freedom to explore a community and education connection, and the results were gratifying. The unfortunate aspect of this unique opportunity is that with today's current philosophy and time constraints, I could never replicate that activity. It simply required too much time to implement and covered too little required curriculum.

Finally, the breadth of knowledge I have attained through reading, analyzing, and application truly stands out in my mind about the last four years. I have kept a majority of the articles I have read for either the classes at the beginning of this dissertation, and it is quite humbling. Though when I look back at not just how I used to gather and study information, I am disappointed in how little I knew about obtaining reliable and viable information and how little scrutiny I placed in terms of who was writing or why. Today, when I look back at all I have exposed my mind to in terms of applicable literary information about so many aspects of education, I cannot imagine going back to where I was.

Project Developer

The essence of what it took to develop and deploy a professional development project to others was quite revealing. I can now with some insight look back at many of the professional development workshops I attended and analyze them in terms of relevance, practicality, and functionality. I can elaborate because I have attended some very organized, detailed, expansive, and ambitious professional development workshops that had little chance of success because the planner assumed that a concept that functions well in one system will translate into success in another system with similar dynamics. Professional development workshops should be designed around strengthening the teacher, not influencing what the teacher does, because the implementation of different educational programs (i.e., NCLB with this focus on the constant testing of students) has not proven ineffective in improve student scores. By strengthen the knowledge in the teacher by using techniques to implement the change, you are empowering the teacher, not just telling the teacher what to do. The workshops should be designed to help the teacher gain an understanding of what the outside influences (i.e., Common Core curriculum) are so that the teacher can make his or her own course changes according to the new outside influences. Give the teacher the proper understanding and knowledge of the concept being pushed so that the teacher can then apply it to his or her students; this is a much more effective manner of improving the educational system. In education, one thing that is universal is the teacher; all other aspects of education are in a constant state of dynamic flux. Therefore, what I have taken away from all I have learned and assimilated in the past four years is that to improve the teacher is the best way to improve the educational system.

Overall Reflection

To begin my reflection, I look back to the problem I perceived, which was the disparity between Title I schools and non-Title I schools in terms of science test scores. The research literature supported my hypothesis by illustrating that, elementary schools, especially those composed of minority and lower SES students, were curtailing science in order to focus on high-stakes testing topics like reading/language arts and mathematics. My literature review also contained information on how NCLB's general design placed more pressure on Title I schools that non-Title I schools because NCLB rewards schools that perform well on standardized tests and penalizes schools that do not. The research showed this philosophy had a more significant effect on Title I schools whose students generally score lower on standardized tests than non-Title I students. Many of these Title I schools started to curtail or eliminate low stakes testing subjects like science in order to avoid the punitive measures NCLB would impose for lack of compliance.

I used a quantitative approach to test my hypothesis. I tested two possible effects of NCLB (a) a growing gap between Title I and non-Title I students' science scores and (b) a significant difference in time dedicated to science between Title I and non-Title I teachers. I addressed the first issue of a possible growing gap in science CK by comparing test scores between Title I and non-Title I students in four subjects (i.e., reading, language arts, mathematics, and science) tested by Georgia's annual CRCT exams. I used an unpaired sample t-test to compare the scores between the Title I and non-Title I students in the four subjects previously mentioned. The process was time-consuming because of the large number of data points needed for the t-test but not mathematically difficult to use and decipher in terms of results. The second issue of Title I teachers dedicating less instructional time to the science curriculum was addressed by using a self report survey questionnaire in order to compare the two groups. This to me was the most frustrating and time-consuming aspect of my entire dissertation. I had no idea the complexity of first applying for permission to perform the survey from the Walden University Institutional Review Board (IRB) and then trying to get permission from the school district to survey the teachers. Getting those two things done was difficult enough but then trying to merge the two together seemed, at the time, nearly impossible.

The results of my study supported my first hypothesis by illustrating that while CRCT test scores in reading, language arts, and mathematics converged between Title I and non-Title I students, the CRCT scores in science were diverging and expanding as the students moved from third grade to fifth grade. The results from a second hypothesis that Title I teachers were spending less time on science curriculum than non-Title I teachers turned out not to be the case with results showing no significant difference between the two. This was the most surprising part of my study because I was connecting depressed science scores in Title I schools to less instructional time dedicated to science, but this turned out, in this study, not to be the case. This led me to question what was causing the growing disparity in science scores between the two groups.

I addressed the problem of the growing science test score gap between Title I and non-Title I students by developing a project that would (a) reinforce fundamental science and NOS concepts in elementary school teachers, and (b) identify and address possible teacher anxieties and negative attitudes toward science. I chose this venue because research shows that many elementary school teachers have poor CK and PCK, and harbor high anxiety and negative attitudes toward science. To combat this, I reasoned through gathered research that the key to student success in science was having a teacher with a fundamentally solid core CK and PCK in science. The other aspect the project addressed was identifying and addressing the level of anxiety and negative attitudes toward science that the teacher carried. I discovered two very useful and well established tests (i.e., the VNOS and MAI) that would identify these two characteristics in a teacher and therefore, establish a starting point. This was a fairly challenging undertaking because not only did I have to know how to address the problem of low science scores but I also had to develop a multi-day project to address those problems. My study while unable to establish that Title I and non-Title I students were being exposed to differing amounts of instructional time in science. It highlights a more serious issue of why are the science scores between Title I and non-Title I students diverging if they are both being exposed to the same amount of instructional time in science at school. A key finding of the study was that it highlighted that there are other variables influencing the science test scores among Title I students. This leaves the unanswered problem of what is causing the two groups studied to have diverging science scores?

Implications, Applications, and Future Directions

NOS can be a daunting and intimidating subject. It is important that today's science educators must be confident in their knowledge of the NOS because if not corrected, they could carry large implications and ramifications for the future of science for our country. Science is separated from other intellectual activity because it is cumulative in nature, requiring individuals to build knowledge layer by layer (Griffith & Scharmann, 2008), which makes science difficult to learn because if one step in the foundation is missing, the whole structure can collapse. Therefore, what is many times needed is simply more time to assimilate the information before moving on to the next concept.

My study showed that the instructional time being dedicated to science between Title I and non-Title I elementary schools in the county I studied were not significantly different, so why the divergent scores? One possibility for future study might be to allot more time for Title I students to properly assimilate science knowledge. This is why it is so important for students to begin building their science foundation as early as possible and to have an understanding of NOS and how it is interwoven into our reality because if we wait until middle school, it may be too late to build up the students' scientific capacity (Mentz, 2010). It is vital that students start to build their science knowledge early in school so that, their core foundation in science can then be expanded to real world applications by teachers with strong foundations in science. My project aligns itself with the idea that innovation has the best chance to flourish when a teacher has a solid fundamental foundation in the topic to be covered (Shonkoff, 2009). The fundamental basis of my project, was to develop an adequate science foundation in elementary school teachers, who then would have the willingness and confidence to delve deeper into the concepts being studied and dedicate more time to science.

This study is relevant because it addresses a serious deficiency in the current manner that educators and others perceive science today, and it brings attention to the discrepancy in science scores between Title I and non-Title I students. My study shows that not all students are developing their crucial core knowledge in science even though the time spent on science curriculum is not significantly different between the two groups (i.e., Title I and non-Title I students). The purpose of my project was to generate a fundamentally confident elementary school teacher who is not afraid of delving into the world of science and NOS with his or her students. The findings of my study showed that the two groups were spending equal time on science curriculum but that their science scores were diverging; therefore, the problem may not be the quantity of time but the quality of time spent on science curriculum or perhaps the lack of exposure and background knowledge developed outside school. My project's key function is to fortify and enhance teacher CK and PCK in science, which is an essential component of improving student's ability to learn science. A deeper understanding of the material can also contribute to more meaningful dialogue with the students about science and the deeper understanding that Title I students may require extended time and exposure to properly accept and understand the concepts being taught. The project should give the teachers the confidence and knowledge to address science elementary topics with students in order to develop an essential core of information and a fundamental curiosity.

Many of today's studies show how the gap between different minorities and lower SES students is slowly narrowing in mathematics and reading/language arts, but what is not being shown is how the gap in subjects like science is widening. My study only addressed the confines of my school district. A more extensive and further reaching study should be conducted to evaluate whether or not this is occurring at the state and even possibly a national level. With all the importance that is placed on science, it seems negligent for this phenomenon not to be addressed. It is, therefore, in our best interest to study if, why, where, and how it is happening and begin to change such a trend.

My study showed that there is no significant difference in the amount of science Title I and non-Title I students are exposed to at the elementary school level, but the results of that science exposure is not producing similar results in the students' abilities to express what they learned in science. I expected to find that Title I students were being exposed to less science. Although this turned out to be a false hypothesis, we are still left with the problem of diverging science scores between Title I and non-Title I students. Future studies like this can help to identify why and where two groups of students who are being exposed to equal instructional time in science are having different results, what exactly is causing the divergence between the two groups, and how can this divergence be rectified. My study has eliminated one possible variable causing the divergence in science scores between Title I and non-Title I students in my county. Other studies may find the variable or variables causing this rift, and by doing so helping science education overcome one of its most daunting obstacles.

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Appendix A: Self Reports Survey Questionnaire

Please circle the answer that best describes your situation. This self-reports questionnaire is to be anonymous so do not supply any personal information.

1. Is the school you are at a Title I elementary school? Yes No Don't know

2. Are you the general education teacher in charge of the entire curriculum in the classroom? Yes No

3. Are you the general education teacher in charge of issuing the report card grades for the student in the classroom? Yes No

4. Are you directly teaching elementary school student this school year (2012-13)? Yes No

5. How much total instructional time do your students get in science from you per week?

A. 0 minutes

B. 1-15 minutes

C. 16-30 minutes

D. 31-45 minutes

E. 46-60 minutes

AB. more than 60 minutes

6. Did the school have a science specialist with a designated timeslot per week? Yes No

7. If yes, how many minutes per week is allotted for the science specialist?

A. 1-15 minutes

B. 16-30 minutes

C. 31-45 minutes

D. 46-60 minutes

E. more than 60 minutes

8. Total instructional time dedicated to science per week (i.e., teacher and science specialist)

A. 0 minutes

B. 1-20 minutes

C. 21-40 minutes

D. 41-60 minutes

E. 61-80 minutes

AB. 81-101 minutes

Please insert the completed questionnaire in the envelope provided and thank you very much for participating in this survey.

Appendix B: Project Timeline

Day	HOURS	ACTIVITY
1 First Half	3-4	The first half of the day, about four hours, will be used in the establishment of the participants' baseline in terms of content knowledge and attitudes toward the NOS. This will allow me to address the teachers' specific strengths and challenges. The participants will be asked to complete these three assessment tools in order to establish a baseline. Participants will take three assessment tools the VNOS, MAI, and EPDI to establish their current baseline in terms of content knowledge and attitude toward NOS. - The participants will first complete the survey questionnaires The Views Of Nature Of Science Questionnaire (VNOS) Form C (see appendix C), available at: http://ret.fsu.edu/Files/Tools/VNOS(C)%5B1%5D.pdf - Follow by the Metacognitive Awareness Inventory (MAI) (see appendix D), available at: http://fincommons.net/wp-content/uploads/2009/03/metacognitive-awareness-inventory.pdf -The National Science Teachers Association (NSTA) electronic professional development indexer (EPDI), available at: https://learningcenter.nsta.org/indexer/default.aspx. Once on this

		website the participants will be instructed to choose these content areas for content knowledge evaluation. 1. Under Earth and Space Science indexer participants will choose (a) ocean effect on weather and climate, (b) earth's changing surface, and (c) earth, sun and moon. 2. Under Life Science Indexer participants will choose (a) cell structure and function, (b) cell division and differentiation, (c) flow of matter and energy, and (d) heredity and variation. 3. Under a Physical Science Indexer participants will choose (a) nature of light, (b) electricity and magnetic forces, (c) atomic structure, (d) chemical reactions, and (e) force and motion. The first two assessment tools will be used to establish the participants' attitudes and perceptions toward science. The third will be used to determine that participants' content knowledge in different science topics that correspond to the science curriculum (i.e., Earth and space science, physical science, and life science).
1 Second Half	1.5-2	Participants will break off into groups of four and discuss and analyze with each other each of their responses to the VNOS and MAI assessment tools. Once the analysis is complete, the participants will classify they're own perceived attitudes toward science on a scale of 1 to 4, where 1 is classified as very poor and 4 is classified as very good.

1 Second Half	1.5-2	The last two hours of the first day will be used to analyze the results from the NSTA EPDI and to discuss, analyze, and correct the incorrect responses with supporting information for each of the EPDI core topics (i.e., Earth and space science, physical science, and life science). Then, each participant will rank the three core topics starting with their weakest topic in terms of content knowledge to the strongest. This will be used as a starting point for Day 2.
2	2.5 / Topic	The second day will begin with the creation of groups of four participants, each group will have a self evaluated participant who considers him or herself (a) high content knowledge and poor attitude, (b) low content knowledge and good attitude, (c) high content knowledge and good attitude, and (d) low content knowledge and poor attitude. If all four of the possible combinations cannot be fulfilled per group the best heterogeneous combination of the four possible combinations will be established. This will happen three times, one for each of the core topics.
2	Topic 1	- Earth and space science component will focus mainly on the driving forces behind weather and climate patterns and states of water in terms of kinetic molecular theory and energy changes. This will be a self driven exploration of driving forces behind weather and climate patterns by exploring these websites that are

		interactive and visually dynamic in explaining the concepts: (1) At this website http://beyondweather.ehe.osu.edu/issue/the-sun-and-earths-climate/the-sun-earth's-primary-energy-source there are five main concepts on how the primary driving force for the earth to whether is the Sun and they are labeled A-E (see appendix H). The participants are to read, described and analyzed each of the main topics and their influence on the Earth's weather. (2) Participants will begin at this NASA website http://science.nasa.gov/earth-science/ then click on the focus on link where they will read, described and analyzed for many areas of research by NASA (a) atmospheric composition, (b) whether, (c) climate variability and change, and (d) water and energy cycle (see appendix I). (3) Participants will view the video at this website http://www.youtube.com/watch?v=N9OL6AwyM5I and evaluate its content in terms of its ability to clarify weather and weather patterns on Earth. (4) Participants will read and watch the videos at this website https://sites.google.com/a/maricopa.edu/obedchem/chemistry/09-30-2012-states-of-matter-and-the-kinetic-molecular-theory in order to evaluate and describe the diagrams in the link in terms of the kinetic but your theory of particles.

2	Topic 2	- Physical science component will focus on light and sound, electromagnetism, forces and motion (i.e., Newton's three laws of motion), and physical and chemical change. The participants will be using for this component the PhET interactive simulation website, http://phet.colorado.edu/en/simulations/category/physics, where the participants will explore and manipulating these 14 simulations (a) bending of light, (b) color vision, (c) photoelectric effect, (d) sound, (e) energy forms and changes, (f) build an atom, (g) states that matter basic, (h) battery voltage, (i) magnets and electronegativity, (j) magnets and compasses, (k) force and motion basic, (l) motion in 2D, and (m) ramp force and motion (see appendix J). By manipulating and analyzing the effects manipulating the different variables on each simulation the participant will gain a unique, in-depth and more robust knowledge of those topics.
2	Topic 3	- Life science component will focus on classification of organisms, genetics, cell structure, and ecology. 1. The participants will be using for this component the PhET

		interactive simulation website, http://phet.colorado.edu/en/simulations/category/biology, where the participants will explore and manipulating these 2 simulations (a) gene expression-the basics and (b) natural selection. By manipulating and analyzing the effects manipulating the different variables on each simulation the participant will gain a unique, in-depth and more robust knowledge of those topics. 2. The participants will explore classification of organisms in this interactive website http://www.emindweb.com/demo/classificationDemo.html as they proceed through the website and follow its format. 3. The participants will then view, take notes, draw and describe cell structures and function of organelles, and interact with interactive simulations when provided by the following three websites http://www.youtube.com/watch?v=o1GQyciJaTA, http://www.johnkyrk.com/, and http://www.wiley.com/college/boyer/0470003790/animations/cell_structure/cell_structure.htm
3	2.5 / Topic	The third day will begin with the pre-established participant groups, following up on the second day's immersion and learning of the main three core components of the science curriculum, with labs

		and activities that reinforce and enhance what was learned in Day 2.
3	Topic 1	- Earth and space science component, there will be two lab activities. The first will be available via an interactive computer simulated weather website, http://weatherlabs.planet-science.com/home.aspx, this website walks participants through a series of steps or activities designed help gather a better understand of not just how weather works but to estimate and predict how accurate it is. The second lab will be a phase change water lab that focuses on energy, temperature, kinetic and potential energy, and the face changes of water (see appendix B).
3	Topic 2	- Physical science component, the participants will pick one lab from the PhET website that corresponds with each of the categories that comprise the physical science curriculum components (i.e., light and sound, electromagnetism, forces and motion, and physical and chemical change). All the simulations have a teacher idea section that contains activities that directly correspond and correlate to the selected simulation. The participants will be asked to choose the level of the lab they believe is best for them, in terms of their ability and the grade level they teach for example (see appendix D and E). These simulations are designed to walk participants

		through a series of steps or activities designed to help gather a better understand of not just how weather works but to estimate and predict how accurate it is.
3	Topic 3	- Life science component, the participants will pick one lab from the PhET website that corresponds with each of the categories that comprise the life science curriculum components (classification of organisms, genetics, cell structure, and ecology). All the simulations have a teacher idea section that contains activities that directly correspond and correlate to the selected simulation. The participants will be asked to choose the level of the lab they believe is best for them, in terms of their ability and the grade level they teach for example (see appendix E). These simulations are designed to walk participants through a series of steps or activities designed to help gather a better understand of not just how weather works but to estimate and predict how accurate it is. At the end of the third day's professional development the participants will be informed when the fourth professional development day will be meeting.
4	3-4	Fourth day will be scheduled to take place at the end of the school year the after the completion of the initial three day professional development took place. The participants will again take the VNOS, MAI, and the NSTA EPDI. Afterward, they will form the

		same four-person group that they were in during the first three days of the program. The participants will discuss, analyze and compare their current attitudes and content knowledge toward science to their previous results to determine if there has been a change.
4	3-4	Second half of the day will consist of participants sharing and presenting activities and/or lessons that they particularly enjoyed and had successful outcomes with their students. The participants will be informed by e-mail of this requirement (i.e., sharing and presenting activities and/or lessons) three weeks prior to the fourth professional development day in order to allow them adequate time to select the activity and/or lesson plan they wish to present.

Appendix C: Views of Nature of Science Pretest

Views of Nature of Science (form C)*

VNOS (C)

* Reference:

Abd-El-Khalick, F. (1998). The influence of history of science courses on students' conceptions of nature of science. Unpublished doctoral dissertation. Oregon State University, Corvallis.

Lederman, N. G., Schwartz, R. S., Abd-El-Khalick, F., & Bell, R. L. (2001). Pre-service teachers' understanding and teaching of the nature of science: An intervention study. *Canadian Journal of Science, Mathematics, and Technology Education, 1,* 135-160.

1 VNOS (C)

VNOS (C)

Name:____________________________

Date: / /

Instructions

- Please answer each of the following questions. Include relevant examples whenever possible. You can use the back of a page if you need more space.
- **There are no "right" or "wrong" answers to the following questions. We are only interested in your opinion on a number of issues about science.**

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?

2 VNOS (C)

2. What is an experiment?
3. Does the development of scientific knowledge **require** experiments?
    - If yes, explain why. Give an example to defend your position.
    - If no, explain why. Give an example to defend your position.

3 VNOS (C)

4. Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, **do you think** scientists used to determine what an atom looks like?

4 VNOS (C)

5. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.

5 VNOS (C)

6. After scientists have developed a scientific theory (e.g., atomic theory, evolution theory), does the theory ever change?
- If you believe that scientific theories do not change, explain why. Defend your answer with examples.
- If you believe that scientific theories do change:
  - (a) Explain why theories change?
  - (b) Explain why we bother to learn scientific theories. Defend your answer with examples.

6 VNOS (C)

7. Science textbooks often define a species as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring. How certain are scientists about their characterization of what a species is? What specific evidence **do you think** scientists used to determine what a species is?

7 VNOS (C)

8. Scientists perform experiments/investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?

• If yes, then at which stages of the investigations do you believe that scientists use their imagination and creativity: planning and design; data collection; after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.

• If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.

8 VNOS (C)

9. It is believed that about 65 million years ago the dinosaurs became extinct. Of the hypotheses formulated by scientists to explain the extinction, two enjoy wide support. The first, formulated by one group of scientists, suggests that a huge meteorite hit the earth 65 million years ago and led to a series of events that caused the extinction. The second hypothesis, formulated by another group of scientists, suggests that massive and violent volcanic eruptions were responsible for the extinction. How are these **different conclusions** possible if scientists in both groups have access to and **use the same set of data** to derive their conclusions?

9 VNOS (C)

10. Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced.

- If you believe that science reflects social and cultural values, explain why and how. Defend your answer with examples.
- If you believe that science is universal, explain why and how. Defend your answer with examples.

10 VNOS (C)

Item Description

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?

Note: Parentheticals are not part of the questionnaire.
[*This question aims to assess respondents' views regarding science as a discipline to address questions about the natural world, the role of science in providing explanations for natural phenomena, and the role that empirical evidence plays in science that separates science from other "ways of knowing." Responses to this question often reveal a common misconception regarding the use of the "Scientific Method" as an objective process by which the knowledge is discovered. Such a view is often presented as an explanation for how science differs from other disciplines of inquiry.]*

2. What is an experiment?
3. Does the development of scientific knowledge **require** experiments?
   - If yes, explain why. Give an example to defend your position.
   - If no, explain why. Give an example to defend your position.

[*Questions #2 and #3 are used in combination to assess respondents' views of investigative processes in science. Question #3 elicits responses regarding the existence of multiple methods of investigation (such as experimentation involving controlled variables, correlational studies, and descriptive investigations) that do not all follow the traditional "Scientific Method" or set of pre-established logical steps requiring a testable hypothesis. Responses to Question #2 clarify respondents' ideas of "experiment," as often this term is defined differently. Question #3 is then interpreted in relation to the provided description of "experiment." Question #3 also may elicit views of subjectivity and creativity in science.]*

11 VNOS (C)

4. Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, **do you think** scientists used to determine what an atom looks like?

[*This question refers respondents to a concept from the physical sciences to assess their understandings of the role of human inference and creativity in developing scientific explanations and models based on available data, and the notion that scientific models are not copies of reality.]*

5. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.

[This question assesses respondents' views of the development of and relationship between scientific theories and laws. The common misconception of the existence of a hierarchical relationship is often revealed. This misconception is presented by the explanation of a progression from scientific theory to law with the accumulation of more and more evidence until the theory has been "proven true" at which time it becomes a law. Views regarding distinctions between observation and inference are also commonly elicited. Additional ideas are often expressed by respondents as they attempt to describe the differences between scientific theories and laws.]

12 VNOS (C)

6. After scientists have developed a scientific theory (e.g., atomic theory, evolution theory), does the theory ever change?

- If you believe that scientific theories do not change, explain why. Defend your answer with examples.
- If you believe that scientific theories do change:
  - (a) Explain why theories change?
  - (b) Explain why we bother to learn scientific theories. Defend your answer with examples.

[This question assesses respondents' understanding of the tentative nature of scientific theories and reasons why science is tentative. Respondents often attribute change solely to the accumulation of new observations or data and/or the development of new technologies, and they do not consider change that results from reinterpretation of existing data from a different perspective. Views of the theory-laden nature of scientific investigations, the notion that the prevailing theories of the time impact the direction, conduct, and interpretation of scientific investigations, are assessed through the explanation of the role of theories in science. Additionally, responses often indicate views of the role of subjectivity, creativity, inference, and the sociocultural embeddedness of the scientific endeavor, as well as the interdependent nature of these aspects.]

13 VNOS (C)

7. Science textbooks often define a species as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring. How certain are scientists about their characterization of what a species is? What specific evidence **do you think** scientists used to determine what a species is?

[This question refers respondents to a concept from the biological sciences to assess their understanding of the role of human inference, creativity, and subjectivity in science. Desired responses describe the idea that "species" is defined by scientists to explain observed and inferred relationships, and that definitions as well as concepts in science are created by scientists to be useful for their endeavors. Additionally, this question elicits responses concerning the role of models in science and that scientific models are not copies of reality.]

8. Scientists perform experiments/investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?

- If yes, then at which stages of the investigations do you believe that scientists use their imagination and creativity: planning and design; data collection; after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.
- If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.

[This question assesses respondents' views of the role of human creativity and imagination in science, and the phases of scientific investigations at which respondents believe these aspects play a role. Often creativity is described relative to design only, and usually in regard to resourcefulness necessary to set up and conduct investigations (such as design of new trapping methods in the wild). Respondents are less likely to recognize the role of creativity in question development, data analysis, and interpretation. Ideas of "discovery" versus "created patterns" are elicited.]

14 VNOS (C)

9. It is believed that about 65 million years ago the dinosaurs became extinct. Of the hypotheses formulated by scientists to explain the extinction, two enjoy wide support. The first, formulated by one group of scientists, suggests that a huge meteorite hit the earth 65 million years ago and led to a series of events that caused the extinction. The second hypothesis, formulated by another group of scientists, suggests that massive and violent volcanic eruptions were responsible for the extinction. How are these **different conclusions** possible if scientists in both groups have access to and **use the same set of data** to derive their conclusions?

[This question assesses respondents' understandings of reasons for controversy in science when scientists use the same available data. Ideas of subjectivity, inference, creativity, social and cultural influences, and tentativeness are often elicited. The question aims to assess respondents' beliefs about what influences data interpretation including personal preferences and bias (personal subjectivity) to differing theoretical commitments and impacts of social and cultural values.]

10. Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced.

• If you believe that science reflects social and cultural values, explain why and how. Defend your answer with examples.
• If you believe that science is universal, explain why and how. Defend your answer with examples.

[This question assesses respondents' views of the impact of social and cultural values and expectations on the scientific endeavor. Naïve views are often indicated by responses describing science as "value free" and stating that different cultures and belief systems do not impact the way science is conducted or the interpretation or use of scientific knowledge. Views of connections between sociocultural influences on science and subjectivity, creativity, inference, and tentativeness are often elicited.]

15 VNOS (C)

VNOS Interview Protocol

Participants are provided with their VNOS responses to read and review.

1. Could you read your response to question # 1 (2-10) and explain and elaborate on your response?
2. What did you mean by [response, written or verbal]?
3. Could you give an example of what you meant by [response, written or verbal]?
4. How does your response on # X relate to what you said on # Y?
5. Have your views changed since you wrote your response? If so, how?

16 VNOS (C)

NOS aspects and descriptions that serve as a basis for evaluation of VNOS responses Aspect	Description
Tentativeness	Scientific knowledge is subject to change with new observations and with the reinterpretations of existing observations. All other aspects of NOS provide rationale for the tentativeness of scientific knowledge.
Empirical basis	Scientific knowledge is based on and/or derived from observations of the natural world.
Subjectivity	Science is influenced and driven by the presently accepted scientific theories and laws. The development of questions, investigations, and interpretations of data are filtered through the lens of current theory. This is an unavoidable subjectivity that allows science to progress and remain consistent, yet also contributes to change in science when previous evidence is examined from the perspective of new knowledge. Personal subjectivity is also unavoidable. Personal values, agendas, and prior experiences dictate what and how scientists conduct their work.
Creativity	Scientific knowledge is created from human imaginations and logical reasoning. This creation is based on observations and inferences of the natural world.
Social/cultural embeddedness	Science is a human endeavor and, as such, is influenced by the society and culture in which it is practiced. The values and expectations of the culture determine what and how science is conducted, interpreted, and accepted.

Observations and inferences	Science is based on both observations and inferences. Observations are gathered through human senses or extensions of those senses. Inferences are interpretations of those observations. Perspectives of current science and the scientist guide both observations and inferences. Multiple perspectives contribute to valid multiple interpretations of observations.
Theories and laws	Theories and laws are different kinds of scientific knowledge. Laws describe relationships, observed or perceived, of phenomena in nature. Theories are inferred explanations for natural phenomena and mechanisms for relationships among natural phenomena. Hypotheses in science may lead to either theories or laws with the accumulation of substantial supporting evidence and acceptance in the scientific community. Theories and laws do not progress into one and another, in the hierarchical sense, for they are distinctly and functionally different types of knowledge.

Appendix D: Metacognitive Awareness Inventory (MAI)

Mark each of the statements below True or False as appropriate.

1. I ask myself periodically if I am meeting my goals.
2. I consider several alternatives to a problem before I answer.
3. I try to use strategies that have worked in the past.
4. I pace myself while learning in order to have enough time.
5. I understand my intellectual strengths and weaknesses.
6. I think about what I really need to learn before I begin a task
7. I know how well I did once I finish a test.
8. I set specific goals before I begin a task.
9. I slow down when I encounter important information.
10. I know what kind of information is most important to learn.
11. I ask myself if I have considered all options when solving a problem.
12. I am good at organizing information.
13. I consciously focus my attention on important information.
14. I have a specific purpose for each strategy I use.
15. I learn best when I know something about the topic.
16. I know what the teacher expects me to learn.
17. I am good at remembering information.
18. I use different learning strategies depending on the situation.
19. I ask myself if there was an easier way to do things after I finish a task.
20. I have control over how well I learn.
21. I periodically review to help me understand important relationships.
22. I ask myself questions about the material before I begin.

23. I think of several ways to solve a problem and choose the best one.

24. I summarize what I've learned after I finish.

25. I ask others for help when I don't understand something.

26. I can motivate myself to learn when I need to

27. I am aware of what strategies I use when I study.

28. I find myself analyzing the usefulness of strategies while I study.

29. I use my intellectual strengths to compensate for my weaknesses.

30. I focus on the meaning and significance of new information.

31. I create my own examples to make information more meaningful.

32. I am a good judge of how well I understand something.

33. I find myself using helpful learning strategies automatically.

34. I find myself pausing regularly to check my comprehension.

35. I know when each strategy I use will be most effective.

36. I ask myself how well I accomplish my goals once I'm finished.

37. I draw pictures or diagrams to help me understand while learning.

38. I ask myself if I have considered all options after I solve a problem.

39. I try to translate new information into my own words.

40. I change strategies when I fail to understand.

41. I use the organizational structure of the text to help me learn.

42. I read instructions carefully before I begin a task.

43. I ask myself if what I'm reading is related to what I already know.

44. I reevaluate my assumptions when I get confused.

45. I organize my time to best accomplish my goals.

46. I learn more when I am interested in the topic.

47. I try to break studying down into smaller steps.

48. I focus on overall meaning rather than specifics.

49. I ask myself questions about how well I am doing while I am learning something new.

50. I ask myself if I learned as much as I could have once I finish a task.

51. I stop and go back over new information that is not clear.

52. I stop and reread when I get confused.

Schraw, G. & Dennison, R.S. (1994). Assessing metacognitive awareness. Contemporary Educational Psychology, 19, 460-475.

The Sun: Earth's Primary Energy Source

Astronaut photograph ISS015-E-10469, courtesy NASA/JSC Gateway to Astronaut Photography of Earth.

Climate Literacy: The Essential Principles of Climate Sciences summarizes the most important principles and concepts of the climate sciences. It presents information that individuals and communities need to understand Earth's climate, the impacts of climate change, and approaches for adapting and mitigating change. This article provides background science content knowledge for understanding Essential Principle 1.

The Sun is the primary source of energy for Earth's climate system is the first of seven Essential Principles of Climate Sciences. Principle 1 sets the stage for understanding Earth's climate system and energy balance. The Sun warms the planet, drives the hydrologic cycle, and makes life on Earth possible. The amount of sunlight received on Earth's surface is affected by the reflectivity of the surface, the angle of the Sun, the output of the Sun, and the cyclic variations of the Earth's orbit around the Sun.

The following concepts are fundamental to understanding Principle 1. Click on a concept to find the background knowledge needed to understand the concept.

Concept A. Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.

Concept B. When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.

Concept C. The tilt of Earth's axis relative to its orbit around the Sun results in predictable changes in the duration of daylight and the amount of sunlight received at any latitude throughout a year. These changes cause the annual cycle of seasons and associated temperature changes.

Concept D. Gradual changes in Earth's rotation and orbit around the Sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and the shorter warm periods between them.

Concept E. A significant increase or decrease in the Sun's energy output would cause Earth to warm or cool. Satellite measurements taken over the past 30 years show that the Sun's energy output has changed only slightly and in both directions. These changes in the Sun's energy are thought to be too small to be the cause of the recent warming observed on Earth.

You can also see where these concepts are found in national standards documents as well as common misconceptions in the *Standards and Curriculum Connections* article.

Note: For additional ideas and resources for teaching each of the Essential

Principles of Climate Sciences go to the Climate Literacy & Energy Awareness Network. Another good introduction to the seven essential principles is Earth: The Operator's Manual, an hour-long film shown on PBS and based on the book of the same name by Richard Alley. The entire film is available but the site also provides short segments for teachers to preview and download (free, simple registration required), both with closed captioning for ESL and science comprehension support. A video from the U.S. Environmental Protection Agency (EPA), Climate 101 (second row, middle) explores what climate change is, signs or indicators that the planet is warming, and why it matters. Watch the video to learn more about the causes and effects of climate change and practical solutions to reduce carbon dioxide and other greenhouse gas emissions. An excellent rebuttal of climate change skeptics can be found in Why the Global Warming Skeptics Are Wrong (published 2/22/2012).

ConceptA. *Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.*

Did you know that the Sun blasts more than a billion tons of matter out into space at millions of kilometers per hour?

Courtesy of SOHO consortium. SOHO (Solar and Heliospheric Observatory) is a project of international cooperation between the European Space Agency and NASA

Ultimately, energy from the Sun is the driving force behind weather and climate, and life on earth. But what kinds of energy come from the Sun? How does that energy travel through space? And what happens when it reaches Earth?

The Sun emits many forms of electromagnetic radiation in varying quantities. As shown in the following diagram, about 43 percent of the total radiant energy emitted from the Sun is in the visible parts of the spectrum. The bulk of the remainder lies in the near-infrared (49 percent) and ultraviolet section (7 percent). Less than 1 percent of solar radiation is emitted as x-rays, gamma waves, and radio waves.

The transfer of energy from the Sun across nearly empty space (remember that space is a vacuum) is accomplished primarily by radiation. Radiation is the transfer of energy by electromagnetic wave motion.

Once the Sun's energy reaches Earth, it is intercepted first by the atmosphere. A small part of the Sun's energy is directly absorbed, particularly by certain gases such as ozone and water vapor.

Some of the Sun's energy is reflected back to space by clouds and Earth's surface.

Most of the radiation, however, is absorbed by Earth's surface. When the radiation is absorbed by a substance, the atoms in the substance move faster and the substance becomes warm to the touch. The absorbed energy is transformed into heat energy. This heat energy plays an important role in regulating the temperature of Earth’s crust, surface waters, and lower atmosphere.

Every surface on Earth absorbs and reflects energy at varying degrees, based on the surface’s color and texture. Dark-colored objects absorb more visible radiation; light-colored objects reflect more visible radiation. Shiny or smooth objects reflect more, while dull or rough objects absorb more. Differences in reflection impact temperature, weather, and climate.

Scientists use the term *albedo* to describe the percentage of solar radiation reflected back into space by an object or surface.

A perfectly black surface has an albedo of 0 (all radiation is absorbed). A perfectly white surface has an albedo of 1.0 (all radiation is reflected).

Different features of Earth (such as snow, ice, tundra, ocean, and clouds) have different albedos. For example, land and ocean have low albedos (typically from 0.1 to 0.4) and absorb more energy than they reflect. Snow, ice, and clouds have high albedos (typically from 0.7 to 0.9) and reflect more energy than they absorb.

Earth’s average albedo is about 0.3. In other words, about 30 percent of incoming solar radiation is reflected back into space and 70 percent is absorbed.

A sensor aboard NASA's Terra satellite is now collecting detailed measurements of how much sunlight Earth's surface reflects back up into the atmosphere. By quantifying precisely our planet's albedo, the Moderate Resolution Imaging Spectroradiometer (MODIS) is helping scientists understand and predict how various surface features influence both short-term weather patterns as well as longer-term climate trends.

Image courtesy of NASA Earth Observatory

The colors in this image emphasize the albedo over the Earth's land surfaces, ranging from 0.0 to 0.4. Areas colored red show the brightest, most reflective regions; yellows and greens are intermediate values; and blues and violets show relatively dark surfaces. White indicates where no data were available, and no albedo data are provided over the oceans.

As shown in the image, the snow- and ice-covered Arctic has a high albedo. (Though no data were available, Antarctica would also have a high albedo.) Desert areas, such as the Sahara in Northern Africa, also reflect a great deal of radiation. Forested areas or areas with dark soil absorb more radiation and have lower albedos.

Human and natural processes have changed the albedo of Earth's land surfaces. Human impacts such as deforestation, air pollution, and the decrease in Arctic sea ice have affected albedo values. These changes alter the net amounts of energy absorbed and radiated back to space.

Resources

SDO First Light The Solar Dynamics Observatory (SDO) is now NASA's best eye on the sun, with a resolution far-exceeding any previous telescope. These are some of the first images from the satellite – they are absolutely amazing.

Striking a Solar Balance This short film (3.6 minutes) from NASA explores the vital connection between the Earth and the Sun.

Earth's Albedo and Global Warming This interactive activity adapted from NASA and the U.S. Geological Survey illustrates the concept of albedo.

Climate Change: How Do We Know? This page from the NASA's Eyes on the Earth Global Climate Change web site provides an overview of the most compelling research that supports human-induced and rapid climate change.

Concept B. *When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.*

Earth's radiation budget is a concept that helps us understand how much energy Earth receives from the Sun, and how much energy Earth radiates back to outer space. Earth's temperature doesn't infinitely rise because heat is always radiating back to space. Solar heat is redistributed from the equator toward the poles as well as from the Earth's surface and lower atmosphere back to space. Clouds also transport energy away from the surface of the Earth.

Astronaut photograph ISS006-E-19436, courtesy NASA/JSC Gateway to Astronaut Photography of Earth.

Solar heating drives evaporation. Warm, moist air becomes buoyant and rises, moving energy from the surface high into the atmosphere. Energy is released back into the atmosphere when the water vapor condenses into liquid water or freezes into ice crystals. This net flow of energy into and out of the Earth system is Earth's energy budget.

NASA Atmospheric Science Data Center. Used with permission.

When the flow of incoming solar energy is balanced by an equal flow of heat to space, Earth is in radiative equilibrium, and global temperature is relatively stable. Anything that increases or decreases the amount of incoming or outgoing energy disturbs Earth's radiative equilibrium; global temperatures rise or fall in response. Changes in Earth's crust, such as glaciation, deforestation, and polar ice melting, alter the quantity and wavelength of electromagnetic absorption and reflection at the Earth's surface. These destabilizing influences are called climate forcings.

Man-made forcings include particle pollution (aerosols), which absorb and reflect incoming sunlight; deforestation, which changes how the surface of the Earth reflects and absorbs sunlight; and the rising concentration of atmospheric carbon dioxide and other greenhouse gases, which decrease heat radiated to space. A forcing can trigger feedback loops that can intensify or weaken the original event.

Hamilton Steel Mill, Ontario, Canada. Photo courtesy of haglundc, Flickr.

Shiveluch Volcano, Kamchatka Peninsula, Russia. Photo courtesy of International Space Station Imagery, NASA Human Space Flight.

The loss of ice at the poles, which makes them less reflective, is an example of a feedback loop. The decreasing extent of ice in the polar regions (in particular, the sea ice of the Arctic) is part of a positive feedback loop that can accelerate climate change. Warmer temperatures melt snow and ice, which decreases Earth's albedo, causing further warming and more melting.

Image courtesy of Hugo Ahlenius, UNEP/GRID-Arendal Maps and Graphics Library.

According to NASA, September Arctic sea ice is now declining at a rate of 11.5 percent per decade, relative to the 1979 to 2000 average. Arctic sea ice reaches its minimum each September. The graph below shows the average monthly Arctic sea ice extent in September from 1979 to 2010, derived from satellite observations. The September 2010 extent was the third lowest in the satellite record. You can see interactive graphs for five key indicators on the NASA's Eyes on the Earth Global Climate Change Key Indicators web site page.

Arctic Sea Ice Levels, image courtesy NASA/JPL-Caltech.

Resources

Climate Change: Striking a Solar Balance (3:35) This NASA video reviews the role of the sun in driving the climate system. It uses colorful animations to illustrate Earth's energy balance and how increased greenhouse gases are creating an imbalance in the energy budget, leading to warming. The video also reviews how the NASA satellite program collects data on the sun.

Earth's Energy Budget This feature article from NASA's Earth Observatory provides additional information on the concept of Earth's energy balance.

Clouds: The Wild Card of Climate Change This resource tries to answer the question "Will clouds speed or slow global warming?"

Concept C. *The tilt of Earth's axis relative to its orbit around the Sun results in predictable changes in the duration of daylight and the amount of sunlight received at any latitude throughout a year. These changes cause the annual cycle of seasons and associated temperature changes.*

The tilt of Earth's rotational axis and the Earth's orbit work together to create the seasons. As the Earth travels around the Sun, it remains tipped in the same direction at an angle of 23.5 degrees, toward the star Polaris. This means that sometimes the northern half of the Earth is pointing toward the Sun (summer), and sometimes it is pointing away (winter).

This figure shows the tilt of Earth's axis, which causes the seasons. Image courtesy of CLEAN.

The points in the Earth's orbit when it is tilted most toward or away from the Sun are called solstices, and mark the seasons of summer and winter. When the Northern Hemisphere is tilted toward the Sun, the Southern Hemisphere is tilted away. This explains why the hemispheres have opposite seasons. Halfway in between the solstices, the Earth is neither tilted directly toward nor directly away from the Sun. At these times, called the equinoxes, both hemispheres receive roughly equal amounts of sunlight. Equinoxes mark the seasons of autumn and spring.

The Earth in its orbit at the solstices and equinoxes. Note that the perspective is unrealistic. It is a side-view and ignores the effect of perspective to convey that the Earth's orbit is nearly circular. Image courtesy of Windows to the Universe.

The intensity of solar radiation is largely a function of the angle at which the Sun’s rays strike the Earth’s surface, called the angle of incidence. If the Sun is positioned directly overhead, or 90 degrees from the horizon, the incoming rays strike the surface of the Earth at right angles and are most intense. If the Sun is 45 degrees above the horizon, the incoming rays strike the Earth’s surface at an angle. This causes the rays to be spread out over a larger surface area, reducing the intensity of the radiation. The following figure models the effect of changing the angle of incidence from 90 to 45 degrees. As illustrated, the lower sun angle causes the radiation to be received over a much larger surface area.

Effect of the angle on the area that receives an incoming beam of radiation. Image courtesy of The Encyclopedia of Earth.

During summer the sunlight strikes the ground more directly (closer to perpendicular), concentrating the Sun’s energy. This concentrated energy is able to heat the surface more quickly than is possible during wintertime when the Sun’s rays hit the ground at more glancing angles, spreading out the energy. From the equator to the poles, the Sun's rays meet Earth at smaller and smaller angles, and the light gets spread over larger and larger surface areas.

Illustration courtesy of Nick Strobel, www.astronomynotes.com.

In addition to less concentrated energy, the time the Earth's surface is bathed in light is also different. Because of the tilted axis, the parts of the Earth's surface spent in daylight (unshaded part of the drawing) and in the shadow (shaded) are usually not equal. North of the equator, day is longer than night, and at the North Pole, there is no night at all.

Amount of daylight in summer and winter. Illustration courtesy of Nick Strobel, www.astronomynotes.com.

At the equator the intensity of the Sun's ray is constant and the length of the day does not change; hence, spring, summer, fall, and winter do not exist although, depending on the weather patterns, there may be a "wet" and a "dry" season.

Resources

Earth's Seasons A computer animation on the reason for the seasons. Voice-over describes the motion of Earth around the sun to show how the sun's light impacts the tilted Earth at different times of the year, causing seasonal changes.

Basic Coordinates and Seasons Lab The seasons module of the University of

Nebraska-Lincoln's Astronomy Education program enables you to understand these concepts by manipulating such things as the position of the Earth in its orbit and your position on the Earth.

Concept D. *Gradual changes in Earth's rotation and orbit around the Sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and the shorter warm periods between them.*

The work of climatologists has found evidence to suggest that only a limited number of factors are primarily responsible for most of the past episodes of climate change on Earth. One of these factors is variations in the Earth's orbital characteristics.

The impact of variations in the Earth's orbital characteristics was investigated by the Serbian mathematician Milutin Milankovitch beginning in the 1910s. He made a series of astronomical calculations that demonstrated how Earth's orbital variations played a role in the ice ages and other climate variations. He found that as the Earth travels through space around the Sun, cyclical variations in three elements of Earth-Sun geometry combine to produce variations in the amount of solar energy that reaches Earth:

Variations in the Earth's orbital eccentricity – the shape of the orbit around the Sun.

Changes in obliquity – changes in the angle that Earth's axis makes with the plane of Earth's orbit.

Precession – the change in the direction of the Earth's axis of rotation. Together, the periods of these orbital motions have become known as Milankovitch cycles.

Milankovitch cycles, such as precession of the equinoxes (23,000 years), obliquity (41,000 years) and eccentricity (100,000 and 400,000 year periods), influence climate change at long time scales because they affect the amount of sunlight that radiates to Earth. They are measured using data derived from marine sediments, geomorphic features, and astronomical observations and calculations. Understanding the Milankovitch cycles helps with reconstructing past climate variability at 100,000-year and longer time scales.

At the present time, the Milankovitch cycles are at a point that places the Earth in an interglacial period – a warm period of relatively stable climate. This warm period is predicted to continue for tens of thousands of years, but is not expected to generate warmer climates over the period of decades. For this reason, recent climatic changes are not considered to be attributable to the natural cycles described by Milankovitch.

Resources

Milutin Milankovitch A biography of Milankovitch with an emphasis on his research.

Causes of Climate Change This article from the online *Encyclopedia of Earth* discusses the factors responsible for past episodes of climate change.

Climate Time Line Information Tool This tool is designed as an interactive matrix to allow users to examine climatic information at varying scales through time.

Concept E. *A significant increase or decrease in the Sun's energy output would cause Earth to warm or cool. Satellite measurements taken over the past 30 years show that the Sun's energy output has changed only slightly and in both directions. These changes in the Sun's energy are thought to be too small to be the cause of the recent warming observed on Earth.*

Solar scientists have long known that solar variability changes the distribution of energy in the Earth's atmosphere, but its direct effect on climate change has been in question. Solar radiation changes have been measured reliably by satellites for only 30 years. These precise observations show changes of a few tenths of a percent that depend on the level of activity in the 11-year solar cycle. While a component of recent global climate change may have been caused by the increased solar activity of the last solar cycle, that component was very small compared to the effects of greenhouse gases.

Measurements made by satellites equipped with radiometers in the 1980s and 1990s suggested that the Sun's energy output may be more variable than was once thought. Measurements made during the early 1980s even showed a decrease of 0.1 percent in the total amount of solar energy reaching the Earth over just an 18-month period. Scientists studying shorter term variations in the Sun's energy output, including the 22-year solar cycle of solar activity measured between a minimum and maximum period, have determined that the amount of extra solar energy reaching Earth is relatively small, not enough to account for recent climate change.

During the initial discovery period of global climate change, the magnitude of the influence of the Sun on Earth's climate was not well understood. Since the early 1990s, however, extensive research was put into determining what role, if any, the Sun has in global warming or climate change. A recent review paper, put together by both solar and climate scientists (Gray, et al., 2010), details these studies. Their bottom line: though the Sun may play some small role, "it is nevertheless much smaller than the estimated radiative forcing due to anthropogenic changes." That is, human activities are the primary factor in global climate change.

Resources

Solar Activity and Climate Change This page provides more information on the link between solar activity and climate change.

'No Sun Link' to Climate Change This article, published in 2007, concludes that changes in the Sun's output cannot be causing modern-day climate change.

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Beyond Penguins and Polar Bears. Retrieved from http://beyondpenguins.nsdl.org

CLEAN. *Teaching Climate Science and Energy Awareness*. Retrieved from http://cleanet.org/clean/literacy/index.html

Encyclopedia of the Earth. *Climate Literacy Handbook. Principle 1*. Retrieved from http://www.eoearth.org/article/Climate_Literacy_Handbook:_Principle_1

Gray, L. J., et al. 2010. "Solar Influences on Climate." *Reviews of Geophysics 48*, RG4001, doi:10.1029/2009RG000282. Retrieved from http://solar-center.stanford.edu/sun-on-earth/2009RG000282.pdf

Kimberly Lightle wrote this article. She received her PhD in science education at The Ohio State University and is principal investigator of Beyond Weather and the Water Cycle, Beyond Penguins and Polar Bears, and the Middle School Portal 2 projects. Email Kim at beyondweather@msteacher.org.

Appendix F: NASA- Focus Areas

Focus Areas

The complexity of the Earth system, in which spatial and temporal variability exists on a range of scales, requires that an organized scientific approach be developed for addressing the complex, interdisciplinary problems that exist, taking good care that in doing so there is a recognition of the objective to integrate science across the programmatic elements towards a comprehensive understanding of the Earth system. In the Earth system, these elements may be built around aspects of the Earth that emphasize the particular attributes that make it stand out among known planetary bodies. These include the presence of carbon-based life; water in multiple, interacting phases; a fluid atmosphere and ocean that redistribute heat over the planetary surface; an oxidizing and protective atmosphere, albeit one subject to a wide range of fluctuations in its physical properties (especially temperature, moisture, and winds); a solid but dynamically active surface that makes up a significant fraction of the planet's surface; and an external environment driven by a large and varying star whose magnetic field also serves to shield the Earth from the broader astronomical environment.

These six focus areas include research that not only addresses challenging science questions, but drives the development of an Earth observing capability and associated Earth system models. In concert with the research community, NASA developed a hierarchy of science questions. The fundamental question: "How is the Earth changing and what are the consequences for life on Earth?" leads to five associated core questions, representing a paradigm of variability, forcing, response, consequences and prediction, leading in turn to the 24 detailed Earth science questions in Table 4.1. NASA strategy for linking the six interdisciplinary science focus areas is to solicit and fund research addressing combinations of these science questions.

The following sections describe each Science Focus Area. Each section describes the scientific field, NASA's current contribution, and next major steps in the period 2007-2016.

Atmospheric Composition Atmospheric Composition is focused on the composition of Earth's atmosphere in relation to climate prediction, solar effects, ground emissions and time.

Weather Our weather system includes the dynamics of the atmosphere and its interaction with the oceans and land. The improvement of our understanding of weather processes and phenomena is crucial in gaining an understanding of the Earth system.

Climate Variability & Change NASA's role in climate variability study is centered around providing the global scale observational data sets on oceans and ice, their forcings, and the interactions with the entire Earth system.

Water & Energy Cycle Through water and energy cycle research we can improve hurricane prediction, quantify tropical rainfall and eventually begin to balance the water budget at global and regional scales.

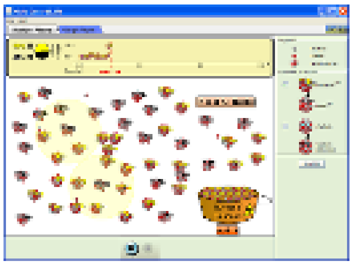
Carbon Cycle & Ecosystems This Focus Area deals with the cycling of carbon in reservoirs and ecosystems as it changes naturally, is changed by humans, and is affected by climate change.

Earth Surface & Interior The goal of the Earth Surface and Interior focus area is to assess, mitigate and forecast the natural hazards that affect society, including earthquakes, landslides, coastal and interior erosion, floods and volcanic eruptions.

Appendix G: PhET Simulation Page

Simulations

> Physics

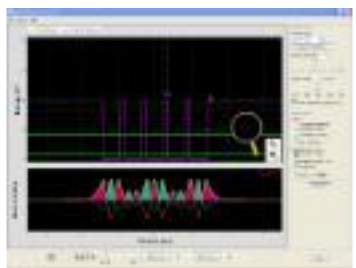


Alpha Decay

Balancing Act

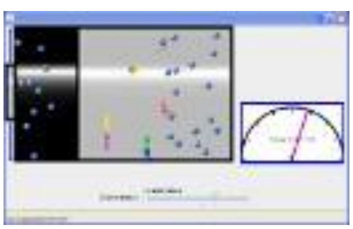
Balloons & Buoyancy

Balloons and Static Electricity

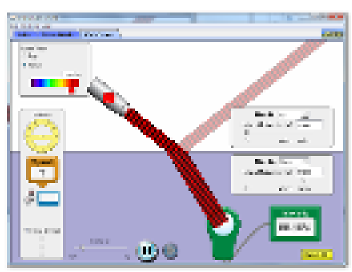


Band Structure

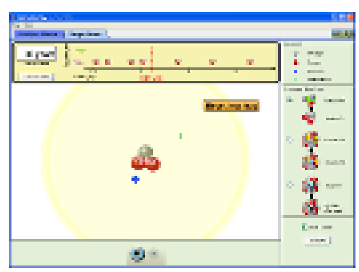
Battery-Resistor Circuit



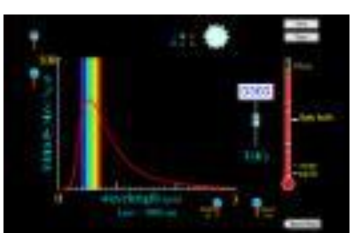
Battery Voltage



Bending Light

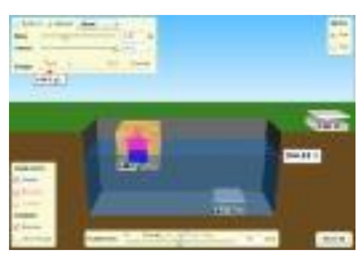


Beta Decay

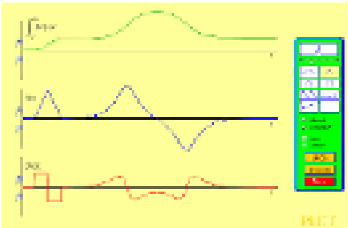


Blackbody Spectrum

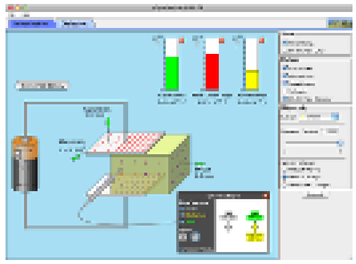
Build an Atom



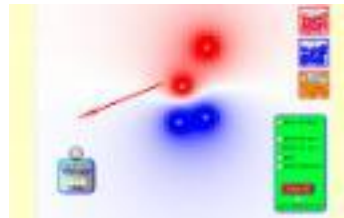
Buoyancy



Calculus Grapher



Capacitor Lab



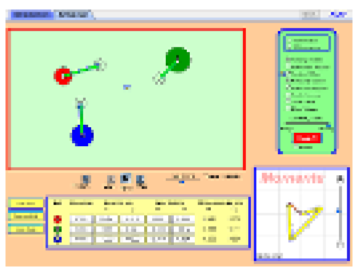
Charges and Fields

Circuit Construction Kit (AC+DC)

Circuit Construction Kit (AC+DC), Virtual Lab

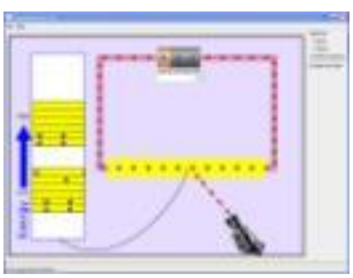
Circuit Construction Kit (DC Only)

Circuit Construction Kit (DC Only), Virtual Lab



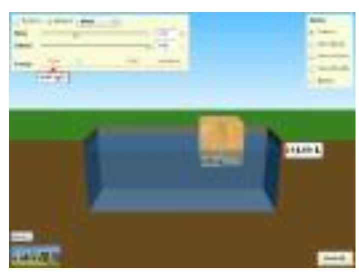
Collision Lab

Color Vision

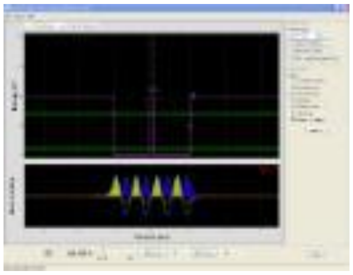


Conductivity

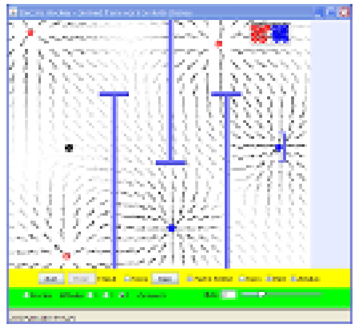
Davisson-Germer: Electron Diffraction



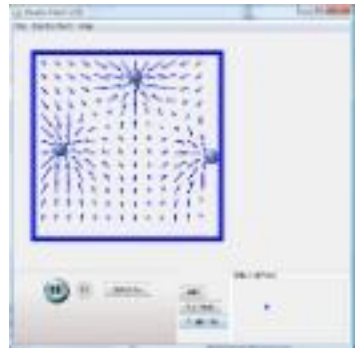
Density



Double Wells and Covalent Bonds

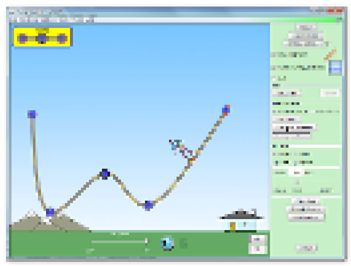


Electric Field Hockey



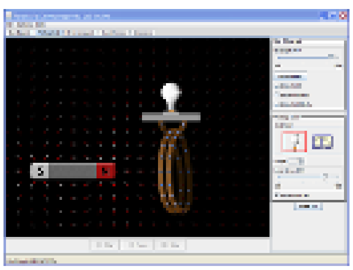
Electric Field of Dreams

Energy Forms and Changes

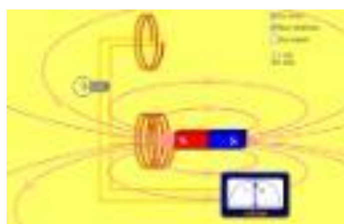


Energy Skate Park

Energy Skate Park: Basics

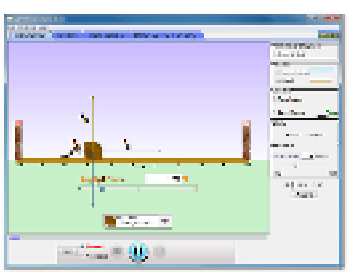


Faraday's Electromagnetic Lab



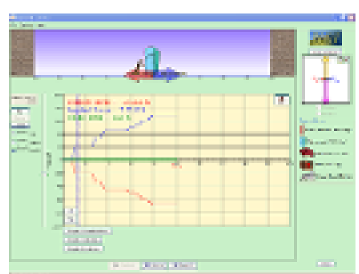
Faraday's Law

Fluid Pressure and Flow

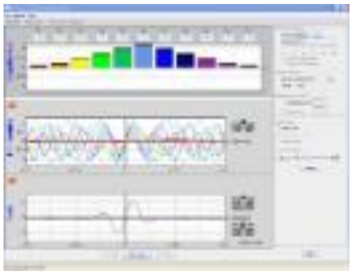


Forces and Motion

Forces and Motion: Basics

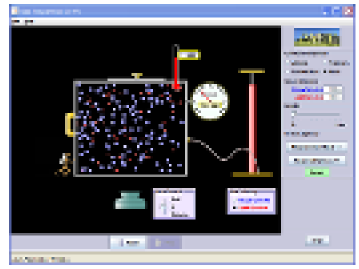


Forces in 1 Dimension

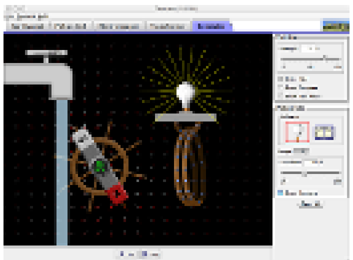


Fourier: Making Waves

Friction

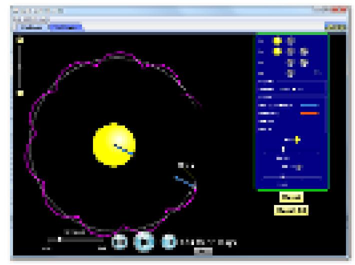


Gas Properties

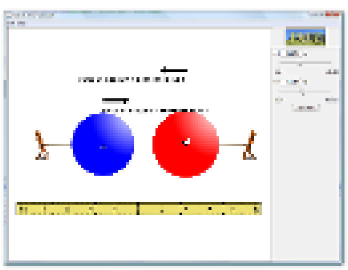


Generator

Geometric Optics



Gravity and Orbits

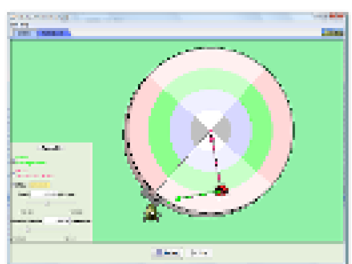


Gravity Force Lab

The Greenhouse Effect

John Travoltage

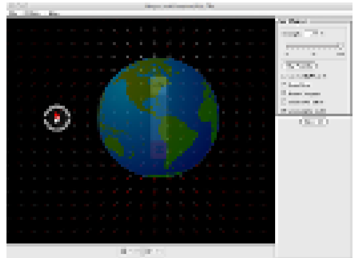
Ladybug Motion 2D

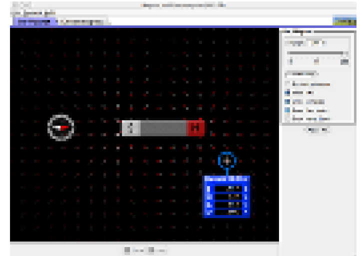


Ladybug Revolution

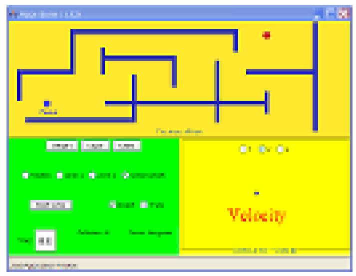
Lasers

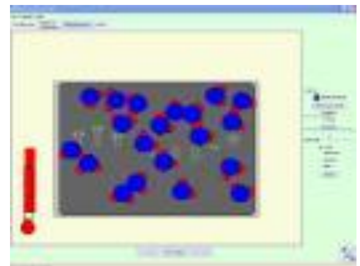

Lunar Lander

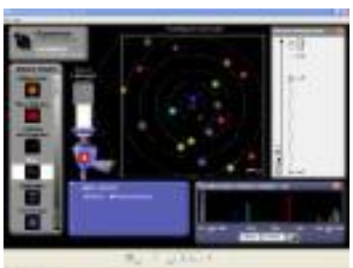

Magnet and Compass

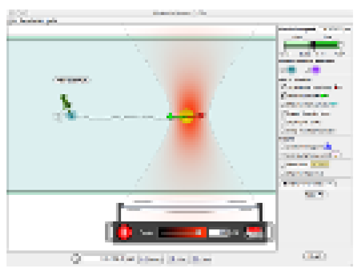

Magnets and Electromagnets


Masses & Springs


Maze Game

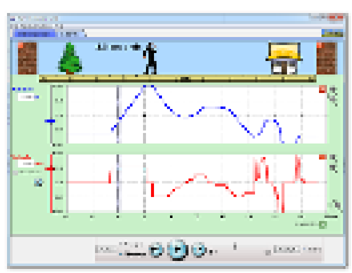

Microwaves

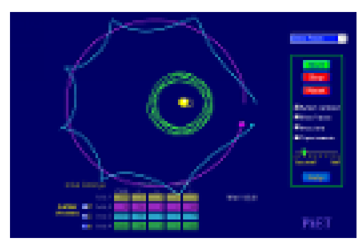

Models of the Hydrogen Atom

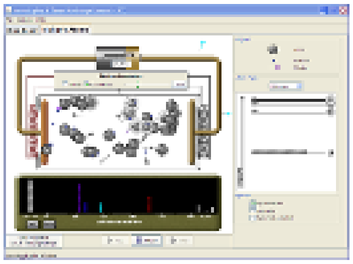

Molecular Motors


Molecules and Light

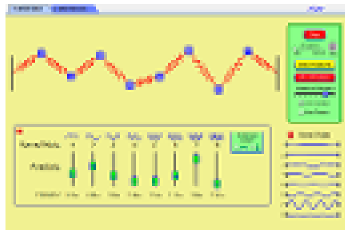

Motion in 2D


The Moving Man

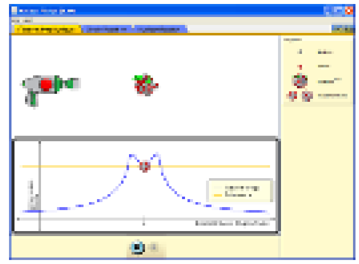

My Solar System



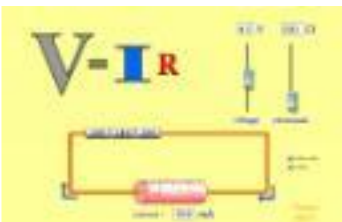
Neon Lights & Other Discharge Lamps



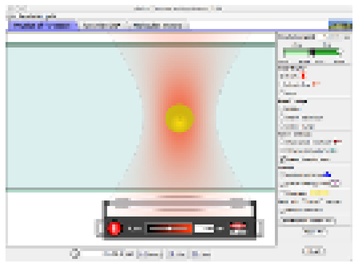
Normal Modes



Nuclear Fission

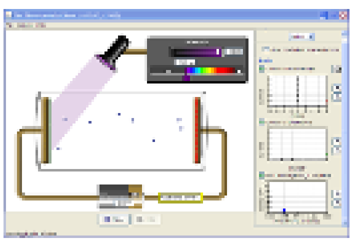


Ohm's Law

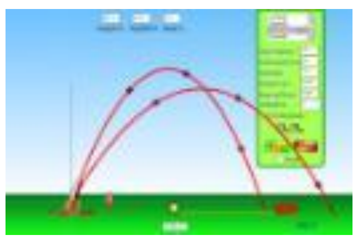


Optical Tweezers and Applications

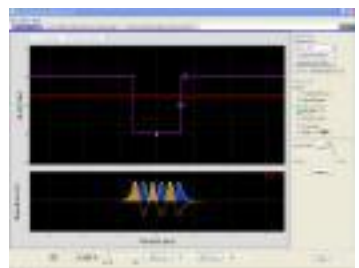
Pendulum Lab



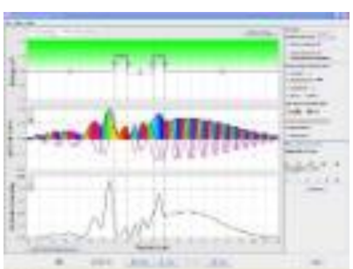
Photoelectric Effect



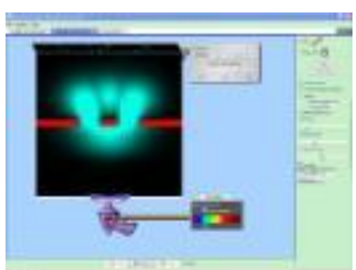
Projectile Motion



Quantum Bound States



Quantum Tunneling and Wave Packets

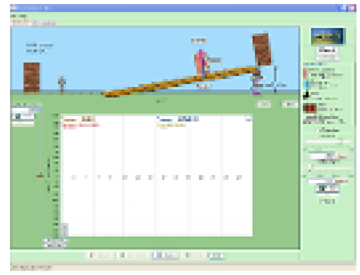


Quantum Wave Interference

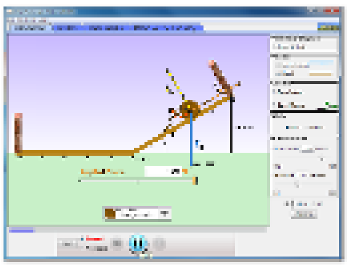
Radiating Charge

Radioactive Dating Game

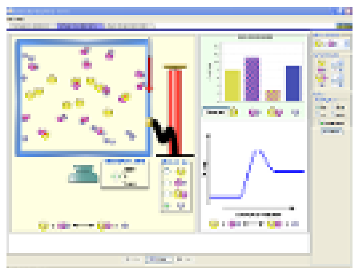
Radio Waves & Electromagnetic Fields



The Ramp

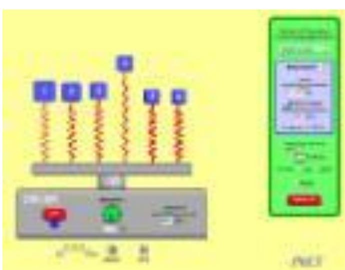


Ramp: Forces and Motion



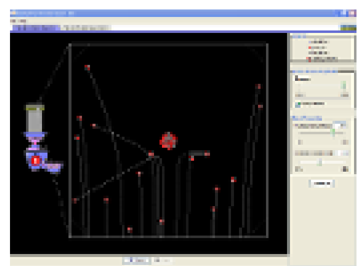
Reactions & Rates

Resistance in a Wire

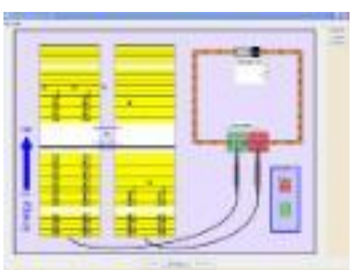


Resonance

Reversible Reactions



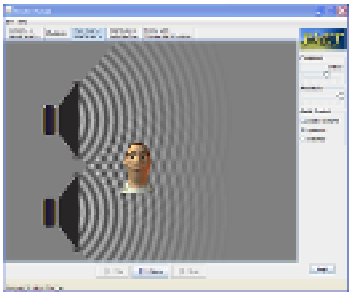
Rutherford Scattering

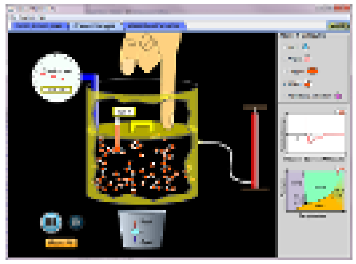


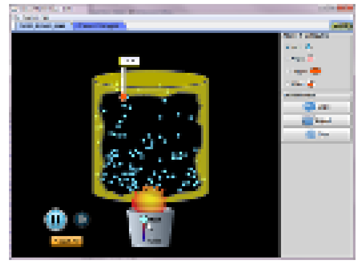
Semiconductors

Signal Circuit

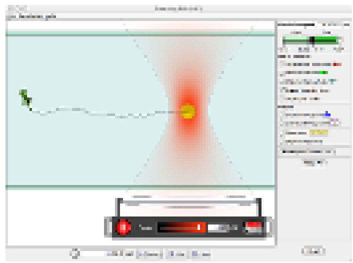
Simplified MRI


Sound


States of Matter

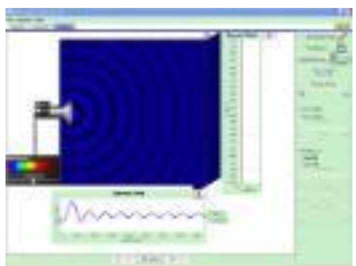

States of Matter: Basics

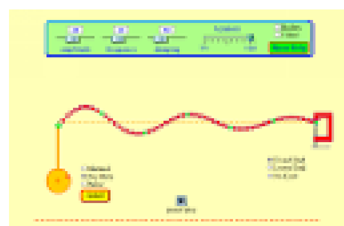

Stern-Gerlach Experiment


Stretching DNA


Torque


Under Pressure


Wave Interference


Wave on a String

Appendix H: Phase Change Lab

Phase Changes of Water (Heating/Cooling Curves)

Standards:

PS.1 The student will plan and conduct investigations in which
k) valid conclusions are made after analyzing data;
PS.2 The student will investigate and understand the basic nature of matter. Key concepts include
c) solids, liquids, and gases;

Resources: "Phase Change Lab" (*Phase Change Lab*. Retrieved October 20, 2008 from 8th Grade Sci-ber Text Website: http://www.usoe.k12.ut.us/curr/Science/sciber00/8th/matter/sciber/phschlab.htm); "Changing the State of Water" overhead graph (Holt Science & Technology. (2001). *Physical Science*. Austin: Holt, Rinehart, & Winston.); Phase Change Diagram for "Extend" part of lesson (*U.S. National Chemistry Olympia*d. Retrieved November 6, 2008 Website: http://dbhs.wvusd.k12.ca.us/webdocs/NChO/NChO-92-Local-30.GIF)

Lesson Plan Outline:

Topic: Phase diagram of water **Concept:** Change; Cycle

Instructional Objective(s):

Students will understand that:

- Phase changes are physical properties that can occur in cycles.

Students will know that:

- At the melting and boiling points of water, energy is added but the temperature remains constant until all ice is melted to liquid water or all liquid water is vaporized to gaseous water.
- The melting and freezing points occur at the same temperature.
- The vaporization and condensing points occur at the same temperature.

Students will be able to:

- Discuss heat transfer and temperature changes on the cooling/heating curve for the phase changes of water (Comprehension).
- Perform a phase change experiment demonstrating the different phase changes of water (Application).

Materials & Resources: Overhead; "Phase Change Lab" and materials (thermometers, thermometer clamps, ring stands, hot plates, beakers (large), and ice); Demo materials (two 500 mL beakers, ice, water); "Changing the State of Water" overhead graph

- ***Engage***: An active demo will be performed to get the students thinking about temperature vs. phases of water. There will be 2 beakers. Both will have 250 mL of water in them, however, one will have 1 cup of ice and the other will have 3 cups of ice. Students will be asked to write down the problem: "Does the amount of ice in water affect the temperature?" Next, students will be asked to write out their hypotheses about the temperature of each beaker. Will one have a lower temperature than the other or will they both be the same? Thermometers will be placed in each beaker of ice water while students are writing down their predictions. After the thermometer sits of a couple minutes, two student volunteers will be asked to read the thermometers in the beakers. They will announce the temperatures to the rest of the class (the temperatures should be the same). Students will be asked to write down their observations and conclusions based on the temperature of each beaker.

- ***Explore***: Students will work in their lab groups of 3-4 students to investigate how the heat added to the system affects the temperature of water by performing the "Phase Change Lab" (Attached). Students will graph their data and understand how temperature changes throughout the phases of water.

- ***Explain*:** First, students will be asked general observations of the lab. What did they notice? What happened during a phase transition, i.e., what happened when the ice was melting or when the water was boiling? Why does the temperature remain constant? Students will begin to understand that during phase transitions, the temperature remains constant. All of the energy is going into breaking the bonds between the water molecules to change phases. What happened when all the ice was melted? Is this different than when both ice and water was present? An overhead will be shown to the class of the heating curve of water (Attached). Each student will also get this sheet. This should look very similar to the students' graphed data. Point out on the graph where the phase transitions are, where each phase is present, etc. Also go over terminology such as melting point/freezing point, boiling point/condensing point, condensing, freezing, boiling, and melting. Students are to label these parts on their sheet. To avoid misconceptions, make sure students completely understand the temperature does not change during a phase change.

- ***Extend***: Now that students have an understanding of the heating curve of water, they will work in their lab groups to analyze a heating curve of an unknown substance (Attached). They will be asked to find the melting and boiling points as well as analyze points on the graph. After they are finished, the results will be discussed with the class.

- ***Evaluate***: Students will complete an exit pass. They will be asked to draw their own heating curve, however, the melting point must be $20^{o}C$ and the boiling point must be $110^{o}C$. They should label where each phase is present on the graph.

Plans for Diversity:

Student(s): ELL students

Accommodations: If needed, help them understand the instructions if confused and/or have them go to the ELL teacher for help

Student(s): Gifted and talented students
Accommodations: Have them come up with the procedure all on their own to challenge their thinking

Student(s): Learning disabled students
Accommodations: Have more of a procedure for them to follow

Connections: Before this lesson, students learned about the different phases. This brought them into going into more detail about the phases of water, and examining the heating curve of water. This lesson is the last part of the unit. In the next unit, students will learn about the modern and historical models of atomic structure.

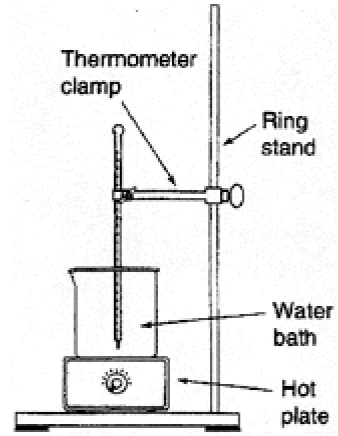
Reflections: I believe students should learn the vocabulary and content on their own instead of having the information lectured to them. The design allows the students to uncover the content through activities and then having the teacher reinforce the content and clear up misunderstandings. Therefore, students will be much more likely to retain the content.

Safety Considerations: During the lab, students are to wear safety glasses, tie back long hair, and secure loose clothing. They are not to ingest any chemicals used in lab.

Phase Change Lab

Materials

- Thermometer
- Thermometer clamp
- Ring Stand
- Hot Plate
- Large Beaker
- Ice



Procedure

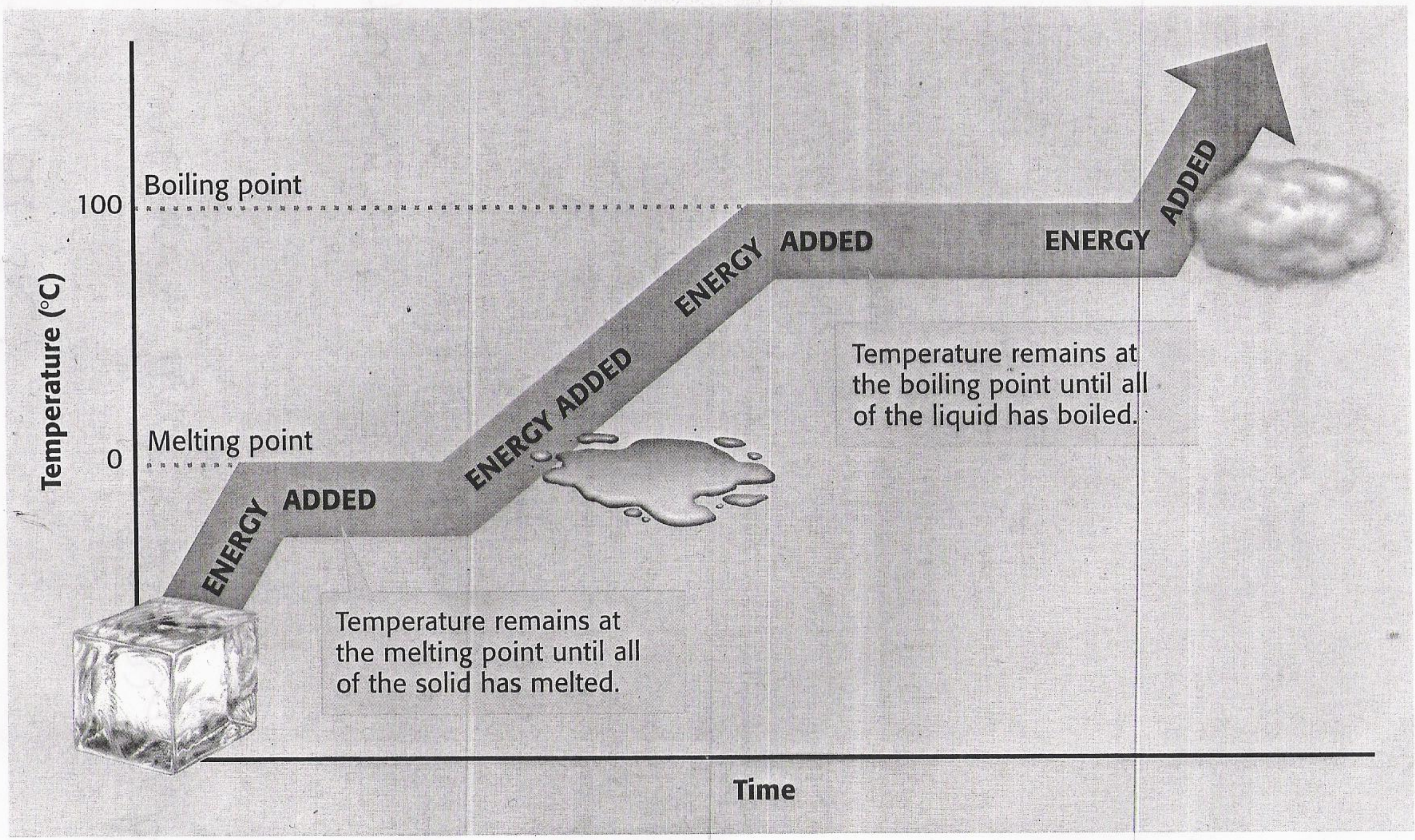
Use the setup to the right to set up your experiment. Your goal is to investigate the phase change of water by recording temperature at different times while heating the ice in the beaker. Before doing the experiment, design your plan for accomplishing this goal and inform the instructor of your plan before you begin. MAKE SURE YOU RECORD THE TEMPERATURE AT TIME = 0 seconds. It will help you to set up some sort of table to analyze your data. When you are done with your experiment, graph your results on a piece of graph paper (make sure you put the correct data on each axis! Think of independent and dependent variables). After you have graphed thee data, answer the questions below.

Analysis

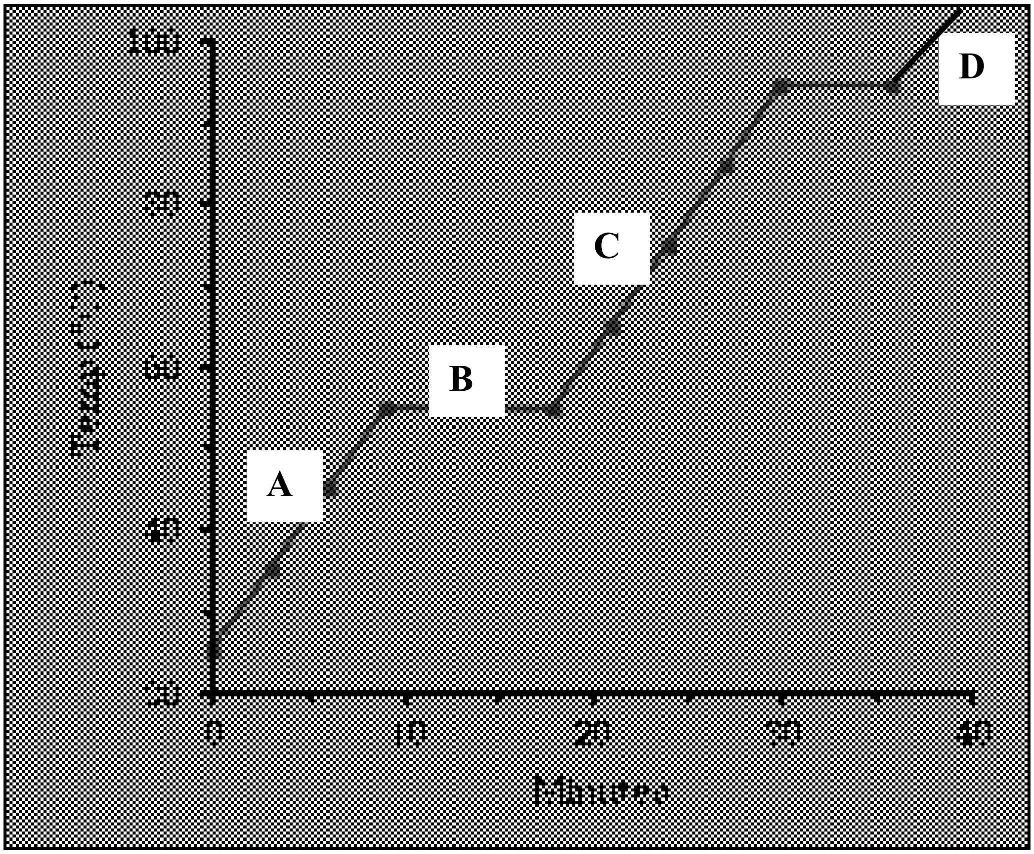
What happened to the temperature of the water as the ice melted? As the water boiled?

Where do you think that the energy from the burner was going?

Changing the State of Water



Analyze the Phase Diagram



What is the melting point of the substance?

What is the boiling point of the substance?

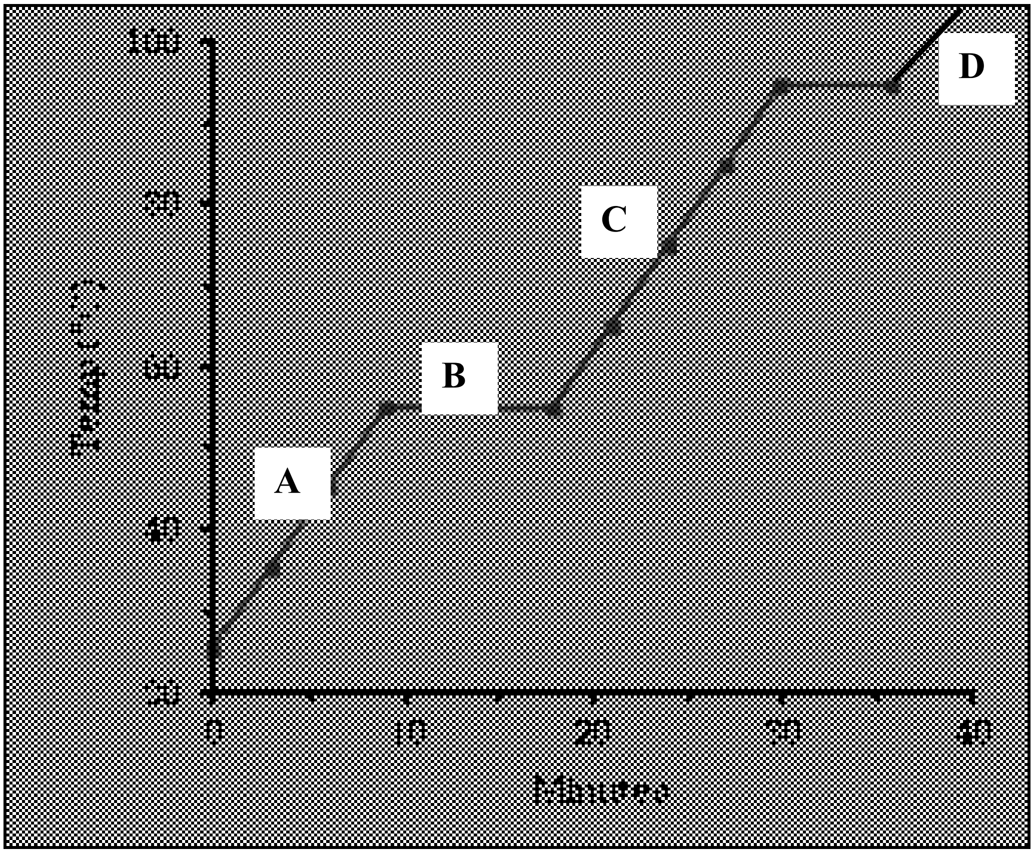
What letter on the diagram indicates solid is present *only*?

What letter on the diagram indicates a gas is present *only*?

What letter on the diagram indicates a liquid is present *only*?

What letter on the diagram indicates both solid AND liquid are present?

Analyze the Phase Diagram (***ANSWER KEY***)



What is the melting point of the substance? **Around 55^{o}C**

What is the boiling point of the substance? **Around 95^{o}C**

What letter on the diagram indicates solid is present *only*? **A**

What letter on the diagram indicates a gas is present *only*? **D**

What letter on the diagram indicates a liquid is present *only*? **C**

What letter on the diagram indicates both solid AND liquid are present? **B**

Appendix I: PhET Computer Simulation Lab

Google: PhET build an atom

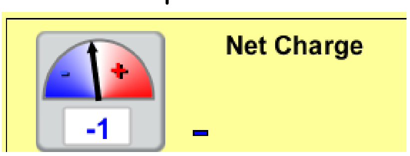
Student Guide for Build an Atom **Name**

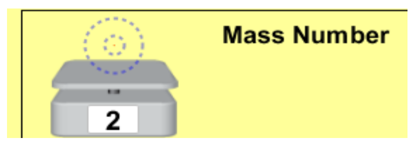
Start: 1.
2. Click on the first link
3. Click on the Run Now! button.

4. Explore the simulation. Be sure to click on everything.

5. When your teacher says it is time to start

- click on the reset all button. Reset All
- open the boxes called **Net Charge** and **Mass number**





- These boxes and the periodic table box will help you fill in the data needed below.

6. Experiment by putting some **protons** into the nucleus of the atom (on the X).

Fill in the table to the right to keep track of what you are learning about

Mass number?	Charge?	Stays on the X?	Symbol changes on the periodic table?

7 Experiment by putting some **neutrons** into the nucleus of the atom (on the X).

Fill in the table to the right to keep track of what you are learning about **neutrons.**
When you finish, put the neutrons back into the

Mass number?	Charge?	Stays on th X?	Symbol changes on the periodic table?

8. Experiment by putting some 10 **electrons** into the nucleus of the atom (on the X).

Fill in the table to the right to keep track of what you are learning about electrons.
When you finish, put all of the electrons back into the bowl.

Mass number?	Charge?	Stays on the X?	Symbol changes on the periodic table?

9. Look over your data tables for **protons**, **nuetrons and electrons**.
Two things we noticed are: 1.
____
2.
____

Have your teacher check your work

Time to apply your understanding of the atom…

10. Put 3 protons into nucleus of the atom. Fill in the following:
Name of atom:______________ atom or ion? ______________ net charge ______________

Decide how you will build a **neutral atom** that is **stable.** Practice making atoms using your ideas.
Once you are able to do this several times on the simulation- starting with different numbers of protons- write out the steps of your building plan!

steps to build a neutral atom starting with protons:

1. First I choose ________ protons and put them in the center (nucleus) of the atom.
2.
3.
4.

*My stable atom: ____ mass ____ protons ___ neutrons ___ electrons _______ name

Appendix J: Teaching Resources

Teaching Resources

Main Topics

- Atomic Structure
- Atoms

Sample Learning Goals

- Use the number of protons, neutrons, and electrons to draw a model of the atom, identify the element, and determine the mass and charge.
- Predict how addition or subtraction of a proton, neutron, or electron will change the element, the charge, and the mass.
- Use the element name, mass, and charge to determine the number of protons, neutrons, and electrons.
- Define proton, neutron, electron, atom, and ion.

Tips for Teachers

The teacher's guide (pdf) contains tips created by the PhET team.

Teaching Ideas

Title	**Authors**	**Level**	**Type**	**Updated**
Build an Atom	UTeach Middle School PhET Team	MS	Lab	6/22/12
Build an Molecule - Inquiry-based basics (homework version)	Trish Loeblein, Kath Perkins	HS UG-Intro	HW	9/12/11
Using PhET in High School Chemistry- all my activities in pdf	Trish Loeblein	HS UG-Intro	CQs&HW Lab Demo	3/19/13
Structure of the Atom	Jackie Esler	MS	Lab	1/10/12
Build an Atom - Inquiry-based basics	Patricia Loeblein, Kathy Perkins	UG-Intro HS	Demo CQs&HW Lab	6/18/11
Build an Atom: Introduction	Patricia Loeblein, Kathy Perkins	HS&MS	Lab&Demo	10/24/11
Concept Questions for Chemistry using PhET	Trish Loeblein	HS&MS UG-Intro	CQs	3/19/13
Chemical Compounds and Subscripts	David Streib	HS&MS	CQs	12/1/12
Build an Ion Inquiry Activity	Paul Broberg	HS&MS	CQs&Lab HW	11/13/12
Atom Builder	Sarah Stanhope	MS&HS	Lab	1/27/11
The Peninsula of Nuclear Stability	Roberto Marrero	HS	HW	11/27/10
Build an Atom PhET Lab	Chris Bires	HS&MS	Lab	12/23/10

Ramon Frias

Summary

Doctorate degree in Teacher Leadership
Master's of science degree
Bachelor's degree in chemistry
24 years of experience teaching science from basic physical science classes to AP Chemistry
AP Chemistry teaching professional with dedication to continuous Professional development, communication with parents, accurate student assessment and providing relevant course materials for effective learning.
Air Force training on F-15 and F-16 fighter jets

Core Qualifications

Innovative lesson planning
Interactive teaching/learning
Instructional best practices
Active participation in [groups, plans, events]
Effectively work with parents

Achievements

Team Building and Leadership
Created collaborative classroom experience through [process, initiative].
Process Improvement
Developed [process or procedure] that resulted in [positive outcome].
Education Strategies
Employed special educational strategies and techniques during instruction to improve the development of sensory/perceptual-motor skills, language, cognition, and memory.

Professional Experience

Cobb County School District August 2006 to April 2013
Chemistry Teacher
Marietta, Georgia
Developed interesting course plans to meet academic, intellectual and social needs of students. Created and enforced child-based hands-on curriculum to promote student interest and receptive learning. Employed [activities] and [techniques] techniques to encourage student learning and build community within the classroom. Combined discipline plan with effective measures and various lesson plans to increase concentration, participation, and progress student accountability.

Miami-Dade County Public Schools September 1990 to June 2006
Chemistry Teacher
Miami, Florida
Developed and implemented interesting and interactive learning mediums to increase student understanding of course materials. Used variety of teaching techniques to encourage student critical thinking and discussion in Chemistry course. Collaborated and implemented teacher professional development programs and training.

Miami Dade Community College August 2002 to May 2006
Adjunct Professor
Miami, Florida
Challenged and motivated students through in-depth lectures and discussions. Lectured and communicated effectively with students from diverse backgrounds. Initiated thought-provoking classroom discussions to help students develop their critical thinking abilities. Kept abreast of developments in the field by reading current literature and attending professional conferences.

Education and Training

Walden University 2013
Educational Doctorate: Teacher Leadership
Minneapolis, Minnesota, USA

Nova Southeastern University 1997
Master of Science: Education
Fort Lauderdale, Florida, USA

Florida International University 1989
Bachelor of Arts: Chemistry
Miami, Florida, USA

Certifications
Georgia Teaching Certificate, 2006-present

Community Involvement
Football and Soccer Coach