THE EFFECTS OF UTILIZING NASA

EDUCATIONAL MATERIALS ON STUDENT

KNOWLEDGE OF SCIENCE CONTENT

By

OTA LUTZ

Bachelor of Arts in Mathematics
Point Loma Nazarene University
San Diego, CA
1989

Master of Arts in Teaching and Learning
Point Loma Nazarene University
San Diego, CA
1990

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Dissertation Approved:

Dr. Steven K. Marks

Dissertation Adviser

Dr. John D. Vitek

Dr. Kevin Allen

Dr. Caroline Beller

Dr. Mark E. Payton

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Introduction

Science literacy is important to citizens of the United States because, through science, we learn about new technologies, make medical advances, and seek to improve society. Though not all students will become scientists, the habits of mind developed in science classes are valuable for reasoning in many careers and other aspects of life. Providing students with educational experiences conducive to developing these habits of mind is imperative. To achieve this goal, teachers continually strive to improve their teaching of science by seeking out the most effective resources and teaching methods.

The No Child Left Behind (NCLB) act of 2001 brought student test scores to the forefront of attention in the nation. As a result of NCLB, the perception, ranking, and funding of a school are dependent on state standardized test scores. Teacher performance is judged according to the performance of their students on state tests. School principals are evaluated on the overall performance of students in their school. The stakes are high and the dictate is clear: increase student achievement and performance on state standardized tests.

Identifying the best teaching resources and methods has always been important to teachers. Now, with the high stakes attached to student performance, teachers are under more external pressure to find the best resources and use best practice teaching methods. Much evidence attests to the efficacy of inquiry-based learning techniques and inquiry is widely accepted as the best practice in the teaching of science. Numerous space-themed standards-based educational materials have been developed by the National Aeronautics and Space Administration (NASA) for use in teaching science concepts. NASA educational materials selected for use in the NASA Explorer Schools (NES) project are inquiry-based materials. As the premier space exploration agency, NASA holds a great deal of allure for the public and especially for students. As a result, students generally find NASA educational materials interesting and engaging. Though evidence exists to support an increase in student interest in science as a result of participation in NASA activities, no study exists on the impact of NASA educational materials on student achievement. This study was designed to address this gap in the body of educational research.

Purpose of the Study

The purpose of this study is to determine if utilizing NASA resources to teach science to fifth grade students affects their knowledge of science content any differently than does utilizing regular classroom resources to teach science. Numerous factors influence student learning and achievement. This study is conducted in the interest of learning more about these influences so that teachers may make informed decisions about utilizing NASA resources.

The original concept for this study emerged in listening to teachers and administrators report to other teachers and administrators on their success as a NASA Explorer School (NASA Explorer Schools, 2007). In addition to accomplishing NES project objectives, some teachers and administrators stated that the state standardized test scores for their schools had increased. When questioned about the subjects affected, most responded that all tested subjects were affected: mathematics, English/language arts, and science (where tested). Because most NASA educational materials target science subjects, this study was designed to assess science knowledge as measured by state standardized test scores.

Significance of the Study

Published research on the utilization of NASA resources to affect knowledge of student science content is nonexistent. Teachers and students find NASA content interesting, enriching, and engaging. With the current focus on state standardized test scores, determining which factors most affect student performance is important. Determining whether the implementation of popular NASA educational materials has an impact on student knowledge of science content will help teachers make informed decisions about the use of NASA educational materials. The results of this study will also be useful for NASA in assessing the efficacy of its educational materials.

Statement of the Hypothesis

This quantitative study will assess the question: does a difference in student knowledge of science content exist between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials? The null hypothesis is: no significant difference exists between student knowledge of science content between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test. The alternative hypothesis is: a significant difference exists between student knowledge of science content between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test.

Assumptions

Certain assumptions were made to conduct this study. First, the control and treatment schools in each state were assumed to be adequately similar for this research. Comparison schools were in the same school district and were, therefore, assumed to have similar access to resources. Likewise, schools were of similar size and demographic composition. The numerous other factors, such as home environment and teacher quality, that potentially influence student achievement could not be measured. Although assumed to be similar, student populations in the comparison groups could be quite different.

Another assumption is that teachers at the treatment schools used NASA educational resources to teach science. Treatment teachers received professional development on different NASA educational resources according to their stated curricular needs and then reported that they implemented lessons based on lesson applicability to local standards and teacher ability.

Another assumption is that teachers at the treatment schools utilized inquiry techniques to teach science. Teachers received professional development on NASA content and inquiry-based teaching of NASA educational materials. When teachers returned to their classrooms to implement the lessons, they had access to email and phone support from NASA staff, but no observation of lessons occurred by NASA staff. Lesson implementation methodology, therefore, is assumed to follow the pedagogical approaches taught during the professional development sessions, but no evidence exists that inquiry was actually used in the treatment classrooms.

Limitations

This investigation was conducted under several limitations. First, the study involved only two schools from the same school district in each of three states: California, Texas, and Massachusetts. Similar schools were identified to decrease the effects of different schools; nonetheless, differences remain. Second, the extent of use of materials at each of the treatment schools was self-reported by teachers and there was no control over which lessons were used at each treatment site. Teachers had little reason to misrepresent their use of materials, but their reports were not validated. Third, the pedagogical approaches used in each classroom were not directly observed. Though teachers received inquiry-based professional development, no evidence exists that they actually implemented inquiry-based instruction in the classroom.

Summary

Determining the factors that influence student achievement in science is important to teachers, parents, and policy makers. Participating in dynamic, engaging science is important to teachers, parents, and students. Developing scientific habits of mind and increasing science achievement is important to society as a whole – locally, to school funding and reputation; nationally to the development of a scientifically literate population and workforce. This study investigates anecdotal claims by teachers and administrators that the utilization of NASA educational resources increases student achievement.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Influences on student achievement and acquisition of content knowledge are numerous and sometimes disputed. Home environmental factors, such as family background, socio-economic status, language barriers, and the number of times a student changes schools, have been researched as have school environmental factors, such as class size, instructional methods, teacher quality, and school resources. Teacher quality is arguably one of the most influential factors in a student's education. Factors that compose and influence teacher quality, as well as ideas for improving teacher quality, are numerous. In this chapter, current and historical research on these factors and ideas will be discussed. Additionally, inquiry learning, the currently accepted best practice in science teaching, and student interest are examined for their influence on student achievement.

Factors Influencing Student Achievement

In his 1976 classic *Human Characteristics and School Learning*, Benjamin Bloom suggested that variance in school achievement could be 50% attributed to these factors: student attitudes toward what they were studying, their school environment, and their concept of self (25%); and quality of instruction (25%). The good news for educators is these identified factors can be influenced at the school site. Teachers can work to improve the quality of instruction and they can provide students with interesting and challenging coursework while contributing to a positive school environment. Naturally, a wide body of research exists on what constitutes these identified factors as well as the factors that make up the remaining 50%. Bloom (1976) identifies the remaining factors as those with which the student comes to class, such as natural ability, previous learning, and home influences.

Current research tends to support Bloom's theories and offers more detailed explanations of factors outside of school control that influence student achievement. Heck's (2007) research determined that student achievement is lower in populations of students identified as English language learners, special education students, minorities, students of low socioeconomic status, and students who changed schools.

Recent research consistently indicates that an achievement gap in science exists between racial and ethnic minority students and majority students (Bacharach, Baumeister, & Furr, 2003; Chapin, 2006) with majority students generally scoring higher on standardized tests. Though African Americans and Latinos made significant gains in science from 2000 to 2005, White and Asian students still score higher in science (*The nation's report card, science 2005: Assessment of student performance in grade 4, 8, and 12. [electronic resource]*, 2006). These are, therefore, important factors to consider when establishing comparison groups.

Likewise, childhood poverty negatively affects student achievement (Duncan, Brooks-Gunn, Yeung, & Smith, 1998; Guo, 1998; Payne, 2001) and cognitive development (Guo, 1998). Guo (1998) found that long-term poverty has substantial influence on student achievement, though poverty experienced earlier in life seems to be less influential to adolescent achievement than poverty experienced during adolescence. Whereas lower-income students made significant gains on national assessments from 2000-2005, they are still outscored by higher-income students (*The nation's report card, science 2005: Assessment of student performance in grade 4, 8, and 12. [electronic resource]*, 2006). Because these factors affect student achievement in science, establishing control groups of similar socioeconomic status is important for conducting valid research.

Reynolds and Walberg (1992) reported that, besides prior achievement, home environment, motivation, and instructional time have the greatest influence on student science achievement. Interactions between home environment and motivation as they relate to prior achievement were noted. Students whose home environments support or encourage science learning tend to have more motivation to learn science and higher science achievement. Supportive home environments set a foundation for early learners, though classroom experiences come into play as the student gets older. Carey and Shavelson (1988) found the ability of parents to foster positive attitudes about science to be one of the most important predictors of science achievement. As Bloom (1976) noted, instructional effects depend, in part, on student attributes and behaviors that are often foundationally developed prior to a child’s entering school. Even in ways that are not directly related to science, the home environment can affect student science achievement. Valadez (2010) found that students who come from homes with 100 books or more score much higher in science than students who come from homes with few or no books.

Because home influences are not generally part of school aggregate data, special care should be taken to assess these influences in research subjects.

Many studies have investigated, with differing conclusions, whether the level of school resources affect student achievement. Urban and suburban schools often have different district and community resources available, a factor that might impact opportunities for learning (Norman, Ault, Bentz, & Meskimen, 2001). Allocation of federal and state funding differs tremendously between school districts and, while some researchers claim correlation to achievement, others assert that the differential usage of funding makes correlation impossible (Ludwig & Bassi, 1999). Cohen, Raudenbush, and Ball (2003) agree and offer a plausible approach for accounting for varied conclusions of studies on resources: The value of resources toward achievement depends on how the resources are used. Resources must be identified for a particular need and allocated toward a researched resource that will accomplish a specific aim. Teaching is a dynamic process and it is difficult to discern the effects of particular resources within the confines of traditional research. Archibald (2006) designed a study following these suggestions that differentiated school expenditures into four categories: instruction, instructional support, leadership, and operations and maintenance. The purpose of this study was to hone in on the exact areas of expenditures and their relationship to student achievement. The results indicate that expenditures for instruction and instructional support significantly impact reading achievement of 3rd, 4th, 5th, and 6th grade students. Related to resources, Archibald also investigated the effects of school size and determined that larger schools tended to have a negative impact on achievement. This study did not, however, show that resources impact math achievement and also did not investigate science achievement. Because much diversity in research findings exists regarding the issue of school resources as related to student achievement, it is important to compare schools that have similar resources whenever possible.

Family location stability is an understandable factor in student achievement. Changing schools mid-year is disruptive to a student both academically and socially. Because pacing and content varies among school sites, student mobility rates can affect achievement and performance on standardized tests. In fact, the results of a study by Ingersoll, Scamman, and Eckerling (1989) indicated a nearly uniformly negative impact of geographic mobility on student achievement, especially at the elementary grade levels. Rumberger (2003; Rumberger, Larson, Ream, & Palardy, 1999) has done extensive research on the impacts of mobility on student achievement. He found that mobility rates are higher for students of low socioeconomic status, further compounding achievement problems in this subgroup. Also, he discovered that mobility rates are higher in some regions of the U.S.; in California, for example, nearly 75% of students make an unscheduled school change between grades one and twelve, compared to 60% in the rest of the nation. In addition to the impact this has on the mobile student, an impact on the classrooms that must deal with mobile students is observable. A teacher whose students are constantly in a state of flux must expend a great deal of energy trying to help incoming students adapt to the new environment. This expenditure of energy can take away from a teacher’s ability to provide uninterrupted learning for the rest of the class. With the inconsistencies in student population that arise in schools with high mobility rates, comparing standardized test scores can be difficult. It is therefore important when comparing schools test scores to have similar student mobility rates at the schools.

Given the wide variety of potential influences on student achievement, controlling for demographic factors is important, while opportunities for research abound. Accurately measuring student learning is crucial in determining what factors affect achievement. Once a method of measurement is established, variable factors may be investigated.

Assessing Student Learning Using State Standardized Tests

Standardized tests are used domestically and internationally to measure student knowledge of core curriculum taught in elementary, middle, and high school. These tests are subject to rigorous validity and reliability standards and are accurate measures of student content knowledge. Though standardized tests accurately measure content knowledge, they should be considered merely one part of a multi-level assessment of student knowledge (Kubiszyn & Borich, 2005).

According to Shavelson, Carey, and Webb (1990, p. 693), “the response format of multiple-choice tests keeps us from measuring some of the things that we consider most important” to science learning, such as procedural understanding and problem solving. Though we need to produce tests that better assess the most important aspects of science learning, “The true test of students’ understanding is to put them in a lab, pose a problem, and let them use lab resources to solve it” (Shavelson, et al., 1990, p. 696).

Shavelson and Baxter (1992) later continue the argument that most multiple-choice tests do not measure thinking processes developed during hands-on inquiry-based science. They suggest implementing performance assessments designed to assess thinking processes in combination with traditional testing instruments which focus more on measuring content knowledge. Developing performance assessments of this type, however, is a delicate and time-consuming task requiring considerable knowledge and testing.

Certain populations of students take modified versions of standardized tests because research shows their skills may not be adequately assessed with regular test versions. Students with disabilities commonly underperform on standardized tests (Horn, 2003; Koretz & Hamilton, 1999) and should, therefore, be assessed with an alternate version of the test whenever possible. Students who are not proficient in English are at a disadvantage when taking a science test in English. Garcia and Bolt (1991) and Solano-Flores (2008) showed that students may have adequate content knowledge but not score well on tests because of unknown vocabulary, lack of cultural knowledge, and use of literal interpretations. These results were verified in a large, extensive study by Maerten-Rivera, Myers, Lee, and Penfield (2010) that concluded English language proficiency is the primary influence in English language learner performance on standardized tests in science. This influence is largely due to students' inability to comprehend test questions and is, therefore, another factor that should be considered in school-to-school comparisons. Adaptive testing techniques can be effectively used to assess the knowledge of special student populations (Frey & Seitz, 2009) but these results cannot be used to directly compare student performance between regular and special populations unless the same testing methods are used for all groups.

Though standardized tests are not all-encompassing measures of science knowledge, they can provide some information on student learning. Standardized tests are efficient, validated tools that provide reliable data linked to student demographics and are good resources for assessing student content knowledge in science.

Teacher quality, a multi-faceted component of student achievement, is difficult to measure because of the interplay among factors that make a teacher effective (Seidel & Shavelson, 2007). The results of Heck’s 2007 study show that teacher quality increases student achievement and higher teacher quality is associated with reduced gaps in student learning rates associated with socioeconomic or minority status. In fact, teacher quality is more strongly related to student achievement than class size, student demographic characteristics, and overall spending levels (Darling-Hammond, 2000). Heck (2009) verified previous research indicating the positive impact of teacher effectiveness on student achievement and further concluded that teacher effects accumulate within schools to provide either academic advantage or disadvantage.

Using data from a four-year experiment, the Tennessee Class Size Experiment, Nye, Konstantopoulos, & Hedges (2004) concluded that teacher effects are important for all subpopulations, but effects are greater for low socioeconomic schools than for high socioeconomic schools. This difference is understandable since students from high socioeconomic schools generally have more opportunities for learning outside of school than students from low socioeconomic schools. This study also affirms that teacher effects are larger than school effects providing interesting implications for reform. Perhaps it is more important to focus on teacher preparation than to engage in efforts of whole school reform. Additionally, this analysis supports the conclusion made by other researchers that class size impacts student achievement. When considering the costs of improving teacher effectiveness and reducing class size, however, an argument can be made that the former is more cost effective. Though this study firmly declares the importance of teacher effects on student achievement, the characteristics that are possessed by an effective teacher remain to be argued. Teacher-education effects were found to be statistically significant in only one case and teacher experience effects, though impactful, were statistically significant in only two cases. This experiment was not designed to assess characteristics of teacher effectiveness so an examination of research with this design is necessary.

Teacher quality is measured by a variety of factors, including certification and a major in the field in which they are teaching (Darling-Hammond, 2000). Archibald (2006) determined, however, that teacher years of experience and educational degree level attained are not related to student achievement. Internationally, similar trends exist in student achievement influences. In studying the relationship between Bulgarian student achievement in science and math and student socio-economic status and teacher quality, Bankov, Mikova, and Smith (2006) found that students of low socio-economic status generally have lower achievement than more affluent students. They also found that traditional measures of teacher quality, such as experience and education, did not predict student achievement. So we must ask the question, what teacher characteristics help students achieve and how can teachers effect change in their practice to become better teachers?

Expecting students to achieve better when their teachers are more knowledgeable in their field and are skillful in teaching the content to others is reasonable. Student achievement in science has been shown to be positively correlated to teacher training in science and education (Druva & Anderson, 1983). Continued learning by science teachers has been shown to influence teacher performance (Penick and Yager, 1983). Additionally, teacher attitudes about science and confidence in their teaching practice can increase with good professional development. Teacher attitude and confidence have been shown to influence student achievement (Woolhouse and Cochrane 2009).

Blank, Alas, and Smith (2008) assert that teacher expertise in teaching requires substantive content knowledge that is connected to other content areas, especially within the sciences. Simpson and Oliver (1990) determined that science is not adequately taught at the elementary school level because teachers are not comfortable with the content or the methodology of good science teaching. A weak background in science content leaves a teacher vulnerable to developing and perpetuating misconceptions. Teacher ability to present and explain science content clearly and effectively dispel student misconceptions is critical. Without adequate content knowledge, teachers may be unable to explain why incorrect student reasoning is indeed incorrect. Additionally, underprepared teachers may be unable to facilitate inquiry-based learning because of the diversity of correct solutions and reasoning paths that students follow. In researching the effects of a project-based inquiry science curriculum on student achievement, Kanter and Konstantopoulos (2010) verified that student achievement gains are directly related to teacher subject-matter content knowledge and pedagogical content knowledge.

The type and quality of in-service teacher professional development can make a difference in developing teacher knowledge. Long-term teacher professional development that is focused on content and content-specific pedagogy changes teacher practice. In fact, with elementary school teachers who often lack content and pedagogical skills for teaching science, dramatic change can be effected using this approach coupled with mentor observations and feedback (Smith & Neale, 1989). Subject matter content knowledge includes teacher knowledge of science facts, concepts and procedures. Pedagogical content knowledge is concerned with the teaching and learning of science (Harrison, Hofstein, Eylon, & Simon, 2008). Teaching through inquiry requires the teacher to have a complex pedagogical skill set that includes the ability to collect, share, and reflect on evidence. In an inquiry learning environment, the teacher offers guidance, tools and support to students (Harrison, et al., 2008). Astor-Jack, McCallie, and Balcerzak (2007) state that effective professional development can be achieved by combining pedagogy and science content with inquiry-based techniques and add that reflection is an important part of teacher development.

Lee, Hart, Cuevas, and Enders (2004) report that students enjoy exploratory learning. In order to foster student learning through inquiry, teachers need to experience learning through scientific inquiry themselves. Professional development in inquiry-based science enabled more frequent and effective teaching of science by elementary school teachers. Targeted professional development yielded an increase in teacher confidence due to more science content and pedagogical knowledge. Using inquiry to teach science has shown potential change in teaching other subjects as teachers become more comfortable with and see the value of student-led learning. After participating in science professional development, teachers reported enhanced content knowledge and stronger beliefs about the importance of science instruction. An informal educator involved in the 2007 study by Astor-Jack et al. (p. 617) remarked that “inquiry itself is kind of a risk-taking piece, so when you aren’t comfortable with the content, you tend to deliver it, and when you're comfortable with it, then you tend to sit back and you can listen and watch and facilitate."

Woolhouse and Cochrane (2009) conducted a study of science teachers in the United Kingdom (UK) who were being asked to teach outside of their areas of specialization. Much like in the United States, biology teachers in the UK dramatically outnumbered physical science teachers and a shortage was occurring. Teachers needing to acquire skills in physical science attended professional development training that focused on subject matter and pedagogical content development. After receiving professional development, teachers report that they have increased subject matter and pedagogical content knowledge, making them more effective teachers of science. Teachers report their increase in subject matter knowledge enables them to answer more student questions and see links to the overall picture of science. These skills enable teachers to have more confidence in encouraging student discourse. Teachers in this study also reported having an easier time teaching science with their newly acquired skills.

Supovitz & Turner (2000) found that changing teacher practice to an inquiry-based or investigative approach requires high-quality, deep, sustained professional development experiences. Both inquiry-based teaching and creating a investigative classroom environment are major paradigm shifts for many teachers and both techniques take time to develop and practice. The quantity of professional development is strongly linked with inquiry-based and investigative teaching practices. It is only after teachers have received approximately eighty hours of professional development that they are able to use inquiry-based techniques in their classroom more than the average teacher.

Additionally, teachers' establishing a culture of investigation in their classrooms occurs only after 40-79 hours of professional development. The work of Blank et al. (2008) supports this in concluding that the most effective programs consist of content-focused professional development delivered over at least 50 hours with a follow-up in-school component of formative assessment for the teachers. Some researchers, including Adey, Hewitt, Hewitt, & Landeau (2004), declare that professional development hours should be spread out over two or more years for maximum effectiveness. Teacher content preparation has a powerful influence on teaching practice and investigative classroom culture. School factors, such as the supportiveness of the school principal, also play influential roles in determining the extent to which teachers use inquiry and investigative techniques for teaching (Supovitz & Turner, 2000).

An added dimension of teacher practice as it relates to professional development is self-perception. Research has shown that teachers' perceptions of the nature of their practice are not always accurate. King, Shumow, & Lietz (2001) discovered that teachers in their study reported using inquiry-based techniques, but when observed, they were using mostly expository techniques. Though the professional development these teachers had experienced was short-term, this finding exposes a potential weakness of self-evaluation: the inability to objectively evaluate one's own performance. Inquiry learning requires a different approach to classroom management than that to which many traditional teachers are accustomed (King, et al., 2001) and assessing one's abilities in teaching using inquiry and constructivist techniques takes some practice. Alesandrini & Larson (2002) assert that until teachers experience learning through constructivism, they will not be equipped to teach in this manner. Part of helping teachers become constructivists is allowing them to learn that outcomes to experiments can be unique and varied and that there are often several good approaches to several good solutions to any given problem.

Effective teachers are lifelong learners, both from external professional development sources (Harrison, et al., 2008) and through their teaching experiences (Shulman & Shulman, 2008).

NASA Professional Development for Teachers

In the NASA Explorer Schools (NES) project NASA partners with schools serving grades 4-9 in order to affect school reform in the areas of science, technology, engineering, and mathematics (STEM). NES third-party evaluation efforts focus on determining whether the objectives of the project have been met. NES project objectives are:

- Increase student interest and participation in STEM
- Increase student knowledge about careers in STEM
- Increase student ability to apply STEM concepts
- Increase the active participation and professional growth of educators in STEM
- Increase the academic assistance for and technology use by educators in schools with high populations of underserved students
- Increase family involvement in student learning

(*NASA Explorer Schools project reference binder*, 2007)

Professional development provided by NES staff utilizes inquiry-based educational materials and is delivered using the basic tenets of constructivism:

1. Learning results from exploration and discovery.

2. Learning is a community activity facilitated by shared inquiry.

3. Learning occurs during the constructivist process.

4. Learning results from participation in authentic activities.

5. Outcomes of constructivist activities are unique and varied.

(Alesandrini & Larson, 2002, pp. 118-119)

The objective of NES professional development is to increase teachers' content knowledge, pedagogical knowledge, and use of NASA inquiry-based materials in order to accomplish NES project objectives. Professional development opportunities were designed by NES staff based on needs expressed by project participants. Attendance at professional development opportunities and use of associated materials is left to the teacher's discretion. Teachers selected opportunities and materials based on their individual needs and adapted materials for use in their classrooms.

In assessing utilization of materials, the NES evaluators determined that, on average, teachers with no professional development used approximately 0.5 NASA resources per year. Teachers who attended some sort of professional development reported using approximately 2.4 resources per year. Additional measures show teachers with professional development using an average of 5.2 resources per year (Davis, Bettinger, & Davey, 2009).

NES evaluators determined that 79% of teachers who participated in short-term (two days or less) professional development with NASA use NASA educational materials in their classroom. This percentage skyrockets to 94% for teachers who participate in long-term (three days or more) intensive professional development with NASA. Of teachers receiving professional development, 98% reported that the NASA resources they used were effective and 96% planned to continue using the resources in the future (Davis, Bettinger, & Davey, 2010b).

In addition to increasing their use of NASA resources, about half (48-66%) of teachers agreed that participating in NES had increased their skills and confidence in teaching STEM concepts. Fifty percent report an increase in their skill in teaching STEM, 48% report increased confidence in teaching STEM concepts, and 57% report increased knowledge of ways to interest students in STEM disciplines (Davis, Bettinger, & Davey, 2010a).

All teacher data from the NES project were the result of teacher surveys and interviews conducted by the NES evaluation team. No direct observation of teacher practice occurred.

Inquiry Learning and Interest of Students

Inquiry learning is an ancient technique employed historically by Greek philosophers to spark creative thought in students. Current research shows that learning through inquiry creates more student interest and positively affects motivation more than traditional learning techniques. Tuan, Chin, Tsai, and Cheng (2005) found that inquiry-based science teaching methods motivate students to learn science because inquiry-based instruction seems to provide students with more meaningful and challenging tasks. Students of various learning styles all experienced an increase in motivation and gained stronger perceptions of their ability to solve difficult science problems when learning through inquiry.

Inquiry learning capitalizes on the natural curiosity of children, encouraging their inquisitiveness with the goal of helping them develop into lifelong learners. Inquiry classrooms are exciting, stimulating places to be. In an inquiry classroom teachers and students are asking questions together, discussing possible answers to their questions, and designing paths to find answers (DuVall, 2001). NASA inquiry-based investigations are more than simple hands-on activities. Students are challenged to devise creative solutions, design better systems, and investigate problems for which even their teachers do not have answers.

Inquiry Learning and Problem-Solving Abilities of Students

According to Dalton, Morocco, Tivnan, and Mead (1997) hands-on learning is effective, but hands-on inquiry-based learning is more effective. In this study, students of a wide variety of ability levels, including some with learning disabilities, conducted the same investigation using one of two learning methods. Dalton et al. conclude that the difference in learning occurs because inquiry draws students into making connections with prior knowledge and develops their problem solving skills. Without inquiry, students are merely following a set of instructions. While some learning will take place, learning can be enriched through the use of inquiry.

In establishing the case for inquiry learning, DuVall (2001, p. 5) reminds us that "students must be provided opportunities to closely observe a phenomenon in order to refine and expand their background knowledge about the phenomenon." Many NASA educational materials build background knowledge while presenting new, unique challenges. DuVall supports the development of curious learning for lifelong learners: "Inquiry is a process they can use across their lives, not just for science" (2001, p. 5). Teaching students "that the nature of science itself is a distinct type of human endeavor, always subject to fallibility and open to revision when new information becomes available" is important in developing their sense as independent learners (DuVall, 2001, p. 6).

Active, design-based inquiry learning results in higher knowledge gain than traditional scripted inquiry learning. Design-based inquiry presents students with a problem to solve and allows them the freedom to completely design their own solution, whereas scripted inquiry presents students with a problem and design specifications for the solution. Design-based inquiry was shown to have an especially strong advantage for low-achieving African American students (Mehalik, Doppelt, & Schuun, 2008). Valadez (2010) showed that elementary school students of teachers who regularly use hands-on learning practices in science achieve higher National Assessment of Educational Progress (NAEP) scores than students who are not engaged in hands-on learning.

Though young students come to us with natural curiosity, teachers must mold their random curiosity into "sophisticated wondering" (DuVall, 2001, p. 6). Teaching students to move from making concrete observations and experiences to asking rich, meaningful questions is the essence of inquiry learning. Students who can ask meaningful questions and methodically seek answers to those questions are well-equipped problem solvers.

Student Interest as a Result of Participation in NASA Activities

In a society that is increasingly technological and enmeshed with scientific issues, scientific and technological literacy of citizens is tremendously important. The two breeding grounds for this literacy are home and school. Because literacy begins with a spark of interest, the NASA Explorer Schools project objectives targeted both home and school with the hopes of increasing student interest in STEM fields.

Over the years of the project, evaluators determined that assessing student knowledge of content was difficult given the scope of the evaluation process and the differing implementation of the project at the various school sites. So, student evaluation measures focused on assessing student interest and knowledge about STEM careers and attitude toward STEM subjects. Data for students were collected using student and teacher surveys.

Teachers report, on average, that participation in the NES project had increased student involvement in STEM activities, increased student interest in STEM careers, and increased student interest in STEM topics. For students in grades four through six, 82% reported that they prefer learning with NASA resources over other resources, 72% report learning being easier with NASA resources, and 78% report that they learn more with NASA resources. Results are similar, though slightly lower, for students in grades seven and eight. For students in grades seven and eight, 79% reported that they prefer learning with NASA resources over other resources, 71% report learning being easier with NASA resources, and 76% report that they learn more with NASA resources. Students enjoy using NASA resources and 83% find themselves interested in learning more about STEM subjects after using NASA resources (Davis, et al., 2010a).

Student Interest and Self-Efficacy Related to Achievement

Substantial research exists linking student attitude and interest to achievement. In particular, Downey, Ainsworth, and Qian (2009) showed attitudes of minority students are linked to general achievement and the research of Singh, Dika, and Granville (2002) indicates that student attitudes, interest, and academic engagement affect achievement in math and science. Intrinsic motivation is a significant construct in student education and should, therefore, be fostered in the school learning environment (Gottfried, 1985). Research by Valadez (2010) supports this and indicates that elementary and middle school students who state that they like science achieve higher standardized test scores than students who do not.

Similar patterns linking student interest to achievement were verified by Shin, Lee, and Kim (2009). They used results from the 2003 Program for International Student Assessment (PISA) to assess factors influencing Korean, Japanese, and American student achievement in mathematics. Their research showed that interest in mathematics is an indicator of achievement in mathematics for students from all three countries.

Simpson and Oliver (1990) summarized the major findings of a longitudinal effort to analyze data collected by a 1978 National Science Foundation-funded multi-year study investigating influences on attitude toward and achievement in science among adolescent students. They reported that student concept of self-efficacy and anxiety about science are the strongest predictors of science achievement. Classroom experiences shape a student's feelings toward their further involvement in science. Males express a more positive attitude toward science than females, regardless of race or ability group. Positive attitudes about science decrease between grades six and ten with the greatest drop between the beginning and middle of each school year. Motivation to achieve drops similarly. Evidence suggests that attrition of students away from science and engineering careers begins in the middle grades (King, et al., 2001; Women, minorities, and persons with disabilities in science and engineering," 2009). Reduced achievement levels may result in students not being able to take science courses that lead to science careers (Kanter & Konstantopoulos, 2010).

For high school students, the future usefulness of current class work is an important motivational factor (Greene, Miller, Crowson, Duke, & Akey, 2004). When tasks are perceived to be important because of future value or usefulness, students are more likely to adopt mastery goals. When tasks are perceived to be important because of peer competition, students are more likely to adopt performance goals. Students invest greater effort and approach learning in a more cognitively strategic manner when they perceive that their learning will be used in the future. Additionally, students' cognitive engagement and achievement, influenced by self-efficacy, can be positively impacted in motivating, positive classroom environments. Teachers who work to provide encouraging, motivating environments and highlight the usefulness of schoolwork to students' futures will assist students in achieving their potential. Simpkins, Davis-Kean, and Eccles (2006) contradict this, however, in reporting that students in their longitudinal study were more likely to pursue math and science courses if they believed they had ability in these areas. They found that student self-concept was more important than valuing math or science in choosing future courses.

Whereas some debate occurs about whether attitude influences achievement or achievement influences attitude, both sides agree that the two are interdependent. Science achievement in elementary and middle school is a predicting factor for science attitude at the high school level (Reynolds & Walberg, 1992). Since science attitude affects course and career choices (Greene, et al., 2004), providing positive experiences that nurture science achievement in students during the early grades is important. Because science achievement influences attitude, a positive attitude about science can influence the amount of time a student spends outside of school gaining additional knowledge about science which will, in turn, affect later achievement. Students who have a positive attitude about science are more likely to spend more time on science homework, one of the strongest factors in student achievement (Singh, et al., 2002).

Gottfried (1985) suggests that curriculum emphases at different grade levels contribute to the intrinsic motivation of students. If more time is spent on a subject, perhaps students become more engaged and develop more intrinsic motivation for that subject. Singh et al. (2002) found that science achievement is influenced by motivation, attitude, and academic engagement. Their research also indicates that students who are more motivated have a more positive science attitude and are more likely to spend time on science homework which, in turn, positively affects science achievement. They report that "researchers have suggested that students' motivation to learn mathematics and science can be increased and improved when teachers create a curriculum that focuses on conceptualizing and creating meaning and relevance" (p. 330). Singh et al. recommend that interventions begin during elementary school so attitudes and class participation habits, which are well-formed by middle school, can be positively influenced.

Research indicates that student interest is linked to academic performance and choices of future coursework and careers. Creating an environment that sparks initial curiosity and fosters long-term interest in science is recommended by the U.S. Department of Education as an avenue through which underserved populations can be encouraged. Out-of-school time can be an influential factor in student academic and social development. Simpkins et al. (2006) found that out-of-school activity participation in fifth grade predicts subsequent values and self-concepts of abilities. Students who have confidence in their ability in math or science are more likely than their peers to continue to pursue these subjects. Simpkins et al. also found that these factors outweighed the traditional influence parent education and family income have on student achievement except that, as expected, parent income negatively predicted girls' activity participation.

Interestingly, in the 2010 study by Kanter and Konstantopoulos, student attitudes toward science and plans to pursue science careers did not show an improvement with project-based inquiry science curriculum. The frequency of use of inquiry-based activities, however, appeared to influence students from underrepresented groups. Higher achievement in underrepresented groups was directly related to frequency of use of inquiry-based activities in the classroom.

Recent and historical research shows that student interest and achievement are linked. Most educators agree that increasing student interest in a subject will lead to increased participation and, hopefully, increased achievement. When students are interested in a subject, they will pay close attention in class and they will pursue the subject outside of class, whether through careful attention to homework or extra-curricular activities related to the subject. More time and attention spent on the subject has been shown to translate into higher achievement in that subject.

Needed Research

The preceding discussion highlights the effectiveness of teacher professional development, student learning through inquiry, and student interest related to achievement. Teacher practice can be effectively influenced through professional development and student learning is improved through inquiry and investigation. Because the NASA Explorer Schools project provides teacher professional development in inquiry-based and investigative learning techniques for science and NASA educational materials have been shown to increase student interest in science topics, a natural topic for research is whether school participation in the NES project affects student learning in science. This study examines standardized test scores to investigate whether student knowledge of science content is affected by the use of NASA educational materials.

The question addressed in this study is: Does a difference in student knowledge of science content exist between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials? Factors known to impact student achievement have been controlled to the greatest extent possible. Control and treatment schools have similar student demographics and school resources. Potential outlier populations for regular standardized testing, those designated as special education and those with limited English proficiency, have been eliminated from the data. Results from this study will contribute to the knowledge base regarding efficacy of NASA educational materials and assist researchers in constructing further related studies.

CHAPTER III

METHODOLOGY

Introduction

This quantitative study will assess the question: does a difference in student knowledge of science content exist between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials? The null hypothesis is: no significant difference exists between student knowledge of science content between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test. The alternative hypothesis is: a significant difference exists between student knowledge of science content between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test.

Student knowledge of science content can be affected by a number of factors including teacher quality, classroom resources and instructional time, student attitudes, and home environment. Teacher quality can be improved by training and experience (Aceves, 2002). Classroom resources can be acquired through various grants and partnerships, though instructional time is generally dictated by school district or state requirements. Student attitudes can be positively affected by increasing student interest in the subject matter. Some factors, such as home environment, are largely out of the realm of influence of the school. As the premier space exploration agency, The National Aeronautics and Space Administration (NASA) holds allure for students of all ages. Schools that are part of the NASA Explorer Schools (NES) project receive teacher professional development opportunities, funding for classroom resources, and targeted student exposure to NASA missions. Cutting edge research being done by NASA scientists excites and interests students and attracts them to the content they are required to learn in school. This study investigates the effects of increasing student interest in science by using the captivating subject of space exploration.

The original concept for this study emerged in listening to teachers and administrators report to other teachers and administrators on their success as a NASA Explorer School (NASA Explorer Schools, 2007). In addition to accomplishing NES project objectives, some teachers and administrators stated that the state standardized test scores for their schools had increased. When questioned about the subjects affected, most responded that all tested subjects were affected: mathematics, English/language arts, and science (where tested). Because most NASA educational materials target science subjects, this study was designed to assess science knowledge as measured by state standardized test scores. Whole-school trends in mathematics and English/language arts scores will be examined as well.

NASA produces a variety of educational materials for use in elementary, middle, and high school classrooms. These materials are aligned with national science, math, technology, and geography standards. NASA educational materials are developed using themes from space exploration and are generally of high interest to students.

The NASA Explorer Schools project, a three-year partnership with selected schools, provides, among other support, professional development for teachers in utilizing NASA educational materials in the classroom. Pedagogically, inquiry-based learning is championed in these professional development sessions. Participating educators may attend a variety of types of sessions that vary in length from a few hours to several days. These sessions may be targeted to a particular subject matter (e.g., robotics, aeronautics) or to a set of standards (e.g., physical science, Earth science). Sessions include experiential training in which educators learn how scientists work and practical training in which educators learn how to bring the content back to their classrooms. The goal is to increase student interest in science through the utilization of exciting contextually related materials.

Research Design and Approach

This research study uses a quasi-experimental post-test-only research design featuring nonequivalent comparison groups. This study assesses the effects of utilizing NASA educational materials on science content knowledge of fifth grade students. Half of the classrooms in this study have participated in lessons involving NASA educational materials. The other half have not been exposed to NASA educational materials in class. Because all classes in a given state are subject to the same curriculum guidelines, all students in that state should have been exposed to the same science content during the school year.

This study was conducted using state standardized testing data provided by six public elementary schools. Two of these schools are located in the same school district in California, two are located in the same school district in Texas, and two are located in the same school district in Massachusetts. California, Texas, and Massachusetts were selected because these states administer standardized tests assessing fifth grade students' knowledge in physical science, life science, Earth science, and investigation and experimentation/nature of science. Fifth grade students in all three states are also tested in mathematics and English-language arts. In this study, California students are measured against each other, Texas students are measured against each other, and Massachusetts students are measured against each other. Students from different states are not measured against each other because the testing instruments and standards tested are not identical. Scores of Special Day Class (SDC) students and first-year English Language Learners (ELL) were removed from all data sets.

The California control group (C1) consists of fifth grade students at an elementary school that is not part of the NASA Explorer Schools (NES) project. The California treatment group (C2) consists of fifth grade students at an elementary school in the same school district as C1. School C2 has been part of the NES project since summer 2004. Fifth grade students in one class at C2 received science instruction using NASA materials; fifth grade students in another class at C2 received regular science instruction without NASA materials until 2006 when both classes received instruction using NASA materials. Fifth grade students at C1 received regular science instruction without NASA materials.

As shown in Table 1, the demographics of schools C1 and C2 are similar. Both schools have similar enrollment numbers and are ethnically diverse with greater than 50% of the school student populations consisting of ethnic minorities. The distributions of the ethnic groups are somewhat different for the two schools and vary slightly over the experimental years, but this difference is not germane to this research because ethnicity is not used as a grouping factor. Schools C1 and C2 have similar rates of student mobility during the school year and a similar percentage of economically disadvantaged students (as measured by percent of students participating in free and reduced lunch programs). Total enrollment at school C2 is slightly higher than at school C1 (California Department of Education, 2010).

Table 1

California School Demographics

	2005		2006		2007		2008		2009	
	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
African-American %	4	3	4	4	3	3	3	3	2	3
Hispanic %	35	34	40	35	38	38	40	38	39	37
White %	44	42	42	44	41	45	39	45	38	40
Native American %	2	1	1	1	1	0	2	0	2	1
Asian/Pac Islander %	16	20	14	15	14	14	12	14	15	17
Non-white %	56	58	58	56	59	55	61	55	62	60
Economically Disadvantaged %	49	50	50	51	56	47	47	47	42	38
Mobility %*	94	94	96	94	93	94	91	94	91	93
Total Enrollment	394	430	368	411	372	388	348	392	340	383

**Mobility rate is the percent of students who were continuously enrolled in the district since October of the school year.* (California Department of Education, 2010)

The Texas control group (T1) consists of fifth grade students at an elementary school that is not part of the NASA Explorer Schools (NES) project. The Texas treatment group (T2) consists of fifth grade students at an elementary school in the same school district as T1. School T2 has been part of the NES project since summer 2004. Fifth grade students at T2 received science instruction using NASA materials; fifth grade students at T1 received regular science instruction without NASA materials.

As shown in Table 2, the demographics of schools T1 and T2 are similar. Both schools have similar enrollment numbers and are ethnically diverse with greater than 65% of the school student populations consisting of ethnic minorities. The distributions of the ethnic groups are similar for the two schools and vary slightly over the experimental years. At-risk and mobility rates for the two schools are similar. School T1 has a slightly higher number of economically disadvantaged students (as measured by percent of students participating in free and reduced lunch programs), but the difference seems to be equivocating over the years of this study. Total enrollment at school T1 is slightly higher than at school T2 (Texas Education Agency, 2010).

Table 2

Texas School Demographics

	2005		2006		2007		2008		2009	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
African-American %	44.2	41.8	46.6	39.2	44.6	38.3	43.1	32.2	43.5	35.6
Hispanic %	28.6	22.9	27.4	24.8	29.4	27.8	28.6	28.3	26.2	30.8
White %	21.4	29.9	21.6	31.0	22.0	30.0	25.2	32.9	26.7	30.2
Native American %	1.3	2.8	0.5	1.6	0.8	0.7	0.4	1.0	0.5	0.2
Asian/Pac Islander %	4.5	2.5	3.8	3.3	3.2	3.1	2.7	5.6	3.1	3.1
Non-white %	78.6	70.1	78.4	69.0	78.0	70.0	74.8	67.1	73.3	69.8
Economically Disadvantaged %	85.5	78.8	86.2	78.3	80.6	78.8	80.3	79.1	81.5	84.1
At-risk %	52.4	48.2	58.3	48.3	52.2	56.6	48.7	52.1	60.6	70.4
Mobility %	47.3	42.5	35.9	43.1	41.1	47.3	41.3	46.6	33.7	39.8
Total Enrollment	532	471	573	451	504	546	524	484	573	483

**Mobility rate is the percent of students who spent less than 83% of the school year in the district.* (Texas Education Agency, 2010)

The Massachusetts control group (M1) consists of fifth grade students at an elementary school that is not part of the NASA Explorer Schools (NES) project. The Massachusetts treatment group (M2) consists of fifth grade students at an elementary school in the same school district as M1. School M2 has been part of the NES project since summer 2006. Fifth grade students at M2 received science instruction using NASA materials; fifth grade students at M1 received regular science instruction without NASA materials.

As shown in Table 3, the demographics of schools M1 and M2 are similar. Both schools have similar enrollment numbers and are ethnically diverse with greater than 80% of the school student populations consisting of ethnic minorities. The distributions of the ethnic groups are similar for the two schools and vary slightly over the experimental years. Schools M1 and M2 have similar rates of student mobility for 2008 and 2009. Mobility data were not archived prior to 2008. Schools M1 and M2 have a similar percentage of economically disadvantaged students (as measured by percent of students participating in free and reduced lunch programs). Total enrollment at school M2 is higher than at school M1 for some years because school M2 served an additional three grade levels (6, 7, and 8) for those years (Massachusetts Department of Elementary and Secondary Education, 2010b).

Table 3

Massachusetts School Demographics

	2006		2007		2008		2009	
	M1	M2	M1	M2	M1	M2	M1	M2
African-American %	15.1	15.7	14.5	13.1	18	11.5	15.1	12.7
Hispanic %	58.7	51.2	62.7	55.6	59.0	56.2	62.0	57.9
White %	17.0	15.9	13.1	13.9	14.0	15.3	12.7	13.5
Native American %	0.4	0.1	0.4	0	0.2	0	0	0.3
Asian/Pac Islander %	6.2	12.9	5.4	13.4	5.4	12.9	5.7	11.5
Non-white %	83.0	84.1	86.9	86.1	86.0	84.7	87.3	86.5
Economically Disadvantaged %	86	90.0	89.6	90.8	91.0	90.4	89.5	90.8
Mobility %	N/A	N/A	N/A	N/A	85.1	90.5	84.3	88.3
Total Enrollment	530	891	557	833	607	776	631	764

**Mobility rate is the percent of students who were continuously enrolled in the district since October of the school year.* (Massachusetts Department of Elementary and Secondary Education, 2010b)

Data Collection Tools

The California state testing instrument, the California Standards Tests (CST), is based on California state curriculum standards. The CST science test consists of 66 questions, all in multiple-choice format. Six of these questions are field-test items and are not scored for reporting (Educational Testing Service, 2009). The Texas state testing instrument, the Texas Assessment of Knowledge and Skills (TAKS), is based on Texas state curriculum standards, known as the Texas Essential Knowledge and Skills (TEKS). The TAKS science test consists of 50 questions, most of them in multiple-choice format with a limited number of items in grid-in format. Ten of these questions are field-test items and are not scored for reporting (Texas Education Agency, 2004). The Massachusetts state testing instrument, the Massachusetts Comprehensive Assessment System (MCAS), is based on Massachusetts state curriculum standards. The MCAS science test consists of 38 multiple-choice questions and four open-response questions. Two questions are field-test items and are not scored for reporting (Massachusetts Department of Elementary and Secondary Education, 2010a).

Reliability is an indication of the consistency of the assessment, giving an estimate of how well an assessment measures actual learning. Reliability of the TAKS instrument is measured using the Kuder-Richardson Formula 20 (KR20) for internal reliability. Reliability for the grade 5 TAKS science assessment ranges from .82 to .84 (1.0 being perfectly reliable) for testing years 2006-2008 (Texas Education Agency, 2008). Reliability of the CST instrument is measured using Cronbach’s Alpha. Reliability for the grade 5 CST science assessment ranges from .88 to .91 over the testing years of

2005-2008 (Educational Testing Service, 2009). Reliability of the MCAS instrument is measured using Cronbach's Alpha and a stratified alpha that corrects for some inherent errors in the Cronbach method. Reliability for the grade 5 MCAS science assessment ranges from 0.85 to 0.89 over the testing years of 2006-2008 (Massachusetts Department of Elementary and Secondary Education, 2008).

Similar methods for establishing test validity were used by California, Texas, and Massachusetts. Development of the instrument involved input from a variety of educational experts including current and former teachers, resource specialists, administrators, curricular experts, and test developers. This wide variety of experienced educators ensures alignment of the questions with state science content standards and decreases the chances of gender, racial/ethnic, or socioeconomic bias. Additionally, each year a small number (six in California, ten in Texas, two in Massachusetts) of questions are field tested as part of the regular test. Student performance on these field test items provides evidence of validity of individual questions. In California, the first year the CST was administered, scores were correlated with scores from the previous testing instrument (CAT/6) for grades nine, ten and eleven. A positive correlation exists between the two sets of scores, and shows that as scores increase on one instrument they likewise increase on the other instrument (Educational Testing Service, 2009). In Texas, another source of validity evidence is comparing student TAKS scores with pass/fail grades in science courses. A positive correlation exists between these two data sets (Texas Education Agency, 2008). In Massachusetts, during the first years of test administration, scores were correlated with several other large-scale assessments including the NAEP and the

SAT I test. A positive correlation exists for every comparison set (Massachusetts Department of Elementary and Secondary Education, 2008).

Test questions for CST are developed based on science content standards for grades 4 and 5. Test questions for TAKS are developed based on science content standards for grades 2-5. Test questions for MCAS are developed based on science content standards for grades K-5. The general content areas for the three tests are similar: Life science, physical science, earth science, and (Texas) nature of science or (California) investigation and experimentation or (Massachusetts) technology/engineering. The specific science standards tested for each state are:

California Science Standards (Grades 4 and 5) Addressed on Grade 5 CST

Life Sciences

- Plants and animals have structures for respiration, digestion, waste disposal, and transport of materials.
- All organisms need energy and matter to live and grow.

Physical Sciences

- Elements and their combinations account for all the varied types of matter in the world.
- Electricity and magnetism are related effects that have many useful applications in everyday life.

Earth Sciences

- Water on Earth moves between the oceans and land through the processes of evaporation and condensation.
- Energy from the Sun heats Earth unevenly, causing air movements that result in changing weather patterns.
- The solar system consists of planets and other bodies that orbit the Sun in predictable paths.
- The properties of rocks and minerals reflect the processes that formed them.
- Waves, wind, water, and ice shape and reshape Earth's land surface.

Investigation and Experimentation

- Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. (California Department of Education, 2000)

TEKS Science Standards (Grades 2-5) Addressed on Grade 5 TAKS

Life Sciences (Science concepts)

- The student knows that living organisms have basic needs.

- The student knows that living organisms need food, water, light, air, a way to dispose of waste, and an environment in which to live.
- The student knows that change can create recognizable patterns.
- The student knows that a system is a collection of cycles, structures, and processes that interact.
- The student knows that some change occurs in cycles.
- The student knows that adaptations may increase the survival of members of a species.
- The student knows that likenesses between offspring and parents can be inherited or learned.

Physical Sciences (Science concepts)

- The student knows that forces cause change.
- The student knows that change can create recognizable patterns.
- The student knows that a system is a collection of cycles, structures, and processes that interact.
- The student knows that matter has physical properties.
- The student knows that energy occurs in many forms.

Earth Sciences (Science concepts)

- The student knows that forces cause change.
- The student knows that change can create recognizable patterns.

- The student knows that a system is a collection of cycles, structures, and processes that interact.
- The student knows that some change occurs in cycles.
- The student knows that certain past events affect present and future events.
- The student knows that the natural world includes earth materials and objects in the sky.

Nature of Science (Scientific processes)

- The student conducts field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices.
- The student uses scientific inquiry methods during field and laboratory investigations.
- The student uses critical thinking and scientific problem solving to make informed decisions.
- The student knows how to use a variety of tools and methods to conduct science inquiry. (Texas Education Agency, 2009)

Massachusetts Science Standards (Grades preK-5) Addressed on Grade 5 MCAS

Life Sciences

- Recognize that animals (including humans) and plants are living things that grow, reproduce, and need food, air, and water.

- Differentiate between living and nonliving things. Group both living and nonliving things according to the characteristics that they share.
- Recognize that plants and animals have life cycles, and that life cycles vary for different living things.
- Describe ways in which many plants and animals closely resemble their parents in observed appearance.
- Recognize that fossils provide us with information about living things that inhabited the earth years ago.
- Recognize that people and other animals interact with the environment through their senses of sight, hearing, touch, smell, and taste.
- Recognize changes in appearance that animals and plants go through as the seasons change.
- Identify the ways in which an organism's habitat provides for its basic needs (plants require air, water, nutrients, and light; animals require food, water, air, and shelter).
- Classify plants and animals according to the physical characteristics that they share.
- Identify the structures in plants (leaves, roots, flowers, stem, bark, wood) that are responsible for food production, support, water transport, reproduction, growth, and protection.
- Recognize that plants and animals go through predictable life cycles that include birth, growth, development, reproduction, and death.

- Describe the major stages that characterize the life cycle of the frog and butterfly as they go through metamorphosis.
- Differentiate between observed characteristics of plants and animals that are fully inherited (e.g., color of flower, shape of leaves, color of eyes, number of appendages) and characteristics that are affected by the climate or environment (e.g., browning of leaves due to too much sun, language spoken).
- Give examples of how inherited characteristics may change over time as adaptations to changes in the environment that enable organisms to survive, e.g., shape of beak or feet, placement of eyes on head, length of neck, shape of teeth, color.
- Give examples of how changes in the environment (drought, cold) have caused some plants and animals to die or move to new locations (migration).
- Describe how organisms meet some of their needs in an environment by using behaviors (patterns of activities) in response to information (stimuli) received from the environment. Recognize that some animal behaviors are instinctive (e.g., turtles burying their eggs), and others are learned (e.g., humans building fires for warmth, chimpanzees learning how to use tools).
- Recognize plant behaviors, such as the way seedlings' stems grow toward light and their roots grow downward in response to gravity. Recognize that many plants and animals can survive harsh environments because of

seasonal behaviors, e.g., in winter, some trees shed leaves, some animals hibernate, and other animals migrate.

- Give examples of how organisms can cause changes in their environment to ensure survival. Explain how some of these changes may affect the ecosystem.

Physical Sciences

- Sort objects by observable properties such as size, shape, color, weight, and texture.
- Identify objects and materials as solid, liquid, or gas. Recognize that solids have a definite shape and that liquids and gases take the shape of their container.
- Describe the various ways that objects can move, such as in a straight line, zigzag, back-and-forth, round-and-round, fast, and slow.
- Demonstrate that the way to change the motion of an object is to apply a force (give it a push or a pull). The greater the force, the greater the change in the motion of the object.
- Recognize that under some conditions, objects can be balanced.
- Differentiate between properties of objects (e.g., size, shape, weight) and properties of materials (e.g., color, texture, hardness).
- Compare and contrast solids, liquids, and gases based on the basic properties of each of these states of matter.

- Describe how water can be changed from one state to another by adding or taking away heat.
- Identify the basic forms of energy (light, sound, heat, electrical, and magnetic). Recognize that energy is the ability to cause motion or create change.
- Give examples of how energy can be transferred from one form to another.
- Recognize that electricity in circuits requires a complete loop through which an electrical current can pass, and that electricity can produce light, heat, and sound.
- Identify and classify objects and materials that conduct electricity and objects and materials that are insulators of electricity.
- Explain how electromagnets can be made, and give examples of how they can be used.
- Recognize that magnets have poles that repel and attract each other.
- Identify and classify objects and materials that a magnet will attract and objects and materials that a magnet will not attract.
- Recognize that sound is produced by vibrating objects and requires a medium through which to travel. Relate the rate of vibration to the pitch of the sound.
- Recognize that light travels in a straight line until it strikes an object or travels from one medium to another, and that light can be reflected, refracted, and absorbed.

Earth and Space Sciences

- Recognize that water, rocks, soil, and living organisms are found on the earth's surface.
- Understand that air is a mixture of gases that is all around us and that wind is moving air.
- Describe the weather changes from day to day and over the seasons.
- Recognize that the sun supplies heat and light to the earth and is necessary for life.
- Identify some events around us that have repeating patterns, including the seasons of the year, day and night.
- Give a simple explanation of what a mineral is and some examples, e.g., quartz, mica.
- Identify the physical properties of minerals (hardness, color, luster, cleavage, and streak), and explain how minerals can be tested for these different physical properties.
- Identify the three categories of rocks (metamorphic, igneous, and sedimentary) based on how they are formed, and explain the natural and physical processes that create these rocks.
- Explain and give examples of the ways in which soil is formed (the weathering of rock by water and wind and from the decomposition of plant and animal remains).

- Recognize and discuss the different properties of soil, including color, texture (size of particles), the ability to retain water, and the ability to support the growth of plants.
- Explain how air temperature, moisture, wind speed and direction, and precipitation make up the weather in a particular place and time.
- Distinguish among the various forms of precipitation (rain, snow, sleet, and hail), making connections to the weather in a particular place and time.
- Describe how global patterns such as the jet stream and water currents influence local weather in measurable terms such as temperature, wind direction and speed, and precipitation."
- Differentiate between weather and climate.
- Describe how water on earth cycles in different forms and in different locations, including underground and in the atmosphere."
- Give examples of how the cycling of water, both in and out of the atmosphere, has an effect on climate.
- Give examples of how the surface of the earth changes due to slow processes such as erosion and weathering, and rapid processes such as landslides, volcanic eruptions, and earthquakes.
- Recognize that the earth is part of a system called the 'solar system' that includes the sun (a star), planets, and many moons. The earth is the third planet from the sun in our solar system.

- Recognize that the earth revolves around (orbits) the sun in a year's time and that the earth rotates on its axis once approximately every 24 hours. Make connections between the rotation of the earth and day/night, and the apparent movement of the sun, moon, and stars across the sky.
- Describe the changes that occur in the observable shape of the moon over the course of a month.

Technology/Engineering

- Identify and describe characteristics of natural materials (e.g., wood, cotton, fur, wool) and human-made materials (e.g., plastic, Styrofoam).
- Identify and explain some possible uses for natural materials (e.g., wood, cotton, fur, wool) and human-made materials (e.g., plastic, Styrofoam).
- Identify and describe the safe and proper use of tools and materials (e.g., glue, scissors, tape, ruler, paper, toothpicks, straws, spools) to construct simple structures.
- Identify tools and simple machines used for a specific purpose, e.g., ramp, wheel, pulley, lever.
- Describe how human beings use parts of the body as tools (e.g., teeth for cutting, hands for grasping and catching), and compare their use with the ways in which animals use those parts of their bodies.
- Identify materials used to accomplish a design task based on a specific property, e.g., strength, hardness, and flexibility.

- Describe different ways in which a problem can be represented, e.g., sketches, diagrams, graphic organizers, and lists.
- Identify relevant design features (e.g., size, shape, weight) for building a prototype of a solution to a given problem.
- Compare natural systems with mechanical systems that are designed to serve similar purposes, e.g., a bird's wings as compared to an airplane's wings. (Massachusetts Department of Elementary and Secondary Education, 2006)

Data Collection Process

Individual student test scores for each CA and TX class were provided to the researcher by the principal of each school. Data were only provided for regular education students. Personal information that would identify a student was removed from the records prior to provision to the researcher. Data were provided to the researcher in spreadsheet form for each CA and TX school for the school years 2005-2009. For school C2, student scores were segregated according to teacher for 2005, 2006, and 2007 because one teacher at school C2 used NASA materials and the other teacher did not. Differentiated classes at school C2 are referred to as C2R (control) and C2N (treatment). For 2005-2007, comparisons are made between C2R and C2N to assess the difference in classes at school C2. Comparison is also made between the entire control group (C1 and C2R grouped together) and the treatment group, C2N. For 2008-2009, no differentiation of classes was made at school C2 and all scores were considered part of the treatment group. Permission to use these data for research purposes was secured in writing from the superintendent of each of the participating school districts.

Individual student test scores for the MA treatment school were made available to the researcher. Because of reorganization within the school district, however, individual student test scores for the control school were not made available to the researcher. The researcher chose to examine publicly available student test data for trends. These data consist of average scaled scores for all fifth grade students at each school in three subject areas: mathematics, English/language arts, and science and technology/engineering.

Data Analysis

Data, individual student science test scores for CA and TX, were analyzed using the *t* test for the significance of the difference between the means for two independent samples. PASW software was used to analyze state standardized science test scores for treatment and control schools. Data from the three states were analyzed separately and are not compared. Exploratory statistics were performed to verify normal distribution of data. In cases of non-normal distribution, outliers were examined and removed as appropriate so that normality was achieved. Levene's test was used to determine equality of variance. Trend lines for whole-school performance in mathematics, science, and English/language arts were examined. In California, trends in Academic Performance Index (API), a whole-school weighted score that incorporates all three subject areas, were compared between schools. In Texas, scaled score averages or passing rates for each subject tested were compared between schools. In Massachusetts, trends in Composite Performance Index (CPI) for each subject area were compared between schools using best-fit trend lines.

CHAPTER IV

FINDINGS

Introduction

The purpose of this study is to answer the question: Does a difference in student knowledge of science content exist between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials? The independent variable is the type of instructional materials used. The dependent variable is science content knowledge as measured by state standardized tests in science. An independent samples t-test was used to test the hypothesis. The study was conducted using test scores of fifth grade students in California, Texas, and Massachusetts.

Description of the Sample

The students in the control group classrooms were taught using state-adopted, district-approved science materials only. No NASA materials were used with students in the control group classrooms.

The students in the treatment group classrooms were taught using state-adopted, district-approved science materials and NASA materials. The extent of usage of NASA materials varied by school. At the California school, NASA materials were primarily utilized at the fifth grade level. Although California science standards exist for every grade level, only standards for grades four and five are assessed on the state standardized test so it is at those grade levels that the majority of science curriculum is taught. At the Texas school, NASA materials were utilized at every grade level, K-5. Standards from all grades, K-5, are assessed by the Texas state standardized test. At the Massachusetts school, NASA materials were utilized intermittently at a variety of grade levels, K-5, and most consistently at grade 5. Standards from all grades, K-5, are assessed by the Massachusetts state standardized test.

Each school that used NASA materials used lessons appropriate for local needs. Educators at NASA Explorer Schools (NES) work with NASA educators to locate materials that fit their identified areas of need. NASA educators provide training on using these materials in the classroom. During training, NASA educators emphasize the use of scientific inquiry in teaching. Educators sometimes use materials as written or presented and sometimes adapt materials to best suit the needs of their students.

Data Analysis

Summary statistics for each California comparison group are shown in Table 4. For 2005-2007, the hypothesis was tested for two sets of comparison groups. For the first comparison, the control group, C2R, consists of test scores from students enrolled in classrooms at school C2 that did not utilize NASA materials. The treatment group, C2N, consists of test scores from students enrolled in classrooms at school C2 that utilized NASA materials. In the second comparison for 2005-2007, the control group, (C1+C2R), consists of test scores from students enrolled at the control school, C1, and students enrolled in the C2R classrooms at C2. The treatment group, C2N, is the same as in the previous comparison. For 2008-2009, the control group is C1 and the treatment group is C2.

Table 4

Summary Statistics for California Schools

Year	School	N	Mean	Std. Deviation	Std. Error Mean
2005	C1+C2R	68	342.47	40.732	4.939
	C2R	16	333.06	30.063	7.516
	C2N	22	341.23	37.752	8.049
2006	C1+C2R	68	346.07	48.144	5.838
	C2R	17	319.88	26.427	6.409
	C2N	21	324.29	22.310	4.868
2007	C1+C2R	77	362.21	40.250	4.587
	C2R	19	342.37	38.862	8.916
	C2N	20	352.65	66.040	14.767
2008	C1	57	372.28	67.450	8.934
	C2	56	353.27	57.879	7.734
2009	C1	49	386.06	68.880	9.840
	C2	52	364.13	56.901	7.891

As shown in Table 5, within the California treatment school, C2, no significant difference exists at the 95% confidence level between mean science scores of students who received instruction with NASA educational materials (C2N) and those who received traditional classroom instruction (C2R). Teachers and the principal perceived that students using NASA materials were scoring higher than their control counterparts because a mean difference each year indicated this trend. When rigorously analyzed, however, these mean differences are not statistically significant.

As shown in Table 6, comparing the larger California control group for 2005-2007, (C1+C2R), and the treatment group, C2N, likewise yields no significant difference in mean scores at the 95% confidence level except in 2006 when the control group outscored the treatment group by a mean difference of 21.8 points. Also shown in Table 7 is the comparison between C1 and C2 for 2007-2008 which yields no significant difference in mean scores. These results astonished the principal of the treatment school as overall state testing data from the treatment school trends higher than the control school.

Table 5

Mean Comparisons within California School C2 (C2R v. C2N)

YEAR	Levene's Test for Equality of Variances		*t* test for Equality of Means						
	F	Sig.	*t*	df	Sig.	Mean Diff.	Std. Error Diff.	Lower	Upper
2005	0.948	0.337	-0.715	36	0.479	-8.165	11.420	-31.325	14.995
2006	0.655	0.424	-0.557	36	0.581	-4.403	7.904	-20.433	11.626
2007	9.479	0.004	-0.596	31.025	0.555	-10.282	17.250	-45.461	24.898

Note. $p \leq 0.05$

Table 6

Mean Comparisons between California Groups

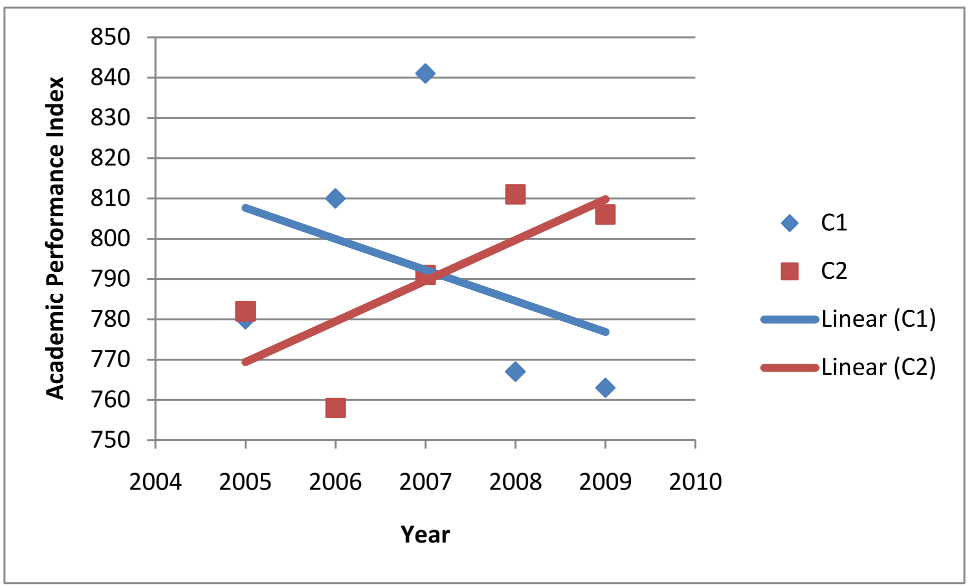
YEAR	Levene's Test for Equality of Variances		*t* test for Equality of Means						
	F	Sig.	*t*	df	Sig.	Mean Diff.	Std. Error Diff.	Lower	Upper
2005	0.077	0.782	0.127	88	0.900	1.243	9.821	-18.274	20.761
2006	10.127	0.002	2.866	73.509	0.005	21.788	7.602	6.639	36.936
2007	15.408	0.000	0.618	22.79	0.543	9.558	15.463	-22.446	41.562
2008	0.436	0.511	1.607	111	0.111	19.013	11.833	-4.435	42.460
2009	0.420	0.519	1.748	99	0.084	21.927	12.542	-2.959	46.812

Note. For 2005-2007, comparison groups are (C1+C2R) v. C2N. For 2008-2009, comparison groups are C1 v. C2. $p \leq 0.05$

The academic performance index (API) summarizes the performance of a school on the California Standards Tests (CSTs). The API of a school incorporates all subjects tested at all grade levels. API scores for schools C1 and C2 for 2005-2009 are shown in Figure 1. Whereas the highest API was achieved by C1 in 2007, a decreasing API trend occurs at C1. The API trend for C2, however, indicates an increase over the years.

Figure 1

California Academic Performance Indices with Trend Lines

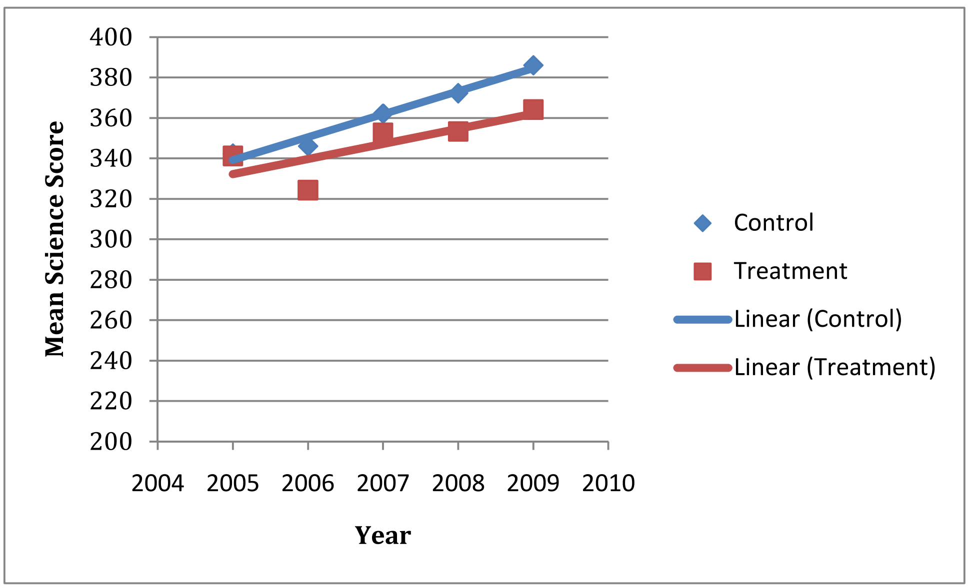


(California Department of Education, 2010)

Shown in Figure 2 are the mean science scores of students in the treatment group (C2N for 2004-2007, C2 for 2008-2009) compared to the mean science scores of students in the combined control groups (C1 + C2R for 2004-2007, C1 for 2008-2009). The CST science test is administered to students in grade 5. The trends for the control and treatment groups are similarly increasing, with the scores of the control group increasing at a slightly greater rate than the scores of the treatment group.

Figure 2

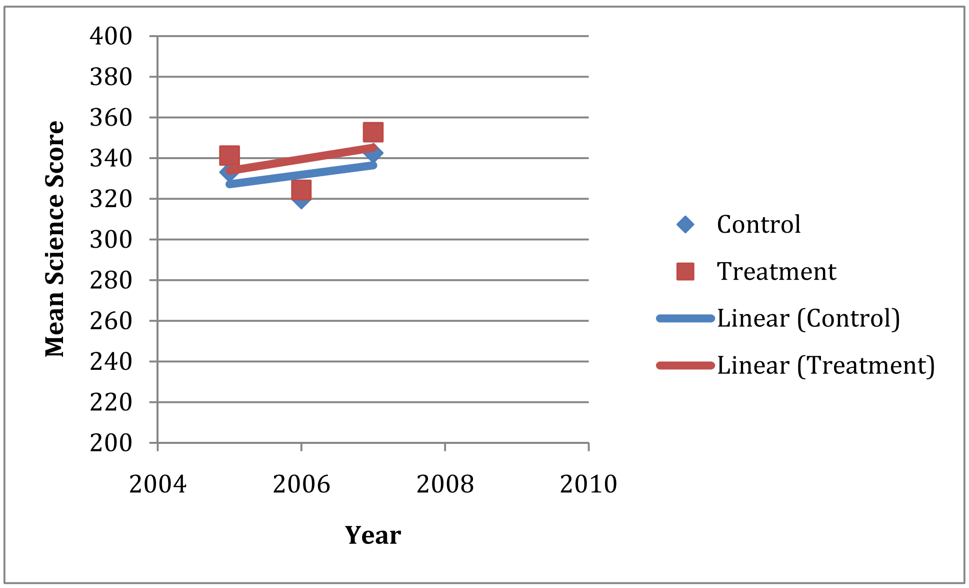
California Mean Science Scores with Trend Lines (combined control groups)



Shown in Figure 3 are the mean science scores of students within school C2 for the comparison years 2004-2007. The mean science scores of students in the treatment group (C2N) are compared to the mean science scores of students in the control group (C2R). The trends for the control and treatment groups are similarly increasing with slightly higher scores for the treatment group.

Figure 3

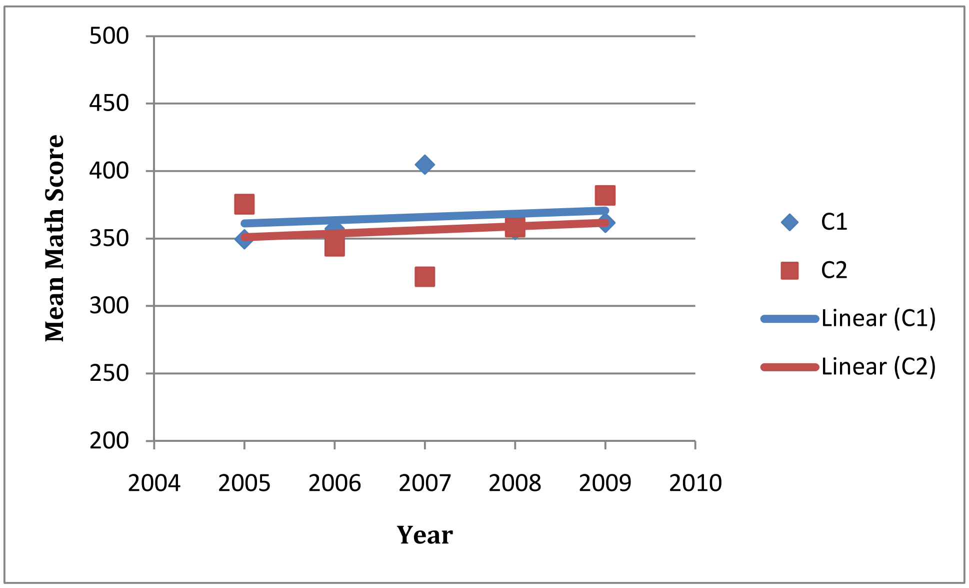
California Mean Science Scores with Trend Lines (within C2)



Shown in Figure 4 are the mean mathematics scores of fifth grade students at the treatment school, C2, and the control school, C1. The trends for the control and treatment groups are similarly increasing.

Figure 4

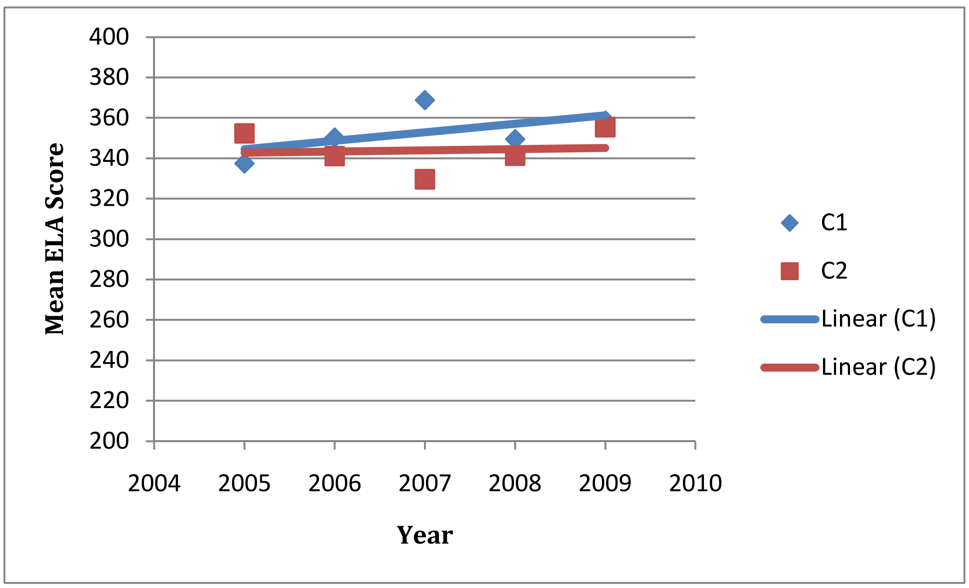
California Mean Mathematics Scores with Trend Lines



Shown in Figure 5 are the mean English/language arts scores of fifth grade students at the treatment school, C2, and the control school, C1. The trends show steady performance at the treatment school and an increase in scores at the control school.

Figure 5

California Mean English/Language Arts (ELA) Scores with Trend Lines



Summary statistics for the Texas control school, T1, and the Texas treatment school, T2, are shown in Table 7. Students at school T1 received traditional classroom instruction and students at school T2 received instruction utilizing NASA materials.

Table 7

Summary Statistics for Texas Schools

Year	School	N	Mean	Std. Deviation	Std. Error Mean
2005	T1	40	2141.83	190.600	30.789
	T2	28	2129.39	213.484	40.345
2006	T1	50	2156.30	230.769	32.636
	T2	29	2204.03	227.965	42.332
2007	T1	34	2210.12	245.389	42.084
	T2	41	2219.05	254.295	39.714
2008	T1	71	2156.20	189.924	22.540
	T2	49	2172.20	219.257	31.322
2009	T1	68	2170.50	194.358	23.569
	T2	46	2311.07	227.482	33.540

As shown in Table 8, comparing the Texas treatment and control schools yields a significant difference in means at the 95% confidence level only in 2009. In 2009, the treatment school fifth grade science scores exceeded those of the control school by 140.6 points. In other years, no significant difference occurs in means between the populations.

Table 8

Mean Comparisons between Texas Schools (T1 v. T2)

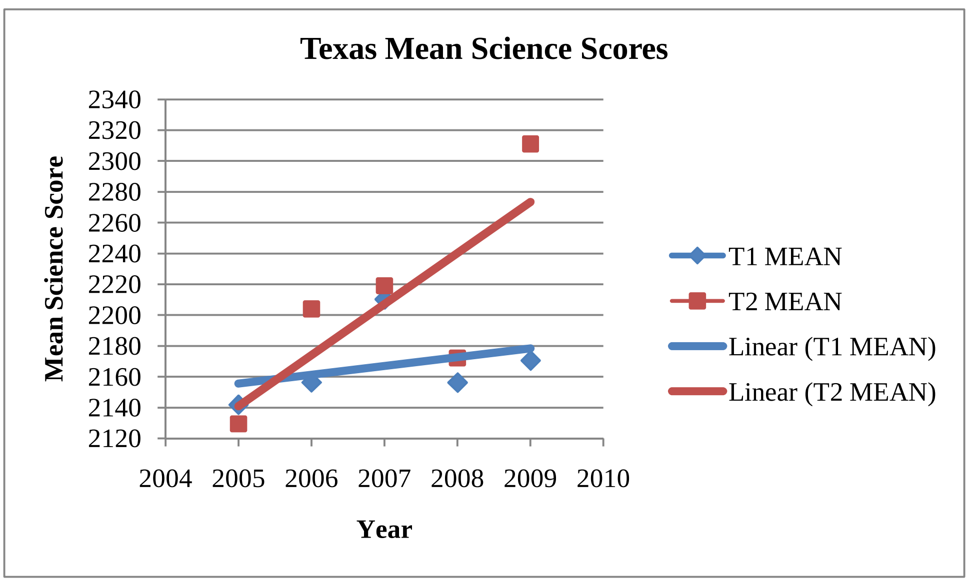
YEAR	Levene's Test for Equality of Variances		*t* test for Equality of Means						
	F	Sig.	*t*	df	Sig.	Mean Diff.	Std. Error Diff.	Lower	Upper
2005	0.211	0.648	0.249	66	0.804	12.432	49.906	-87.208	112.073
2006	0.264	0.609	-0.692	73	0.491	-30.734	44.432	-119.287	57.820
2007	0.040	0.843	-0.154	73	0.878	-8.931	58.060	-124.644	106.781
2008	0.888	0.348	-0.426	118	0.671	-16.007	37.585	-90.435	58.421
2009	1.338	0.250	-3.535	112	0.001	-140.565	39.766	-219.356	-61.774

Note: $p \leq 0.05$

Just as with the California schools, the Texas teachers and principal perceived that their scores were higher than those of the control school because of a difference in means in 2006-2009 indicating this trend. When rigorously analyzed, however, these differences in means are not statistically significant except in 2009 when scores for T2 were significantly higher than scores for T1. Figure 6 shows mean science scores for schools T1 and T2 for 2005-2009. Trend lines show an increase in science scores for T1 and T2, with a greater increase over time at T2.

Figure 6

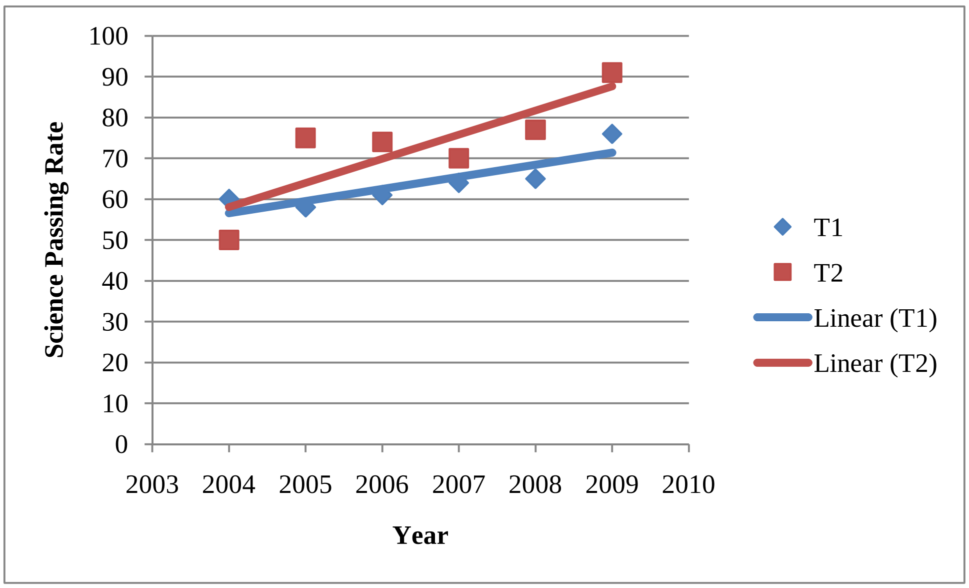
Texas Mean Science Scores with Trend Lines



Shown in Figure 7 are the percentages of students who passed the TAKS science test according to state passing guidelines. The trends in the passing rates for both schools are increasing, with a slightly steeper increase at T2.

Figure 7

Texas Science Passing Rates with Trend Lines (Grade 5)

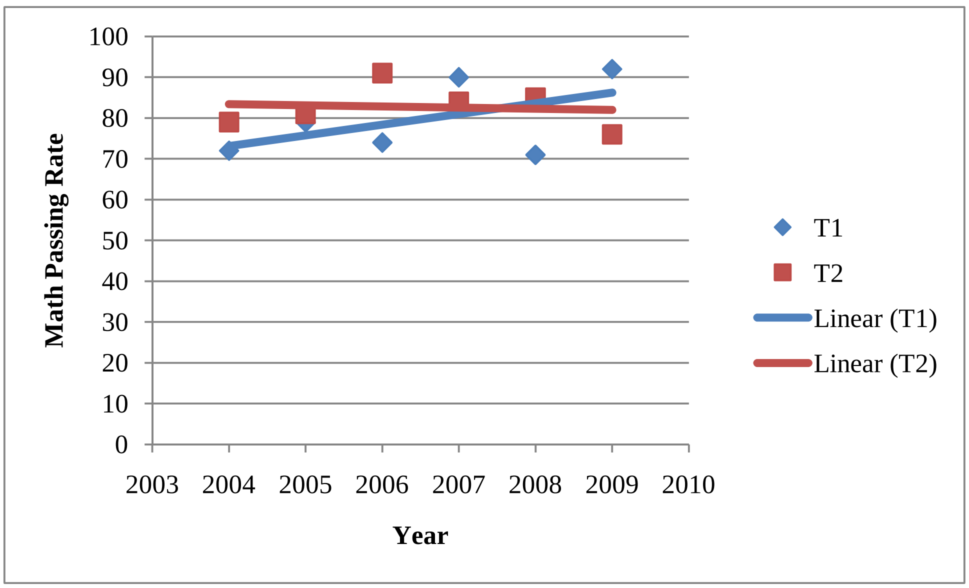


(Texas Education Agency, 2010)

Shown in Figure 8 are the percentages of students who passed the TAKS math test according to state passing guidelines. The TAKS math test is administered to all students in grades 3-5. The passing rate trend for T1 is increasing, whereas the passing rate trend for T2 is remaining somewhat steady.

Figure 8

Texas Math Passing Rates with Trend Lines (Grades 3-5)

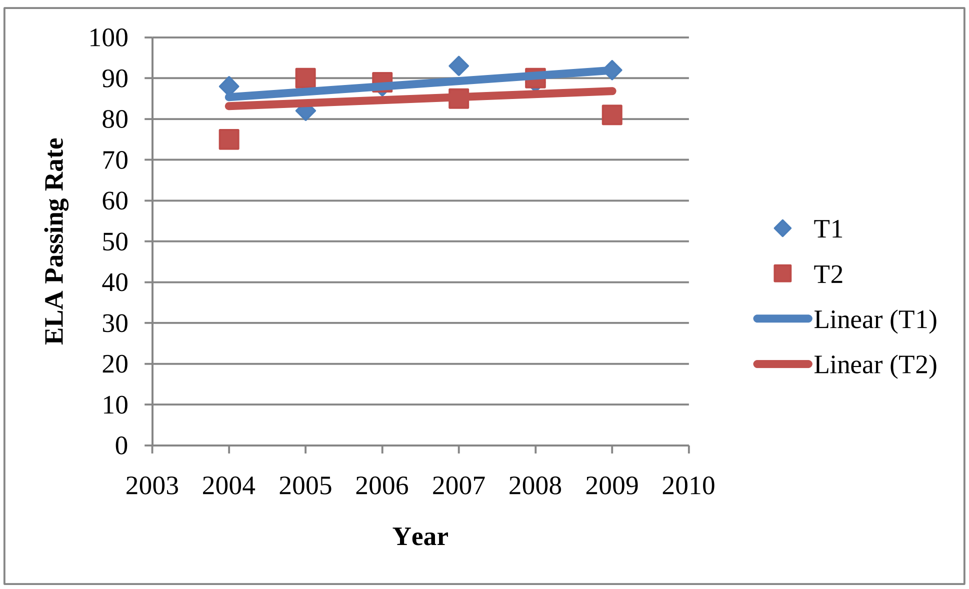


(Texas Education Agency, 2010)

Shown in Figure 9 are the percentages of students who passed the TAKS English/Language Arts test according to state passing guidelines. The TAKS reading test is administered to all students in grades 3-5. The trends in the passing rates for both schools are increasing similarly.

Figure 9

Texas English/Language Arts (ELA) Passing Rates with Trend Lines (Grades 3-5)

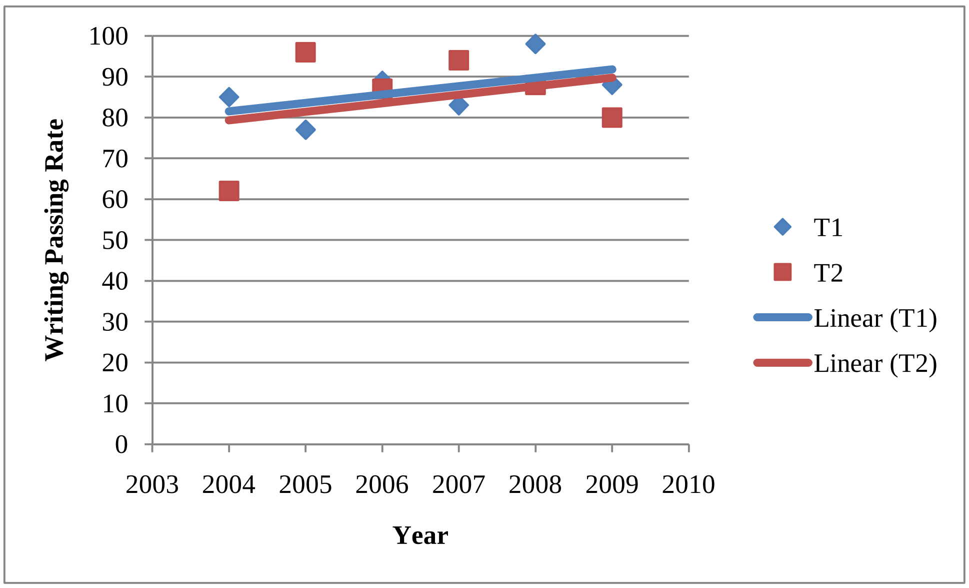


(Texas Education Agency, 2010)

Shown in Figure 10 are the percentages of students who passed the TAKS writing test according to state passing guidelines. The TAKS math test is administered to all students in grade 4. The trends in the passing rates for both schools are nearly identical.

Figure 10

Texas Writing Passing Rates with Trend Lines (Grade 4)



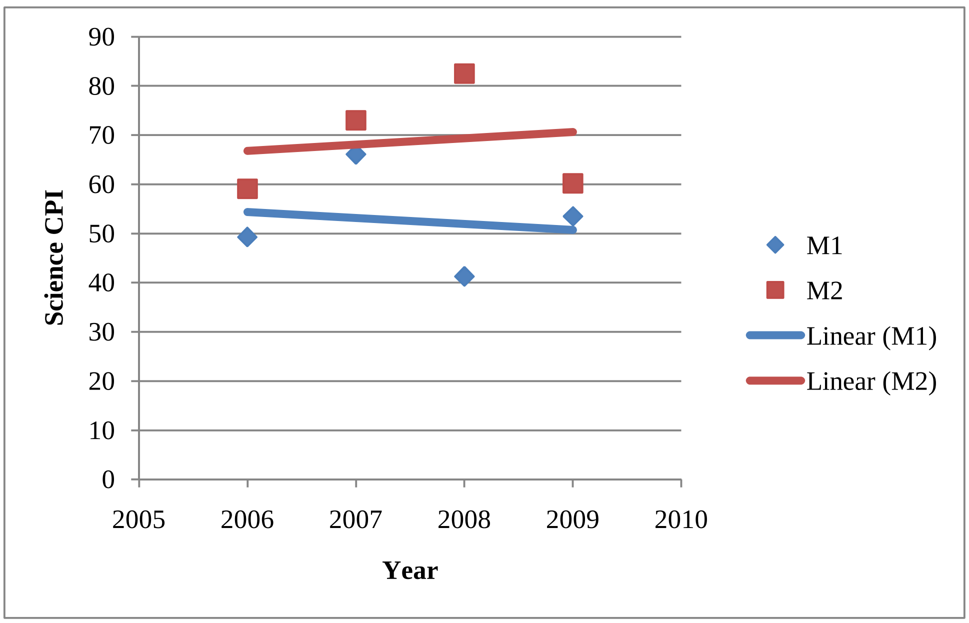
(Texas Education Agency, 2010)

Composite Performance Indices (CPIs) in science, math, and English/langauge arts (ELA) were used in lieu of individual student test data for the Massachusetts school comparisons. In Massachusetts, science is tested at grade 5, math at grades 3-5, and ELA at grades 1-5. A school receives a CPI in each subject area based on whole-school performance on the MCAS test for that subject area, but a CPI is also assigned to each individual grade level in each subject tested. For this study, grade 5 CPIs in science, math, and ELA were examined.

Shown in Figure 11 are the grade 5 science CPIs with trend lines. The trend in the passing rate for M1 is decreasing slightly, whereas the trend in the passing rate for M2 is increasing slightly.

Figure 11

Massachusetts Grade 5 Science Composite Performance Indices with Trend Lines

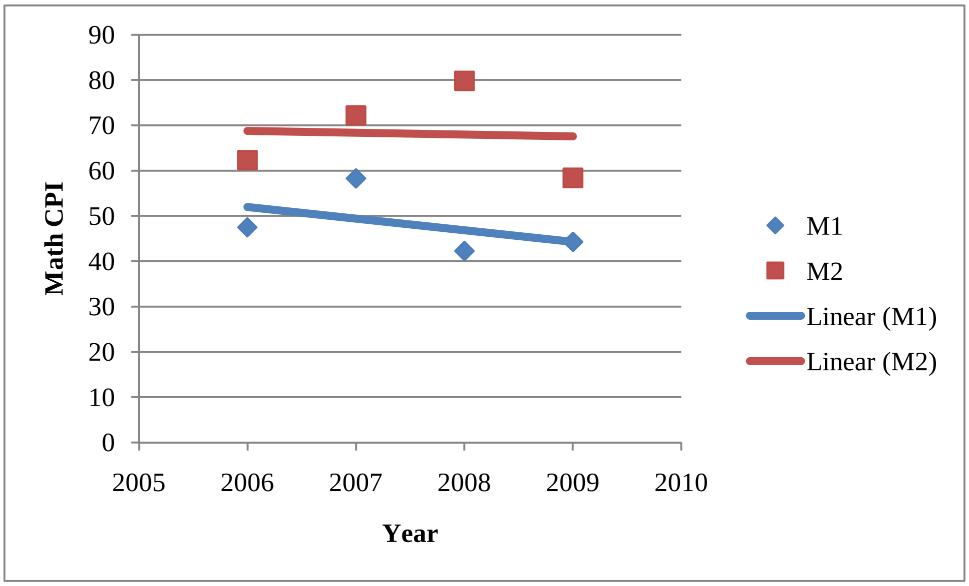


(Massachusetts Department of Elementary and Secondary Education, 2010b)

Shown in Figure 12 are the grade 5 math CPI with trend lines. The trend in the passing rate for M1 is decreasing slightly, whereas the trend in the passing rate for M2 is also decreasing, but at a slightly lower rate.

Figure 12

Massachusetts Grade 5 Math Composite Performance Indices with Trend Lines

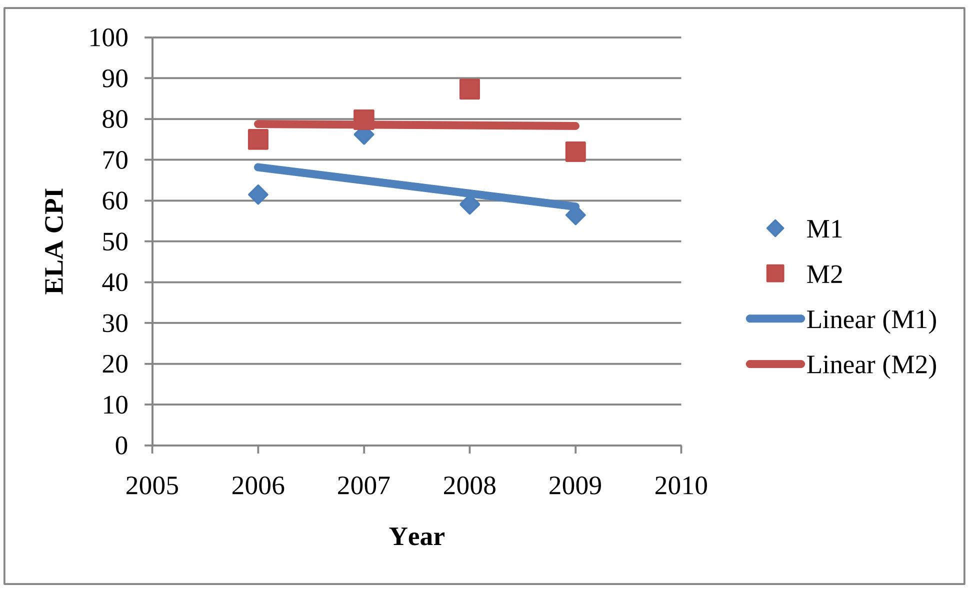


(Massachusetts Department of Elementary and Secondary Education, 2010b)

Shown in Figure 13 are the grade 5 English/language arts CPI with trend lines. The trend in the passing rate for M1 is decreasing, whereas the trend in the passing rate trend for M2 is remaining mostly steady.

Figure 13

Massachusetts Grade 5 English/Language Arts Composite Performance Indices with Trend Lines



(Massachusetts Department of Elementary and Secondary Education, 2010b)

Summary

The purpose of this study was to answer the question: Does a difference in student knowledge of science content exist between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials? The independent variable was the type of instructional materials used. The dependent variable was science content knowledge as measured by state standardized tests in science. Pairs of schools in three states were studied: California, Texas, and Massachusetts. Data for California and Texas were rigorously analyzed using an independent samples t-test. Trend lines were examined for all three states.

In only two of the thirteen rigorous comparisons could the null hypothesis be rejected: one in California which indicated that the control school scored higher in science than the treatment school; and one in Texas which indicated that the treatment school scored higher in science than the control school. Because the two cases of rejection of the hypothesis are not in agreement and in eleven of thirteen comparisons the null hypothesis could not be rejected, this study indicates that no difference in student knowledge of science content exists between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science materials. Graphs of data indicate potential trends and these will be discussed in the next chapter.

CHAPTER V

CONCLUSION

Overview

This research study assessed the question: does a difference in student knowledge of science content exist between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials? The null hypothesis is: no significant difference exists between student knowledge of science content between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test. The alternative hypothesis is: a significant difference exists between student knowledge of science content between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test.

This study used a quasi-experimental post-test-only research design featuring nonequivalent comparison groups. This study assessed the effects of utilizing NASA educational materials on science content knowledge of fifth grade students in California, Texas, and Massachusetts. Students in the treatment classrooms in this study participated in lessons involving NASA educational materials. Students in the control classrooms were not exposed to NASA educational materials in class. Data were examined from two demographically similar schools in each state. Individual student scores from state standardized science tests were compared for students in California and Texas over a period of five years. Trend lines were compared for California Academic Performance Indices (API), whole-school composite scores for all tested subjects. Trend lines were compared for passing rates of Texas fifth grade students in science, mathematics, writing and English/language arts. Trend lines were compared for students in Massachusetts over a period of four years.

Discussion

For the California schools, the null hypothesis cannot be rejected at the 95% confidence level for the comparison groups within school C2 for 2005-2007 or for the comparison between schools for 2005, 2007, 2008, and 2009. For these years, no significant difference exists in science content knowledge between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test. The null hypothesis can, however, be rejected for 2006. In 2006, students at the control school, C1, scored higher in science than students at the treatment school, C2 (Table 4). Interestingly, the trend lines for student scores (Figure 1) show a distinct pattern of increasing Academic Performance Index (API) at the treatment school and decreasing API at the control school during 2005-2009. A pattern of increase in Academic Performance Index suggests that progress is being made at the treatment school across the curriculum, though not specifically in science. A comparison of fifth grade student performance in mathematics (Figure 4) and English/language arts (Figure 5) does not seem to account for this difference in API. Because API is a whole school score we can conclude that the difference in API may be accounted for by student score differentials for grades 2-4. Because science is not tested in grades 2-4, CST scores for mathematics and English/language arts should be examined to further investigate trends at these schools. Once the subject and grade level that are creating the difference in API are known, a comparison of teaching resources for that subject should be conducted.

For the Texas schools, the null hypothesis cannot be rejected at the 95% confidence level for 2005-2008. For these years, no significant difference exists in science content knowledge between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science educational materials as measured by a state standardized science content test. The null hypothesis can be rejected for Texas for 2009. In 2009, students at the treatment school, T2, scored higher in science than students at the control school, T1. Trends indicate that, whereas students at the control school and the treatment school perform similarly in English/language arts (Figure 9), writing (Figure 10), and mathematics (Figure 8), a greater increase exists in science (Figures 6 and 7) achievement at the treatment school. This is a comparison case that should be closely monitored in the future. Because NASA materials were used in all grades, K-5, students enrolled in the Texas treatment school received greater exposure to NASA materials than students enrolled in the California or Massachusetts treatment schools. Additionally, the cumulative effects of greater exposure may potentially have more influence on student learning over the years. Analyzing data for 2010 and subsequent years will provide valuable information on the continuation of the observed trends.

For the Massachusetts schools, only trend lines were examined. Overall, student performance at the treatment school remains relatively stable, whereas student performance at the control school is decreasing. Science composite performance indices (Figure 11) show a slight increasing trend for the treatment school and a slight decreasing trend for the control school. Math composite performance indices (Figure 12) show a slight decreasing trend for the treatment school and a more substantial decreasing trend for the control school. English/language arts composite performance indices (Figure 13) show a relatively stable trend for the treatment school and a decreasing trend for the control school. Further research is warranted for schools in Massachusetts to determine if the overall decreasing performance trend is unique to the selected control school or if it is a statewide trend for similar schools. Fifth grade test scores at the treatment school are higher in every subject for every year. This consistent difference seems to indicate that an achievement gap occurs between the two schools. Factors influencing this potential achievement gap should be investigated.

Conclusions

For most years, no significant difference exists in student knowledge of science content when NASA educational materials are used. The strongest trends indicating a difference in student knowledge of science content occurred in Texas. Similarities in passing rates in all subjects except science seem to indicate that something differs in science instruction between the two Texas schools. Interestingly, the Texas treatment school had the most thorough integration of NASA educational materials throughout grades K-5. The Texas treatment school also began using NASA educational materials in 2001, earlier than the treatment schools in the other states. Given this additional time, teachers had more experience with the materials and were able to incorporate lessons at all grade levels. Full-school implementation of NASA resources at the Texas treatment school took place starting in 2004. Additionally, cumulative effects on student learning may only now be appearing in test scores because 2009 fifth grade students had received instruction utilizing NASA materials for their entire five-year elementary school career. Because academic progress and implementing new teaching methods and materials take time, it seems logical that the Texas comparison would show the greatest indicators of difference in student knowledge of science content.

The California treatment school started utilizing NASA educational materials in one fifth grade classroom during the 2004-2005 school year. Throughout the years of this study, NASA materials were used occasionally at other grade levels at the treatment school and more consistently at grade 5. The inconsistent of use of NASA materials throughout the K-5 grades at the treatment school may be a contributor to the inconclusive results of this study. Additionally, California schools were pressured to increase mathematics and English/language arts performance over all other subjects. Mathematics and English/language arts scores more profoundly impact the API of a school with mathematics contributing 38%, English/language arts contributing 56%, and science contributing 6% of the total API ("API composition in 2008/2009 API cycle," 2009). This lower weighting of science and, thus, lower pressure to perform well on standardized science tests may impact the focus of teachers in the various curricular areas.

The Massachusetts treatment school started utilizing NASA educational materials in all fifth grade classes during the 2005-2006 school year. Throughout the years, NASA materials were increasingly used at grade 5, but were only occasionally used in lower grades. The inconsistent of use of NASA materials throughout the K-5 grades at the treatment school may be a contributor to the inconclusive results of this study. The overall achievement gap that exists between the two Massachusetts schools has slightly widened during the years this study was conducted. Scores at the treatment school remained relatively stable while scores at the control school decreased. The scores for 2009 were out of trend for the treatment school and leveled the previously increasing trend lines. Data for future years should be examined to gain better perspective on the trends at both schools. Also, data should be examined from other demographically similar schools in Massachusetts to determine if the achievement gap exists elsewhere.

Because most comparison groups show no significant difference in student knowledge of science content when NASA educational materials are used, the hypothesis of this study cannot be rejected. Generally, no difference occurs in student knowledge of science content when NASA educational materials are used.

Limitations

One limitation of this research is that no direct observations of teacher implementation of lessons were made. It is not known whether lessons were implemented using inquiry methods that were modeled in professional development or if more procedural based methods were used. According to the research of Dalton et al. (1997), this can affect the amount of learning that takes place. Also, follow-up with teachers after professional development training was inconsistent and the amount of reflection they were able to do about the lessons was not documented.

Another limitation of this research is that the extent of implementation varied among school sites and different resources were used. Although important to the NASA Explorer Schools model, this individualized selection and implementation of resources added uncontrollable variability to this study.

Another factor that had a potential impact on the results of this study is the amount of instructional time experienced by students. Though dictated by state requirements, instructional time can vary because of student attendance. Student attendance information was not available and instructional time is an important factor in student achievement (Reynolds & Walberg, 1992; Singh, et al., 2002).

Numerous external factors such as student home environment could not be controlled and may be significant sources of error in this study. Research has shown that home influences can profoundly impact student attitudes and achievement in science. Exposure to science content through reading, television programs, visits to science museums, and exploration of the natural world can affect student attitude and achievement in science.

Additionally, science test scores were analyzed for fifth grade students only. Demographics were reported for the whole school. Though care was taken to select demographically similar schools within each state, the possibility exists that demographics varied among grade levels and the comparison classes were not good demographic matches. Because student demographics are directly related to student achievement, this is a possible source of error in this study.

Recommendations

Future studies should include the examination of other resources and methods teachers are using to increase student achievement in science. Because student interest can be a factor in student achievement, any science teaching methods or materials that pique student interest could be equally effective in increasing student knowledge of science content. A number of non-NASA high-interest science teaching resources are available and should be examined for efficacy compared to NASA materials.

Future studies should include a control for the extent of integration of NASA educational materials. Though teachers and administrators at each treatment school were exposed to much of the same NASA content, they chose different materials to integrate into their classrooms. Whereas this individualized approach is good for the teacher and students, it tends to complicate impact measurement. The extent of use of NASA materials throughout the supporting grade levels, K-4, should be factored into future studies. If the entire school, K-5, consistently implements NASA resources into classroom learning at every grade level, students receive more instruction and the results of the study are better substantiated.

The interrelationships between factors affecting student science achievement are difficult to parse and, thus, difficult to measure independently. Many of these factors are self-reported, such as attitude and home environment, yet have dynamic interactions with motivation and achievement. Interested students are more likely to engage in content acquisition outside of school, thus, additional effects come into play. Home environment influences on achievement, such as access to a computer, parent attitudes, and behavioral commitment toward school, are strong and not accounted for in this study.

Haury (2001) points out that high-stakes standardized tests focus on factual knowledge, whereas the National Science Education Standards emphasize learning through inquiry and focus on science as a way of knowing. Science is more than a body of information to be learned; it consists of content and learning processes. Current standardized tests focus more on assessing content knowledge than process development. When considering true scientific literacy, ways of thought are at least as important as content knowledge. Habits of mind are life long, whereas facts can change with increased knowledge about the natural world. The use of NASA materials possibly impacts habits of mind that are not measured by standardized tests. This is a question that should be addressed in future research.

Ways must be found to increase science achievement in disadvantaged elementary school students. Bacharach et al. (2003) showed that “secondary schooling did not reduce or compensate for the achievement differences that developed during primary school.” Achievement gaps in science between Black and White students and between males and females continued to grow during secondary school. This tells us we need to improve science education in the elementary schools, so research must continue to find the most effective ways of accomplishing this goal.

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VITA

Ota Lutz

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE EFFECTS OF UTILIZING NASA EDUCATIONAL MATERIALS ON STUDENT KNOWLEDGE OF SCIENCE CONTENT

Major Field: Environmental Science

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Environmental Science at Oklahoma State University, Stillwater, Oklahoma in May, 2011.

Completed the requirements for the Master of Arts in Teaching and Learning at Point Loma Nazarene University, San Diego, CA in 1990.

Completed the requirements for the Bachelor of Arts in Mathematics at Point Loma Nazarene University, San Diego, CA in 1989.

Experience:

October 2010 – present	Education Programs Specialist NASA Jet Propulsion Laboratory Pasadena, CA
January 2000 – October 2010	NASA Explorer Schools Coordinator Aerospace Education Specialist NASA DFRC, JSC, and JPL Oklahoma State University Stillwater, OK
July 1989 – December 1999	High School Mathematics Teacher Hesperia Unified School District Hesperia, CA

Professional Memberships:
National Science Teachers Association
National Council of Teachers of Mathematics
International Technology and Engineering Educators Association

Name: Ota Lutz Date of Degree: May, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE EFFECTS OF UTILIZING NASA EDUCATIONAL MATERIALS ON STUDENT KNOWLEDGE OF SCIENCE CONTENT

Pages in Study: 97 Candidate for the Degree of Doctor of Philosophy

Major Field: Environmental Science

Scope and Method of Study:

This study investigates the effects of utilizing NASA educational materials on student knowledge of science content. This research study uses a quasi-experimental post-test-only research design featuring nonequivalent comparison groups. The sample consists of fifth grade students in California, Texas, and Massachusetts. One control and one treatment school were compared in each state. Students at the treatment schools participated in lessons involving NASA educational materials. Students at the control schools did not participate in lessons involving NASA educational materials. Because all classes in a given state are subject to the same curriculum guidelines, all students in that state should have been exposed to the same science content during the school year. Data utilized for this study were retrieved from state standardized test databases and consist of individual student test scores and group performance indices. Individual student test scores were compared for schools in California and Texas using an independent samples *t* test. Trends in performance indices were examined for California, Texas, and Massachusetts.

Findings and Conclusions:

Analysis of data showed no significant difference in student knowledge of science content exists between students receiving instruction utilizing NASA educational materials and students receiving instruction utilizing traditional classroom science materials. Teachers may utilize NASA educational materials to teach science and accomplish the same student knowledge of content as if they had utilized traditional teaching materials.

ADVISER'S APPROVAL: Dr. Steven K. Marks