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The Influence of an Interdisciplinary Elementary Curriculum on Student Outcomes: Providing Cognitive Student Learning Through an Integrated Approach

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THE INFLUENCE OF AN INTERDISCIPLINARY ELEMENTARY CURRICULUM ON STUDENT OUTCOMES: PROVIDING COGNITIVE STUDENT LEARNING THROUGH AN INTEGRATED APPROACH

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ABSTRACT

In order to provide students at the elementary level a thorough and efficient method of learning, the integrated–interdisciplinary approach to teaching curriculum was explored to reveal the impact on student achievement of fourth graders across the state of New Jersey in a randomly selected grouping of 50 schools using integrated–interdisciplinary curriculum and 50 schools using subject-specific curriculum. The research was an investigation of the integrated–interdisciplinary approach to teaching when compared with subject-specific curriculum to explore the impact on student achievement.

Integration of curriculum aligned to the state standards at the elementary level was a focus for this research; elementary curriculum is always expanding with the increased expectations from the demands of society. Using the state's Grade 4 PARCC testing device to measure achievement over a 3-year time period revealed a significant positive difference in the outcome of student achievement for students using an integrated–interdisciplinary curriculum. These findings suggest a further consideration for using an integrated–interdisciplinary curriculum whenever possible at the elementary level for student learning. Throughout this research, the terms *integration* and *interdisciplinary* curriculum were utilized with an understanding that the terms may be interchangeable. The meaning produces the same outcome: a combination of various subject ideas taught in the same lesson to make connections across the curriculum.

Keywords: interdisciplinary curriculum, integrated curriculum, thorough and efficient education, student achievement

DEDICATION

This dissertation work is dedicated to the members of my family:

To my Dad who encouraged punctuality and lessons in humility, skills that have served me well throughout my life.

To my Mother who taught the importance of planning, organization and always sharing and caring with love and kindness, at an early age.

To my Husband for the kind and patient, loving encouragement throughout the years it continues to guide my pathway in education and leadership.

To my Daughter for the thoughtful, thorough, and efficient ways you help and guide others and your creativity in making life extra special.

To my Son for the help with technology, your insights and perspectives, and your willingness to use your design skills to always help others achieve success.

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"If we teach today as we taught yesterday,

we rob our children of tomorrow."

John Dewey, *Democracy and Education*, 1916

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CHAPTER 1

INTRODUCTION

Background of the Study

Over the years, curriculum has seen many educational changes made in the name of the standards reform movement. Fitting into this movement, "yet based historically in much earlier events, exists the concept of interdisciplinary education" (Hurley, 2001, p. 259). Having taught in schools for 32 years, my colleagues and I have had many conversations over the years about the increasing demands of the elementary curriculum. According to Furner and Kumar (2007),

> More and more educators are coming to realize that one of the fundamental problems in schools today is the "separate subject" or "layer cake" approach to knowledge and skills. The separate subject curriculum can be viewed as a jigsaw puzzle without any picture. (p. 186)

With the increase in mandated curriculum additions such as anti-bullying and other initiatives increasing demands on our educators, we are increasing the layers on the cake or providing more jigsaw pieces without giving any picture to all the students. As we hope to teach and make the meaningful connections to provide increased student achievement; sometimes the only focus in lesson planning seems to be on achieving a checklist of mandated, individualized curriculum goals by subject area.

Reviews of interdisciplinary studies have been conducted through many years by educational researchers; most of the studies are centered on an integrated curriculum for science and mathematics and almost all at the middle school, high school, and postsecondary levels (Berlin & Lee, 2005). In the 1940s, methods and forms of integration were developed for a core curriculum in which science was taught through societal themes with mathematics included; reviewers agreed that although a small gain was indicated for the "core" students, the interdisciplinary or integrated curriculum approach did show positive gains in student achievement (Baker, Travers, & Cassell, 1941; Chamberlin, Chamberlin, Drought, & Scott, 1942; Kermoade, 1972; Mickelson as cited in Hurley, 2001). In a compilation of readings on the subject there seems to be a summative conclusion: “Research indicates that using an interdisciplinary or integrated curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for learners” (Furner & Kumar, 2007, p. 186; see also Frykholm & Glasson, 2005; Koirala & Bowman, 2003; Jacobs as cited in Furner & Kumar, 2007). In a historical analysis of the integration of science and mathematics curriculum, Berlin (1991) found that from 1901 until the first half of 1991 there were 555 documents published concerning the integration of science and mathematics. From the second half of 1991 to 2001 another 402 documents were researched and identified for the same criteria as the previous review using the five categories of curriculum, instruction, research, curriculum-instruction, and curriculum evaluation (Berlin & Lee, 2003).

Although the majority of the latest studies for integrated–interdisciplinary curriculums analyze science and math effort at the secondary level, there have been some very successful integrated programs in the elementary schools over time. According to Berlin and Lee (2005), “It appears that integrated science and mathematics instructional activities were initially designed for elementary school and middle school science teachers during the years 1901-1989” (p. 15). Steen (as cited in Berlin & Lee, 2005) extended the reasoning for this combined effort for the integration of mathematics and science: “This is not unexpected, as the integration of science and mathematics education may be easier within a self-contained classroom with one teacher or within a middle school science classroom that traditionally applies or uses mathematics to develop science concepts” (p. 12). There is an opportunity for elementary classroom teachers to make connections and tie ideas together as they introduce the elementary curriculum, and the integration of mathematics, science, and even literacy would seem to be a natural fit for helping students increase their learning potential.

The theoretical framework for this research began with the concepts that the elementary curriculum is increasingly overflowing with curriculum demands and that curriculum is never taken away, only added onto existing curriculum demands. The delivery of that curriculum, continually enlarged by the needs of increased academic and societal demands, must be met in the same timeframe, 180 days of school and, on average, 5 and one half hours each day. The increased focus on student achievement as measured by high-stakes testing for language arts and mathematics may be short-changing the other academic subject areas; especially for science, which requires more advanced preparation for hands-on student participation. As elementary educators face the increased curriculum demands of the 21st century skills, they develop their lessons around the dictates of standards and teaching resources of individual academic disciplines, including mathematics, science, and literacy.

Curriculum guidelines are provided to teachers with the state standards and their districts' expectations to fulfill what the state of New Jersey has guaranteed for public education in the state constitution since 1875: a thorough and efficient education. Having observed the current unfolding of curriculum demands through standards, the expectations for increased student achievement through high-stakes testing, and textbook companies compiling a broad spectrum of content on subject matter for each academic subject taught, there is a concern for how students are able to retain this conglomeration of information. It would not appear that this process of teaching individual subject-specific matter is the most efficient way for students to make sense of their learning, to increase their knowledge, and to understand the world around them. Without a method to combine efforts in the curriculum, students may become disenchanted with life-long learning or lose focus because little makes sense to them if presented in piecework, or taught as subject-specific. With a disconnected, single-subject learning style, some students may not be able to retain or increase their individual knowledge if they cannot formulate an understanding of how to make sense of the piecemeal delivery of the curriculum. Thus enhanced learning expectations created by the demands of 21st century skills needed for success today seem to be compromised by the lack of making integrated–interdisciplinary connections. To begin to unravel these thoughts and the theoretical framework of this study, an understanding of how curriculum works is in order.

Statement of the Problem

The demands of the elementary school curriculum have increased over the years; it includes more than the traditional subjects of reading, writing, and the arithmetic of bygone years. Reading, writing, and arithmetic were once the core of the curriculum, but as the years passed, school reformers pushed for the inclusion of spelling, geography, history, the U. S. Constitution, nature study, physical education, art, and music in the schools (Boham & Null, as cited in Iorio & Yeager, 2011). Educational policy that leads to curriculum change is created by stakeholders and policymakers to help keep America at a competitive edge in a fast-paced global economy (Achieve, Inc., 2008b). Ravitch (2016) stated that there are three general points of view on how schools can improve: the first point of view is only introducing teacher and learning practices based on “systematic, scientifically validated knowledge” (p. 36). Second, when teachers are given greater opportunity to exercise their skills and judgment with more control over conditions of their work, then our schools will improve; and finally, schools must be made more accountable to students and parents to become more effective, thus creating the needed improvements. Currently and mainly because of the social demands in our changing times of technology, our American educational policy has also mandated that teachers incorporate character education, anti-bullying, lock-down drills, and the increased academic expectations of the Common Core state curriculum standards currently being addressed in New Jersey as the New Jersey Student Learning Standards (New Jersey Department of Education [NJDOE], 2012, 2016b) and the recognition of the national Common Core Standards. The stress and tension of trying to include what is best for everyone have created problems in teacher retention, especially in science and mathematics (NJDOE, 2015). In addition, there is distrust among concerned parents as evidenced by their opting out of the Partnership for Assessment of Readiness for College and Careers (PARCC) testing initiated in 2013 (Achieve, Inc., 2014) as well as confusion among administrators, and anxiety in students and teachers when facing high-stakes testing which begins at the third grade level (Clark, 2015a).

The problem explored in this research was as follows: Can an integrated–interdisciplinary elementary curriculum help balance expectations for the increased student achievement in the quest for maintaining a thorough and efficient education emphasizing 21st century skills? The combination of disciplines might help motivate students' learning and provide more understanding of the importance of learning from a multifaceted perspective.

Research Questions

Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC?

Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC?

Will an integrated–interdisciplinary curriculum increase academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science Assessment?

Hypothesis

The integration of curriculum, also known as interdisciplinary curriculum, is an effective method of using value-added instruction that develops and displays an increase in student achievement as measured by the PARCC for language arts and mathematics and New Jersey Assessment of Skills and Knowledge (NJASK4) Science scores. If this is true, student achievement will show an increase over the time span from 2014–2017.

Null Hypotheses

There is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC.

There is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC.

There is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment.

Purpose of the Study

The purpose of this study was to determine if an advance in student achievement at the fourth grade level is indicated by the analysis of scores for the PARCC between 2014–2017 and the NJASK4-Science testing from 2014 through 2017. The study utilized multiple randomly selected public schools with an integrated–interdisciplinary curriculum as evidenced by curriculum maps or narrative information for instruction with fourth grade peers in multiple randomly selected public schools that have not indicated integrated–interdisciplinary curriculum in their instructional curriculum maps or mentioned integrated–interdisciplinary curriculum in school narratives.

Research Design

The methodology included the collection of measured outcomes through school percentiles given in the state performance reports for each school included in the study. This theoretical framework comprised test scores from the NJDOE for fourth graders to determine if integrating a curriculum can increase student achievement on the literacy, mathematics, and science test scores. The current materials were publically available on the newly initiated PARCC testing from 2014–2017 to meet the increased needs of 21st century skills. This was a causal-comparative study, known as an ex post facto research design in which the researcher had no manipulation or control of the independent variable, which was the integrated–interdisciplinary curriculum. Further means of verifying standards, assessments, and curriculum can be gained through the use of Webb's (1997) study using the web alignment tool to measure the depths of knowledge with a focus on fourth grade curriculum. This was a consideration after having analyzed the data from the PARCC and NJASK4-Science scores from 2014–2017.

Significance of the Study

The goal of this study was to explore matched-pair elementary schools that display a focused framework of self-identified integrated–interdisciplinary curriculum at the fourth grade level when paired with a school using subject-specific curriculum to analyze if there is a significant difference in student learning as reported in the New Jersey State Performance Reports for PARCC and NJASK4-Science for a period of 3 years: 2014–2017. If subjects are successfully integrated for a thorough effort toward efficiency, then a more sustainable learning environment for increased student achievement and teaching effectiveness could be the outcome.

An anticipated knowledge of the integrated concepts will lead to a better understanding of the connectivity to learning from combinations of various learning disciplines and reduce the redundancy of repeated attempts to teach these concepts in the isolation of each subject or discipline. This will not only save time, but also create more efficiency and connectivity in learning. Results of this study will provide students with a meaningful purpose for developing their learning skills in a way that helps them gather information to view a much broader vision often referred to as the "big picture" by using 21st century skills described in the Atlas of Science Literacy, (American Association for the Advancement of Science [AAAS], 2009). Using a resource of this nature will aid teachers in helping parents understand and guide students to learn why curriculum standards are important in their everyday patterns for seeking knowledge, developing more problem-solving and critical thinking skills. The Atlas of Science Literacy (AAAS, 2009) maps how strands of learning are tied together through curriculum integration. Analysis of the student achievement through a causal-comparative study, also known as an ex post facto design, of scores for PARCC literacy, mathematics, and NJASK4-Science from fourth grade students will be helpful in gathering information for student understanding and achievement. If achievement is shown to increase, then education is meeting the goals for a thorough and efficient education.

Limitations of the Study

A limitation of this study was that it was only focused on elementary level (K–4) curriculum and only utilized the New Jersey state standards, currently known as the New Jersey Student Learning Standards, with a focus on student achievement in the Grade 4 level. A second limitation of this study was that the science curriculum and expectations of the testing in the elementary level have changed rapidly from year to year and does not, in and of itself, provide an opportunity to do a long-term study of science concepts deemed important to increasing student knowledge and achievement. In their new testing using PARCC only, Achieve, Inc. (2014) focused on literacy and mathematics and left the NJASK4-Science intact. A third limitation of this study was the fact that with the current increase in technology, changes and advances in testing for student achievement that continue to mold the education system in our schools, develop rapidly and by the printing of this research, other types of assessment evaluations may be created to measure student achievement. A fourth limitation which may influence student achievement in testing results is the use and availability of computers in individual school settings and familiarity with usage for each student rather than the former pencil-and-paper testing previously given for elementary students. The fifth limitation of this study was the self-identified integrated curriculum, and the presentation of such curriculum on district and school websites may not always include the same units of study for integration. Finally, the most current state testing information, known as the PARCC testing, piloted in 2013 and reported in the 2014–2015, 2015–2016, and 2016–2017 school years, has had a rocky start to being implemented. PARCC has met with much resistance from parents, with some opting to not have their children participate in the testing. Teachers have complained that the test is too long for elementary students to be able to focus and deliver without stress and feelings of duress. As such unrest has been publicized; the use of PARCC scores may not be viewed by some as a solid framework in this study.

Definition of Terms

The following terms are included to help with the comprehension and interpretation of this research and to provide a clarification of terms should further research be conducted or the study be duplicated.

American Association for the Advancement of Science (AAAS): The AAAS seeks to "advance science, engineering, and innovation throughout the world for the benefit of all people" (AAAS, 2016, "Mission Statement"). This organization, established in 1848, was a national initiative for building a scientific community across the nation. It has helped to advance science in the United States and science education through an education and human resources program, Project 2061, a science, technology, engineering, and math (STEM) volunteer program and Science Net Links to help teachers with their education curriculum goals for students.

Atlas of Science Literacy: Volumes 1 and 2 are a two-volume collection of conceptual strand maps—and commentary on those maps—that show how students' understanding of the ideas and skills that lead to literacy in science, mathematics, and technology might develop from kindergarten through 12th grade. The maps in each Atlas are built from the K–12 learning goals presented in Project 2061's Benchmarks for Science Literacy. Benchmarks publication was derived from the recommendations for adult science literacy proposed in Project 2061's landmark report, "Science for All Americans" (AAAS, 1989a)

College and Career Readiness Standards: With the ever-increasing challenges of keeping up with technology, these standards were created to insure that students are able to make informed decisions and compete as a global citizens with 12 career-ready practices to help students be adaptable, reflective, and proactive in life and career choices using personal financial literacy, career awareness, exploration and preparation for career and technology learning (NJDOE, 2016a).

Common Core Content Standards (CCCS): The CCCS are not a curriculum; instead, they provide the appropriate grade level expectations for students. Originally developed in 1990 for nine subject areas and as a revision in 2010, then adopted by the state board of education, "the standards provide a guideline for what students should know and be able to do" (NJDOE, 1996a) ("Mission Statement"). Teachers are expected to use these standards to guide their student expectations for age-appropriate, challenging objectives to motivate student learning.

Curriculum Alignment: A match or agreement between two categories. Standards can be aligned to curriculum. Standards are general; curriculum more specific (Squires, 2009).

Integrated Curriculum: "A way of teaching and learning that does not depend on the usual division of knowledge into separate subjects" (Association for Supervision and Curriculum Development [ASCD], 1997a, 2016).

Interdisciplinary Curriculum: Often an interchangeable term with integrated curriculum, both are intended to help students see connections, but unlike an integrated curriculum, an interdisciplinary curriculum draws its content from two or more identifiable disciplines (ASCD, 2016).

National Association of Education Progress (NAEP): Nationally based assessments using consistent tests nationwide to gather student knowledge on academic subjects. In 2017, tests began to be administered digitally. The Commissioner of Education Statistics for the Center of National Educational Statistics oversees the NAEP assessments.

National Center for Educational Statistics (NCES): The federal department for collecting and analyzing data for U.S. education at all levels.

New Jersey Common Core Content Standards (NJCCCS)*:* State-adapted standards based on the national Common Core Standards and modified to meet the expectations of the state board of education.

New Jersey Student Learning Standards: In 2015, under the direction of the governor, the New Jersey State Common Core Content Standards were reviewed and revised to make them easier for parents to understand and for teachers to use for their students. This new title is essentially the same as the New Jersey State Common Core Content Standards with a few minor revisions and took effect during the 2016–2017 school year.

Next Generation Science Standards (NGSS): Through a collaborative, state-led process, new K–12 science standards have been developed that are rich in content and practice and arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. The NGSS are based on *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* developed by the National Research Council (NRC; National Science Teachers Association [NSTA], 2016).

New Jersey Assessment of Skills and Knowledge (NJASK) Testing: Tests used to measure fourth and eighth grade science recall of information and the application of skills to solve problems using science concepts. Tests for Grades 3–8 are used to check yearly progress in reading literacy and mathematics for student achievement (NJDOE, 2014-2017c).

Partnership for Assessment of Readiness for College and Career (PARCC) Testing: This testing began in the 2014–2015 school year, and is more aligned with new challenging standards including real-world skills. The PARCC test is used for students in Grades 3–8 and high school as a measurement of critical thinking and problem-solving.

Progress in International Reading Literacy Study (PIRLS): An international assessment study of student achievement for fourth grade students in over 60 countries, providing an international comparative study of student achievement in reading trends. Created in 2001 and administered every 5 years, the PIRLS was developed to complement the Trend in International Mathematics and Science Study (TIMSS). PIRLS is now in its fifth cycle of being administered to students. Both TIMSS and PIRLS are housed at Boston College's Lynch School of Education (PIRLS & TIMSS, 2016).

Program for International Student Assessment (PISA): An international assessment of 15-year-old students (age nearing the end of compulsory education) to measure knowledge of reading, mathematics, and science literacy; newly added is an optional measurement for financial literacy. In 2015, over 70 countries and educational jurisdictions participated in the assessment and results were made available in 2016. This program began in 1997, with testing beginning in 2000 as 32 countries participated; it is coordinated by the Organization for Economic Cooperation and Development (OECD). Testing is done every 3 years with randomly selected groups. Massachusetts, Connecticut, and Florida participated in 2012 for the United States.

Project 2061: Goals of this initiative by the AAAS are to create literacy for Americans in science, mathematics, and technology before Halley's Comet returns in the year 2061. The project has included the publishing of curriculum maps for science education known as the Atlas of Science Literacy (Volumes 1 and 2), a website for science assessment and links to the AAAS website to help teachers design standards-based science lessons.

Science for All Americans: A book published 25 years ago after a 3-year collaboration among hundreds of scientists, mathematicians, and other scholars that had a significant impact on science education reform, by helping to define the concept of science literacy and lay the groundwork for national education standards in STEM (AAAS, 2016).

Science Inquiry: The National Science Education Standards (NSES) defines scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work." Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NSTA, 2016, p. 23).

Science, Technology, Engineering, and Mathematics (STEM): An acronym created by the National Science Foundation (NSF) in the 1990s after realizing through research that these subjects cannot and should not be taught in isolation as they are not isolated in the workforce (Woodruff, 2013).

Science, Technology, Engineering, Arts, and Mathematics (STEAM): A movement led by the Rhode Island Institute of Design (RISD) and widely adopted by institutions, corporations, and individuals. Objectives included in the STEAM movement are to transform research policy to place art and design at the center of STEM, to encourage integration of art and design into kindergarten through college-level education, and influence employers to hire artists and designers to drive innovations (Michaud, 2014).

Trends in International Mathematics and Science Study (TIMSS): An international assessment measuring science and mathematics in Grades 4 and 8. Beginning in 1995, tests are administered every 4 years; the 2015 results were available in 2016. In 2011, over 60 countries participated. The TIMSS is sponsored by the International Association for the

Evaluation of Educational Achievement and managed in the United States by the NCES as part of the U.S. Department of Education.

Anticipated Outcomes

The anticipated outcome of this research project was to explore the findings of the students in the control group who have self-identified as receiving instruction through an integrated–interdisciplinary curriculum in literacy, mathematics, and science; looking to explore if there are significant gains in scores on the NJASK4-Science and PARCC testing for literacy and mathematics when compared with other peer school scores of students who have not received integrated–interdisciplinary instruction, otherwise known as subject-specific instruction.

Organization of the Study

Chapter 1 included an explanation of the background of the problem as well as a clearly defined statement of the problem and research questions to help delineate the directions of the study. Following a statement of the hypotheses for this study, there was a list of defined key terms and the limitations, and methods of the study. The chapter concluded with the expected outcomes of the study, which provided a focus for the problem of this research.

Chapter 2 is a review of the related literature on the topics of elementary mathematics, elementary science, the integration of mathematics and science teaching, integration of science and literacy projects, elementary technology and engineering principles as they relate to the common core standards and 21st century skills, the meaning of a thorough and efficient education, and the testing of student achievement through the lens of the newly adopted PARCC testing. Possibilities were researched for collaborative learning, inquiry science, and hands-on learning in an integrated–interdisciplinary curriculum; looking for student motivation in science and mathematics learning as well as student achievement. A brief exploration of what other countries are doing to enhance or meet the needs of their students for elementary literacy, science and mathematics education, as well as for technology and engineering are presented. The NGSS are explored, as well as alignment of curriculum to the state standards. Examples of mathematics and science and science and literacy combined efforts for teaching results are explained.

Chapter 3 contains an explanation of the research design, variables, and information with regard to subjects, instrumentation, and data collection and recording, as well as methodological assumptions. A closer look at student achievement of the New Jersey State Standards, now known as the New Jersey Student Learning Standards, was provided through data analysis of the causal comparisons in student achievement between the PARCC scores at the fourth grade level testing literacy, mathematics, and NJASK4-Science. A comparison was then made using scores from student achievement by elementary schools throughout the state that do not use an integrated–interdisciplinary curriculum in their teaching advancement toward the goals of preparing students for 21st century learning and meeting the New Jersey State Standards, now known as New Jersey Student Learning Standards. This curriculum analysis was done by reviewing each school's website for narratives on curriculum in literacy, mathematics, and science and checked with a criteria list as presented in Appendix J. The chapter concludes with a summary analysis.

Chapter 4 serves as a report on the focused, quantitative discoveries of this research on student achievement causal comparisons, also known as an ex post facto research method, including a more detailed analysis of the research findings through addressing the research questions. Chapter 5 is a summary of the purpose of the study, the research questions, subsequent questions, and the null hypotheses. The chapter concludes with recommendations for educational next steps for future research.

CHAPTER 2

LITERATURE REVIEW

There is much discussion about the Common Core Standards as part of our current American educational reforms. Valid questions to be asking are how, when, and why did these reform standards begin? In looking at the reasons for the reform movement that led to Common Core Standards, an analysis of the possibilities to help improve our American education might be a way to help guarantee thorough and efficient education and to provide a new system of checks and balances, now known commonly as accountability. The answers to questions that will help to solve the complexity of the global competitiveness and educational reformation began in the 1980s when the report by the NSF (1982), "Educating Americans for the 21st Century" suggested "mathematical and science education needed many reforms in order to be prepared for the 21st century even stating that the evaluation of achievement by testing process skills and integrated knowledge as well as facts and concepts should be implemented" (p. 36). This was followed by *A Nation at Risk* (National Commission on Excellence in Education, 1983), which outlined the need for educational reforms and called for unity:

> This unity, however, can be achieved only if we avoid the unproductive tendency of some to search for scapegoats among the victims, such as the beleaguered teachers. On the positive side is the significant movement by political and educational leaders to search for solutions—so far centering largely on the nearly desperate need for increased support for the teaching of mathematics and science. This movement is but a start on what we believe is a larger and more educationally encompassing need to improve teaching and learning in fields such as English, history, geography, economics, and foreign languages. We believe this movement must be broadened and directed toward reform and excellence throughout education. (pp. 20–21)

A brief history of educational reforms indicates reforms are not new, but in 2001, what became new were the rapid expectations for transformation set forth in the No Child Left Behind Act of 2001 (NCLB). The NCLB legislation came on the heels of close to 20 years of educational reforms that instituted more rigorous standards and assessment practices across the nation in response to the report *A Nation at Risk* published during the Reagan Administration (National Commission on Excellence in Education, 1983). The NCLB added a new layer of stringent accountability and sanctions in terms of loss of federal funding that significantly raised the stakes associated with student performance on standardized assessments. "The No Child Left Behind Act of 2001 (NCLB) represents the most extraordinary expansion of federal power over public schools in American history" (Sunderman & Orfield, 2006, p. 526).

The state of New Jersey has over 650 school districts, each exerting its own local control over curriculum and instructional methods. However, while each district may chart its own course, all must align with the standards established by the NJDOE. These standards are used to determine the learning goals for students and the assessments to determine if students have met these goals. It is through the local school districts that the curriculum and textbooks are adopted. Much of the decision making occurs at the local level (PIRLS & TIMSS, 2016).

The PIRLS is an international assessment of student achievement in over 60 countries that is administered to fourth grade students in the subject area of reading literacy. The TIMSS is an assessment that provides international information for over 60 countries on measuring student achievement at the fourth and eighth grade levels in the areas of mathematics and science. In studying trends in other countries compared with the United States for PIRLS and TIMSS research, most countries have a ministry of education to centralize the decision-making for educational policies, curriculum, and assessment (PIRLS & TIMSS, 2016). Although the United States has a Department of Education at the federal level of government, it has very limited control over decision making for education (TIMSS & PIRLS, 2006). Federal funding and the commissioning of reports are the two ways that the federal government can influence education. *A Nation at Risk* (1983) was such a report. Its intended purpose was to raise concern about the quality of education in the United States. As this report, *A Nation at Risk* (National Commission on Excellence in Education, 1983), began raising concerns and identifying issues, it then becomes the responsibility of each state to take action. Throughout the years, many such reports have guided the direction of mandated curriculum in the classroom. In recent years, the NCLB was such an initiative which drew controversy and failed initiatives (Geivertz, 2014).

With the NCLB initiatives not increasing student achievement as successfully as anticipated, came the formation of a coalition known as Achieve, Inc., working in collaboration with the National Governor's Association and the Council of Chief State School Officers to establish a way to support a Common Core Curriculum. This consortium was charged with the task of developing guidelines for each state to be able to adapt the state curriculums and align curriculums in the hopes of achieving a more organized, unified, and efficient way of reaching goals for U. S. students who now need a 21st century learning style and curriculum initiatives for programs in order to be competitive in a global world. Textbooks are adopted by local school districts and that influences the curriculum (TIMSS & PIRLS, 2006). The elementary reading curriculum is guided by instructional segments as shown in Appendix M showing a comparison chart of the reading instruction as reported by PIRLS in 2006.

Mathematics curriculum is determined in much the same way as is the reading curriculum. Remillard (2015) noted that curriculum includes four key features: (a) an emphasis on local and regional control of the curriculum, (b) a limited role of the federal government; (c) a distributed, rather than central, authority; and (d) a strong influence of textbook publishers. Other stakeholders such as academic and professional organizations such as the NSTA and the AAAS, the National Council of Teachers of Mathematics (NCTM), and the International Literacy Association, to name only a few examples, can provide expert commentary by undertaking research and presenting research findings and sometimes offering solutions to states and school districts. Funding organizations like the NSF and the International Reading Association can have influence when they help provide professional development, grant opportunities, and resources for curriculum development. All of the decision-making provided at the state level is influenced by many stakeholders. As the decisions made become state policy, the policies then become what elementary classroom teachers are mandated to teach their students in what is known as the curriculum of the public schools.

As the more standards-based reforms were introduced, the national educational reform documents published by the AAAS (1989a, 1989b, 1993, 1998), NCTM (1989, 1991, 1995, 2000a, 2000b), NSTA (1992, 1997) and the National Research Council (NRC; 1989, 1990, 1996) all recommended the integration of science and mathematics. With the increased interest in technology for learning, the International Technology Education Association (ITEA; 1996, 2000) has also endorsed the integration of science and mathematics (Berlin & Lee, 2005).

In research findings, the way science and mathematics is taught is a continuing concern to provide effective teaching and increased understanding and learning for students. In an era dominated by science, mathematics, and technology, Furner and Kumar (2007) emphasized that "classroom teachers in K-12 be equipped with knowledge and skills to teach both mathematics and science to students in a meaningful way"(p. 186) and recognized that the high-stakes testing to measure student achievement in mathematics and reading have made this a challenge for educators.

Despite compelling research rationales, the desire for integration remains unfulfilled, with mathematics and science being taught as two separate disciplines in the curriculum (Watanabe & Huntley as cited in Pang & Good, 2000). The roadblocks that create a barrier to implementing an integrated curriculum are the lack of high quality materials and detailed guidance for development as well as a clearer focus on students' understandings and misconceptions (Pang & Good, 2000).

The focus of this current research was concentrated on the elementary level, "providing an integrated or interdisciplinary approach to teaching elementary students also might provide opportunities to provide more relevant, less fragmented and more stimulating motivation for learners" (Furner & Kumar, 2007, p. 186; see also Frykholm & Glasson, 2005; Koirala & Bowman, 2003; Jacobs as cited in Furner & Kumar, 2007). While providing generalist classroom teachers with an integrated curriculum that covers the mandated demands of the standards reform movement and societal concerns for today's elementary students, this approach to teaching might also help to ease some of the stress and the retention of quality teachers. Questions as to how this type of integrated elementary curriculum would begin to take hold might include: How would an integrated–interdisciplinary curriculum be introduced to teachers? How does curriculum get disseminated to the students? Who would have the knowledge, skills, and ability to write and implement such an integrated elementary curriculum? These are some of the questions that helped to develop the theoretical framework for this research, along with the question of how to measure the outcomes of an interdisciplinary–integrated curriculum.

Thorough and Efficient Education

The term *thorough and efficient* education became part of the New Jersey Constitution in the year 1875. Its adoption has become a discussion point at many times during the course of history, especially when educational funding is the topic. In its entirety, the constitutional Article VIII found in Taxation and Finance Section IV, Paragraph 1 stated: "The Legislature shall provide for the maintenance and support of a thorough and efficient system of free public schools for the instruction of all the children in the State between the ages of five and eighteen years." How did this idea originally become part of the New Jersey State Constitution?

Since New Jersey became a thriving community for business and manufacturing after the Civil War, the number of immigrants increased rapidly, which created an opportunity for advancing the economy and also became a challenge for the schools. With an increased illiterate population in the state after the Civil War, there was concern for the economy of New Jersey being held back in the new industrial age. A commission was established in the legislature to review the Constitution; the hope was that schools could be the improvement needed to spur the economy. Since the term *thorough and efficient* was used as a descriptor for being a desirable business trait, private academies boasted of being able to provide a thorough and efficient education. Public schools that were able to demonstrate these attributes were viewed as models. Harriet Sepinwall, a professor at St. Elizabeth's College, had completed her doctoral dissertation on the subject and noted that the Constitution Commission could only come to a consensus that the state would provide a rudimentary education, but several members of the legislature that had been educated in the public school system thought that the public schools should be as good as the private academies and the term *thorough and efficient* education replaced the term *rudimentary* (Mooney, 2011). It has remained as part of the New Jersey Constitution since adopted in 1875. The goal of a public education in the State of New Jersey is a thorough and efficient education of its students. It is a valuable asset to our standards of living as United States citizens and is a guarantee of our government (Liss, 2016).

Our educational policies, which once seemed thriving with American academic successes in the industrial revolution, have become ever increasing concerns for continued success in our global status during the age of technology. Concerns are highlighted by U. S. standings in the international reports: the PISA, TIMSS, and NAEP.

The TIMMS 2015 report cited the top five countries for fourth grade mathematics achievement: Singapore (618), Hong Kong SAR (615), Republic of Korea (608), Chinese Taipei (597), and Japan (593). For fourth grade mathematic achievement, the United States scored 539, ranking 14th of 49 countries participating. In science, the United States scored 546, ranking 10th out of the 47 participating countries for fourth grade achievement. The NAEP is used to assess what U.S. students know and can do in different subject areas including civics, economics, geography, mathematics, reading; science, technology, and engineering literacy; U.S. history, and writing. In 2015, 40% of fourth graders performed at or above proficient in mathematics, while 36% of the fourth graders performed at or above proficient in reading, and 38% of the fourth graders performed at or above proficient for science. Comparisons of the achievement in reading of fourth grade students in 2011 were made among the 53 education systems that participated at Grade 4. The overall reading average scale score for U.S. students (556) was higher than the international PIRLS scale average, which is set to 500 (NAEP, 2017a, 2017b).

The data from these reports seemingly raise some flags to investigate how other nations have surpassed our U.S. student achievement over the years. The United States spent $11,800 per full-time-equivalent (FTE) student on elementary and secondary education, which was 28% higher than the OECD average of $9,200. At the postsecondary level, the United States spent $27,900 per FTE student, which was 89% higher than the OCED average of $14,800 (IES, 2017; NCES, 2017).

Tienken (2016) cautioned against using test scores to create more standardized programs to increase the U.S. standing to number one among international reviews. As research indicates that successful achievement in education helps drive economic growth (Hanushek & Woessmann, 2008), many state policymakers have formed consortia such as the PARCC or the Smarter Balanced Assessment Consortium (SBAC) to measure student progress toward meeting rigorous core standards common to all states and establish teacher and school accountability measures as well. Americans have historically placed enormous expectations on what public education can accomplish (Cremin, 1972; Perkinson as cited in Donato & Lazerson, 2000). Many studies have been done with the focus of high-stakes testing. In one such study, findings suggested,

There is significant relationship between the implementation of high-stakes testing and changes in the current curriculum, the structure of knowledge contained within the content, and the types of pedagogy associated with communication of that content. These changes represent three types of control that high-stakes tests exert on curriculum, content control, formal control, and pedagogic control (Au, 2007, p. 263).

Other researchers have challenged the value of high-stakes testing and accountability and questioned the validity of such measures of student progress:

> Student learning is indeterminate, remains at the same level it was before the policy was implemented, or actually goes down when high-stakes testing policies are instituted. Because clear evidence for increased student learning is not found, and because there are numerous reports of unintended consequences associated with high-stakes testing policies (increased drop-out rates, teachers' and students' cheating on exams, teachers' defection from the profession, all predicted by the uncertainty principle), it is concluded that there is a need for debate and transformation of current high-stakes testing policies. (Amrein & Berliner, 2002, p. 58)

It is the future economic growth and development that concerns the policy makers and stakeholders. Thus, in our nation, came an initiative that was organized and developed by governors and chief school officers to push for common standards to help guide our education system toward 21st century skills achievement.

The National Governors Association and the Council of Chief State School Officers led this initiative after the failing efforts of a standards movement in the 1990s (Geivertz, 2014). The resulting benchmarking report of 2008 stated,

> America cannot maintain its place in the world economically, socially or culturally– unless all of its students gain the skills that allow them to compete on a global scale. The United States will only achieve true international competitiveness when state education policies and institutions are restructured to meet 21st century realities. (p. 43)

The National Governors Association and the Chief State Officers in 2008 compiled a report that lists five actions toward building a globally competitive education system. Their recommendations were as follows:

1. Upgrade state standards by adopting a common core of internationally benchmarked standards in math and language arts for K-12, equipped with the knowledge and skills that are globally competitive.

2. Leverage states' collective influence to ensure that textbooks, digital media, curriculum and assessments are aligned to internationally benchmarked standards and draw on lessons from high performing nations and states.

3. Revise state policies for recruiting, preparing, developing and supporting teachers and school leaders to reflect the human capital practices of top-performing nations and states around the world.

4. Hold schools and systems accountable through monitoring, interventions and support to ensure consistently high performance, drawing upon international best practices.

5. Measure state-level education performance globally by examining student achievement and attainment in an international context to ensure that overtime, students are receiving the education they need to compete in the 21st century. (Achieve, Inc., 2008b, pp. 28–34)

With the focus for current education from the Benchmarking Report of 2008 in mind and the importance attached to meeting educational standards in the elementary classroom, it becomes imperative to understand how the rigors or demands of the curriculum with ever-increasing expectations would be managed on a day-to-day basis in the average American elementary classroom. Balancing those expectations for curriculum and student achievement and meeting the needs of the standards for every student to have a thorough and efficient education for 21st century skills through an integrated curriculum at the elementary level was the focus of this current research.

Over 140 years ago a thorough and efficient education guarantee was created as part of the New Jersey constitution (Liss, 2016). Maintaining this guarantee is problematic due to the fact that the state grew to include over 650 independent school districts that all are exercising local control with each district invested in its own control of the curriculum for its students. Many years later, the resulting adoption of the Common Core Curriculum Standards was a plan that would define the results of those 650 independent school districts. The curriculum that schools were expected to create from this framework would provide the rationale for the thorough and efficient guarantee. Although only a resource for the districts, the curriculum framework was provided to guide in developing each independent school districts' curriculum and for the classroom teachers to be able to modify lessons to conform to the new standards. The Common Core Standards would define the high school graduation requirements, testing originally Grades 4, 8, and 12 were to allow for the assessment of the Cumulative Progress Indicators (NJDOE, 1996a).

Since the 1983 report *A Nation at Risk*, the federal government has expanded authority and requirements by adding course requirements, implementing mandatory state assessments and the reporting of more test score data by district and by individual school (Sunderman & Orfield, 2006). With the demand for accountability at all levels, the state was charged with providing for assessments to measure student achievement. The problem with this federal mandate was that states lacked the resources, knowledge and leadership to effectively implement the new legislative requirements (Sunderman & Orfield, 2006). There is little evidence that any state is capable of achieving the vast transformations and rapid progress for all subgroups as required by the NCLB (Hunter, 1997; Mathews, 2000; Strauss & Loeb, 1998; Weizel, 1997; Wyatt, 2000). With the passing of the NCLB, the focus of school effectiveness and accountability was narrowed to academic outcomes produced on standardized, high-stakes testing. Unfortunately the background of prior education successes or conditions within the school that may affect the student learning outcomes are not taken into account (Takanishi, 2012). Academically improving schools takes identifying problems and implementing strategies to solve those problems. With the apparent looming failure of the NCLB, the National Governors' Association met to find a solution. The creation of the Common Core Standards was the outcome of their efforts to unify the education system for America.

Common Core Standards

The Common Core Standards are the result of a national movement spearheaded by the state and local governments participating in the alliances developed with corporations, governors, and progressive educators in various roles, and school employees' unions (Darling-Hammond, 1991). The Common Core Standards were developed to provide teachers with common guidelines to be able to teach today's students the needed 21st century skills, especially focusing on college readiness and careers. As the U.S. industrial and manufacturing economy of the 1900s was rapidly moving toward a technology-based informational economy in a global society, it was evident that evaluation and change were needed. U.S. education moved toward visions of the 21st century with the focused attention of the nation drawn to the mediocre placement of U.S. students on international testing scores. The educational requirements to meet these changing needs meant an assessment and revision of the goals of the American education system, which once provided a skilled labor force for farming and industry while only focusing on academic successes for few elite or privileged members of the population (Sunderman & Orfield, 2006).

The testing and assessments of the past were focused on what proved to measure lower level and rote memory thinking skills, but now needed to be focused on problem-solving and more critical thinking skills for students to compete in the newly developing global economy. Student scores on national assessments, as well as world-wide assessments, seemed to indicate that American students were not adequately prepared and scored near the bottom for the needed skills of 21st century learning and technology. Various groups working in a consortium agreed that "the world's knowledge-and-innovation economy favors workers who have post-secondary education or training, strong fundamental skills in math and reading, and the ability to solve unfamiliar problems and communicate effectively" (Achieve, Inc., 2008b, p. 5; NGA & CCSSO, 2008, 2010). The stakes are higher in a global economy where jobs can be outsourced and workers can live in countries across the world. Technological, economic, and political trends have combined to heighten the expectations for high quality jobs with global competitive skills.

The NGA, a group including the governors of the 50 states, three territories, and two commonwealth representatives, created a report analyzing the condition of U.S. education. Along with the Council of Chief State School Officers (CCSSO), a nonpartisan, nationwide group representing the elementary and secondary public officials who lead schools, and Achieve, Inc., a bipartisan group organized by the governors and businesses to help raise standards, improve assessments, and prepare students for careers of the 21st century. So began the addition of another reform by policymakers to improve the condition of the U.S. educational system.

> The Benchmarking Report noted that human capital in the United States is falling short of what is needed most in the global outlook, career-oriented skills are needed as in science, mathematics, engineering and technology training. American students ranked 26th in math and 21st in science achievement during the year of 2006. The high rank in inequity

> also concerned policymakers as the United States had the third largest gap in science scores between students from different socioeconomic groups. (NGA & CCSSO, 2008, p. 9)

New Jersey Core Curriculum Content Standards (NJCCCS) were first adopted in 1996. The Standards define a thorough and efficient education as guaranteed since 1875 by the New Jersey Constitution (NJDOE, 1996a).

The intent of the standards is to help teachers better prepare students for college and career readiness by the end of their K–12 education (NJDOE, 1996a). Standards were created to develop expectations of what students should know and be able to do at various developmental levels of their education, targeted at Grades 4, 8, and 12. The NJCCCS were to be revised every 5 years to continue to provide clear and specific benchmarks for students to be able to achieve in the nine content areas. A few of the nine areas would be reviewed each year to make for an organized and manageable system, so as not to focus on all nine areas of content for the entire curriculum at one time. Curriculum areas were noted as 21st century life and careers, comprehensive health and physical education, science, social studies, technology, visual and performing arts, world languages, mathematics, and language arts literacy (NJDOE, 1996a). These standards were developed and reviewed by panels of teachers, administrators, parents, students and representatives from higher education, businesses, and the community. The NJCCC standards were influenced by the national standards, research-based practice and student needs; standards have had significant impact on classroom practices and an impact on assessments.

Assessments are pivotal to standards-based reform because they are the measurement that hold students, teachers, and administrators accountable for improvement and progress made based on the standards (Pellegrino, Chudowsky, & Glaser, 2001). Many people do not understand what the Common Core Standards mean or encompass. The Benchmarking Report (Achieve, Inc., 2008b) defined the standards as follows:

> The Common Core Content Standards (CCCS) are not a curriculum, they provide a broad outline of learning expectations from which teachers and district leaders develop their curriculums. They are developed to provide a set of measurable expectations for what students should know at various levels of their education and typically target levels of grade 4, grade 8 and grade 12 where assessments can readily show student achievement towards those expectations. (Achieve, Inc., 2008b, p. 4)

Many people in the public are also confused by the initiatives that have led to the Common Core Standards. For example, in 1998 the NSTA wrote a position statement for the National Science Education Standards. This statement referred to the level of quality toward a goal to provide students with quality instruction and a means for judging the criterion for quality science programs. Clearly enunciated in this position statement was the fact that Americans strongly value local control over their educational systems and the National Science Education Standards emphasized the importance of local control (Anderson, Druger, James, & Katz, 1998). The purpose of these standards was to provide a framework for educational systems across the United States to make decisions and evaluate how well each educational system was moving toward the reform for a scientifically literate society as referenced in Project 2061's *Science for All Americans* (AAAS, 1989b) and *Benchmarks for Science Literacy* (AAAS, 1993). An essential question raised for supporting the National Science Education Standards was: "If we don't know where we are going, how will we know when we get there?" (Anderson et al., 1998 p. 32). The support of the NSTA came as a result of the existing 1996 vision of the NRC and their efforts to try and improve science teaching and learning.

Anderson et al. (1998) reported the beginnings of this movement to unify, define, review and evaluate efforts have been updated by other reports, studies, and evaluations over the years. The values and goals of educational systems are dynamic. They change in response to the needs of our citizens and society. Many changes and needs have been addressed by the more current updates brought to national attention by the Common Core Standards. Researchers in policy have bought attention to a de facto or de jure national curriculum, meaning that the Common Core Standards might have suggested a national effort toward more national or federal control of the education system. In the initiatives set forth by President Bill Clinton and Goals 2000, there was an attempt to create voluntary national standards and assessments that would imply a national intended curriculum, but this attempt fell short and the state-by-state system prevailed (Porter, Polikoff, & Smithland, 2009). President George W. Bush in the 1990s displayed an inclination toward moving educational goals forward by national standard efforts. Because the United States is a country of states' rights in education, the NCLB implemented by the G.W. Bush administration made clear that the federal government was not to be involved in the setting of the content standards or the creation of NCLB assessments. Each state sets its own content standards and uses its own student achievement tests, except for those states in special cooperatives such as the New England Common Assessment Program (Porter et al., 2009).

A national effort to set standards and measure student achievement was not the intention of the governors in their efforts to present a Common Core of Standards or we would not presently have 50 states scrambling to implement Common Core Standards as they have been reviewed, adapted, and applied to the needs of their individual states. These educational goals hinged on the 50 individual states having created their own needs and setting individual policies to accomplish educational goals in their individual states. When the governors came together to come up with a solution to the public concern for increasing the test scores on international testing and to continue to challenge our United States students for 21st century skill preparedness in a global economy, the International Benchmarking Report 2008 was the resulting outcome. This led to the widely discussed Common Core Standards focusing on what students are to learn. The mathematics standards are explicit in the intention to be more focused than the current state standards. Both mathematics and English language arts standards are intended to influence and enact curricula (Porter, McMaken, Hwang, & Yang, 2011).

Within the Achieve, Inc. (2008b) Benchmarking Report update is found an explanation for "the standards which aim to align instruction with this framework so that many more students than at present can meet requirements of college and career readiness" (NJDOE, 2010, p. 27). As Porter et al. (2011) explained, the Core Curriculum Content Standards are an opportunity to develop a national curriculum around shared expectations and greater efficiency by creating common curriculum goals, standards, and assessments, along with a unified vision for the quality of those assessments rather than combining the efforts of 50 individual states. Developing and adopting a common set of standards was included among the criteria for President Obama's initiative for the states to receive grant awards in the Race to the Top competition. Appendix B shows a brief summary of state standards and evidence of interdisciplinary curriculum endorsement.

Constructivist Theory: Scaffolding Learning

The reformation of science education aligns with the constructivist theory of learning, focusing on how learners are able to make sense of new information and how students attach or construct meaning, attaching it to what they already know or think they know about a topic. "Constructivist-oriented curriculum and instructional strategies focused on students' thinking about the material to be learned, and through carefully thought-out prompts and questions, students are enabled to arrive at a deeper understanding of new material" (Parkay & Hass, 2000, p. 168).

The foundations of constructivist teaching come from the learning theories of John Dewey (1938), Jerome Bruner (1966), Lev Vygotsky (1978b) and Jean Piaget (1970b). Learners were encouraged to actively engage in learning rather than gain knowledge from rote memory and passively listening to delivered lectures (Gibbons, 2004). Cognitive change and new learning involve building increasingly inclusive and robust concepts (Bruner, 1975).

Effective teachers are able to structure learning experiences that include active learning (Carin & Bass, 2001). The teachers working directly with students are the ones who must adapt and adjust lessons on the basis of evolving student needs. It is paramount to constructivist educational practice that the classroom teacher's autonomous, ongoing, professional judgment must be at the forefront of the classroom lesson planning (Brooks & Brooks, 1999).

Reform-based teaching using the integration of science and literacy uses a cyclical foundation that involves activating prior knowledge, promoting interest, and setting a purpose; providing teacher guidance to create student understanding, and being able to apply new understandings to new learning situations (Baker cited in Bradbury, 2014).

Grennon-Brooks and Brooks (1993) identified five central tenets of constructivism:

- First, constructivist teachers seek and value students' points of view. Knowing what students think about concepts helps teachers formulate classroom lessons and differentiate instruction on the basis of students' needs and interests.
- Second, constructivist teachers structure lessons to challenge students' suppositions. All students, whether they are 6 or 16 or 60, come to the classroom with life experiences that shape their views about how their worlds work. When educators permit students to construct knowledge that challenges their current suppositions, learning occurs. Only through asking students what they think they know and why they think they know it are we and they able to confront their suppositions.
- Third, constructivist teachers recognize that students must attach relevance to the curriculum. As students see relevance in their daily activities, their interest in learning grows.
- Fourth, constructivist teachers structure lessons around big ideas, not small bits of information. Exposing students to wholes first helps them determine the relevant parts as they refine their understandings of the wholes.
- Finally, constructivist teachers assess student learning in the context of daily classroom investigations, not as separate events. Students demonstrate their knowledge every day in a variety of ways. Defining understanding as only that which is capable of being measured by paper-and-pencil assessments administered under

> strict security perpetuates false and counterproductive myths about academia, intelligence, creativity, accountability, and knowledge. (p. 20)

Research on constructivist applied curriculum has identified several effective ways of teaching, including use of authentic materials to make the learning relevant both in the class as well as in everyday living.

A constructivist approach also calls for limiting curriculum content to provide greater depth of understanding about key essential principles and the application of skills to help maintain a conceptual understanding. Students thus make sense and construct meaning from the learning experiences that connect with the prior knowledge base of the learners. Research in science education has found evidence to support the social constructivist theory for how children learn science (Brown & Campione, 1994; Driver, 1989; Roth, 1995). Teachers in a constructivist classroom scaffold the material taught to be able to respond to the students' learning efforts. This entails providing greater support in the initial learning stages and then relinquishing a constant support as the learner gains responsibility and competence in their learning (Seed, 2008). Building on what students know and addressing any misconceptions help to maintain a stimulating learning environment.

Piaget (1970a), recognized by many psychologists as the founder of constructivism, claimed that an individual modifies what he or she knows through interaction with the environment and others. Maturation, in addition to the environmental and social interactions, influence how an individual's reasoning and intellect develops. As peers share ideas they become aware of others' ideas and gain different views of the problem and its solutions (Krajcik & Czerniak, 2007). Vygotsky (1978a), a Russian psychologist, influenced by Piaget, believed that development depends on biological factors such as brain growth and maturation, in addition to the social and cultural aspects like the influence of others at home, school, or during play. He concluded that children construct knowledge or understanding as a result of thinking and actively doing in social contexts.

Using the constructivist theory of learning involves giving students time for reflection about alternative ideas, hypothesizing alternate outcomes, analyzing steps taken, and drawing conclusions. It also suggests that the students develop learning through multiple representations that integrate understanding. Using artifacts to help students develop meaning as well as sharing ideas and debating with peers and teachers help to not only formulate knowledge, but model what scientists do in their work (Krajcik & Czerniak, 2007).

Integrating the Curriculum

Research findings tend to indicate integration of curriculum as a recurring theme in education. During the 20th century, there were over 500 studies about the integration of curriculum from 1900 to the present (Berlin, 1999). The evidence for some of those studies is revealed below, as Venville, Wallace, Rennie, and Malone (2000) found that integrated teaching was able to result in student learning that exceeded what would have been learned in individual subjects. The NSTA, NCTM, Association for Childhood Education International, and the International Reading Association have all endorsed the benefits of interdisciplinary connections for improved student learning. The integration of mathematics and science positively impacts not only student attitudes, but their motivation to learn (Stinson, Harkness, Meyer, & Stallworth, 2009). Children's literature provides a meaningful context for learning mathematics. When mathematics is integrated with literature, mathematical concepts become more relevant to the students and their mathematical skills for content improve (Capraro & Capraro, 2006).

Why has the integration of curriculum not included a more fervid approach to solve a seemingly insurmountable problem of ever-increasing demands in curriculum? Ball (1991a) found that preservice teachers sometimes lack the content knowledge, not feeling confident to teach mathematics using student-centered methods with integration techniques. Research by Hancock and Gallard (2004) revealed that there are limited opportunities for teachers to observe the delivery of integrated instruction to students, thus preventing the transforming of belief to action.

Elementary Instruction Changes: A Historical Perspective

In the 1970s came the push to introduce learning centers to help supplement the curriculum for elementary students. This method was based on the teachings of the Montessori methods for student learning. This allowed students active engagement in activities using novel and independent ways to gain knowledge for their learning experiences in the elementary level for new expectations and demands. Teacher-guided direction and management of centers tailored to the needs of the class were expected to supplement the basal reading and mathematics programs. Learning centers provided time for students to explore and create, but the classroom teacher was left with the task of developing new centers for students based on their individual or class needs for reinforcement or enrichment. Attractively displaying an invitation to learn for the students to encourage them to want to be challenged by the activities was a daunting job, but a creative initiative of ownership for most teachers in addition to lesson planning, record-keeping, progress reports, and general communications with the parents.

In the late 1980s and early 1990s, the elementary curriculum was based on a whole language curriculum, an approach introduced by Ken Goodman (1986). The whole language movement had many students invested in theme-based units of learning. Using reading text to springboard the phonetics and writing elements, incorporating mathematics, science, and social studies into the theme-based units provided a curriculum that seemed comprehensive in its goals for learning (Goodman, 1986). The whole language curriculum helped students to perhaps make better sense of what and how they were learning as witnessed by personal observations during teaching, but the curriculum relied on sounding out words for writing, and this led to a lack of spelling and phonetic structure for students to scaffold on their writing experience (Routman, 1994). Perhaps the demise of the whole language approach for teaching was rooted in the controversy called the “Reading Wars” and the need to find common ground for reading instruction (Reyhner, 2008).

In the 1990s, schools were reporting success with programs that implemented science-centered curriculum for the elementary schools. The Mid-California Science Improvement Program (MCSIP) began in 1987, an integrated, thematic learning model that was based on Susan Kovalik’s (1986) work. It was a program that gained the support of the David and Lucile Packard Foundation to help increase the status of science education in Monterey County’s elementary schools (Greene, 1991). A survey leading to this funding found that many elementary teachers did not feel qualified to teach science, had limited access to appropriate materials, and did not have the strategies for integrating science into their overcrowded days (Greene, 1991).

In 1990, the state of California was recommending the integrated approach to thematic learning through which making science the center of focus for theme-based units enabled teachers to unite all the learning efforts throughout the day for increased student outcomes. Literature was based on the science theme so students were reading and writing about the main theme. The diversity of the themes blended science, language arts, social studies, mathematics, and fine arts. Unlike most improvement programs which require teachers to add more tasks to the already full curriculum, this program integrated all of the academic disciplines around science as the focal point to unify all the other subjects. This integrated thematic approach provided teacher training during a 2-week period in the summer and then a steady reinforcement of coaching during the school year. Of the students who took part in the project, it was found that by the end of the second year the student achievement showed substantial and statistically significant gain (Greene, 1991). Test items developed by the NAEP in 1987 through a "process of inquiry," provided results that 78% of the students improved their scores, exceeding the NAEP nationwide figures. It was concluded that this thematic approach to learning science was improving student achievement in science (Okamoto, 1989). AAAS director, James Rutherford, leading the Project 2061 initiative, cited MCSIP's project as one that showed unusual promise and possibly of nationwide significance:

> The insightful use of science as the conceptual focus for instruction in reading, arithmetic, social studies and other subject provides an approach to changing the attitudes, skills, and knowledge of elementary teachers. It promises to be more than superficial and fleeting, and seems to foster teacher creativity, and may prove to be affordable. (Rutherford, 1990, para#1)

Such a seemingly promising program met with the legislation for NCLB and the high-stakes testing that would be focused on reading and mathematics. The new set of educational demands in the NCLB had taken the focus off the promising programs of integration and turned educators' focus to increased instruction in reading and mathematics, in order to prepare students for high-stakes testing programs. Educational reforms would once again create a narrowed view for curriculum and instruction:

> The emphasis on content standards which has its roots in the years immediately following the release of A Nation at Risk, was strengthened with the passage of No Child Left Behind (NCLB) Act. Among its many mandates, NCLB required that beginning in the 2007-08 school year, schools must administer annual tests in science achievement at least once during three grade spans: 3–5, 6–9, and 10–12. Yet despite its own requirement, the law has succeeded in putting science to the back burner. Schools now focused on reading and mathematics with little time left for science in the rush to prepare teachers and students for high-stakes standardized tests. (Brady, 2008, p. 607)

Due to reforms, time for science instruction was minimized as evidenced by research at the Lawrence Hall of Science at the University of California in Berkeley (NSF, 2007a, 2007b). An indication of this is provided in the Bay Area study where children were asked what they did in science class and some of the children's responses indicated they did not know what science was. The NSF (2008) created a video presentation alerting the public to the serious lack of science education as the NCLB legislation took effect and the policy mandating more focus on raising mathematics and reading scores became the national focus along with high-stakes testing. Rena Dorph (2007), a leading researcher and director of the Center for Research, Evaluation and Assessment at the Lawrence Hall of Science in Berkley, California, reported that 80% of the teachers spent less than 1 hour per week teaching science at the elementary level and 16% had no time to teach science at all. This was in contrast to a national study 7 years prior that indicated elementary science instruction to average more than 2 hours per week (Asimov, 2007). In order to have science be a subject students want to pursue, the impetus for studying science must come to the forefront, creating opportunities for students to use hands-on, inquiry-based curriculum and methods recommended for teaching science. We must also encourage the creativity and problem-solving skills connected with critical thinking. While educators are developing these student skills in the classroom, implementing engineering skills and connections to the ideas presented in the study of mathematics could help students make sense of their learning in a way that provides vision for their future careers. Students learn best when encouraged to construct their own knowledge of the world around them and integrated STEM projects provide this type of learning for the students (Laboy-Rush, 2007).

At the University of Maryland (1987, 1990, 2000, 2015-2017), studies with limited investigations of integrated curriculums showed effective results. Studies revealed statistically significant gains for student learning when analyzing student achievement in mathematics, science, and writing scores as well as reading scores. The integration of instruction was credited for the increase in student scores. With instructional variables in reading comes the opportunity to expand learning in other content areas (Guthrie & Wigfield, 2000).

Curriculum integration helps to make connections using topics for students that enhance learning through semblance to real-life situations. It keeps students actively engaged and motivated to learn through the stimulation of problem-solving and critical thinking about topics they can relate to, so students are not overloaded with rote information (Krajcik & Czernick, 2007). Since *Science for All Americans* (AAAS, 1989b) and the National Science Standards (NRC, 1996) were written as science reform initiatives, the integration of curriculum has been stressed. The national reform efforts of the International Reading Association (1996), the NCTM (1989, 2000b), the NRC (1996), and the NCTE and the National Council for the Social Studies (as cited in Krajcik & Czernick, 2007) all have stressed and endorsed the need for the integration of curriculum. Howard Gardner's work on multiple intelligences further accentuates the benefits for integrated curriculum to be able to reach all types of learners (as cited in Krajcik & Czernick, 2007, p. 466).

Beginning with the policy changes in elementary education in 1957, with the launch of Sputnik increasing the demand for more science education, and continuing with the Elementary and Secondary Education Act (ESEA, 1965); the Civil Rights Legislation in the 1960s which addressed the inequality of access to resources and programs across racial, gender, linguistic, socioeconomic and ability grouping, there have been strides made and then rescinded. The NCLB (2001) was an effort to connect quality and equality in education through the promotion of statewide standards and assessments (Iorio & Yeager, 2011). These educational legislations have created nationwide reforms that present continuous changes and place increased demands on teachers' time and planning for instruction as well as increased societal demands to keep children safe while in school as a result of incidents such as those at Columbine High School in 1999 and Sandy Hook Elementary School in 2012. The laws require that schools practice lock-down drills, learn safe hiding spots, and teach what to do in an emergency if a student is not in the classroom.

Perhaps some of these policy changes are a partial reason why elementary teachers have not been able to integrate the curriculum with more confidence, knowing that it will enhance student learning. The aligning of curriculum to the state standards might hold the key to successful implementation of an integrated or interdisciplinary curriculum that provides for student achievement measured by current high-stakes testing.

Aligning the Curriculum

With the reform-based movements comes the topic of alignment of curriculum to the standards. Squires (2009) defined the alignment of curriculum as an agreement or a match between two categories. Standards can be aligned to the curriculum. Standards are more general, while the curriculum is more specific. Although there has been limited research on the efficacy of aligning state tests to district assessments, student assignments, and teacher lesson plans or instruction; some studies have shown that aligning curriculum with standards and assessments "can level the playing field for poor or minority students and reduce the achievement gap. Aligning produces increases in state testing even after one year of implementation" (Squires, 2009, p. 3). Aligning the curriculum takes time and team effort to insure that curriculum and standards are being met effectively. There are many considerations when including Squires's (2009) work for alignment into a district curriculum plan.

A model known as the depths of knowledge (DOK) created by Norman Webb in 1997 is being used to help gauge the extent to which students express and share their learning from the curriculum. Webb has updated his model in 1999, 2002, 2005 and 2006 to continue to keep up with the demands of changing standards. The model provides a means by which to analyze the levels of thinking and applications of knowledge that students must employ to answer a test question, address a problem, or complete a task. Levels of knowledge ranging from 1 to 4 are used to measure assignments or assessments as follows:

- Level 1: Students' experience acquiring and gathering information is known as the knowledge acquisition stage. This provides the level of information students will need to strengthen and support their thinking. It is the level of recall and reproduction.
- Level 2: At the second level, students use knowledge application in demonstrating and communicating information to acquire a certain answer, outcome, or result. This second level contains the basic knowledge application of skills and concepts to answer the question of how this knowledge can be used, helping students to refine their thinking.
- Level 3: At this level, students think strategically and use their reasoning to analyze and evaluate causes, connections, and consequences. Students can recognize why the information is essential and relevant to know in order to study, solve problems, or solidify an idea.
- Level 4: The fourth level, knowledge augmentation, refers to the ability to extend thinking and transfer knowledge. Students demonstrate the ability to recognize how and why information is beneficial and can apply their knowledge to various situations

combining inductive and deductive reasoning to explain outcomes and results (Francis, 2016).

The DOK model is used to measure more updated requests mandated in the skills needed for 21st century learning with the college and career readiness expectations. It has been compared to the revision of Bloom's taxonomy by Anderson and Krathwohl (2001), Marzano's (2007) cognitive and metacognitive systems of new taxonomy, and the solo taxonomy of Biggs and Collis (1982), in Appendix C is Bloom's taxonomy as compared with Webb's DOK model and in Appendix D Hess's Cognitive Rigor Matrix and Curricular Examples. Webb (1997) developed his DOK model with the purpose of increasing cognitive complexity and addressing the demands created by standardized testing. The DOK model is most closely associated with the solo taxonomy model. All of the models are shared as evidence-based practices used in educational leadership.

Achieve NJ is the nonpartisan group that is responsible for creating and overseeing the reform-based initiatives in the state of New Jersey. Achieve, Inc.'s "Ten Criteria for Essential Elements of States Longitudinal Data System" has been created (Squires, 2009, p. 83) The longitudinal data systems encourage states to make continuing progress in the quality of their data with an integrated, accessible pre-kindergarten through college-level format to provide information about student achievement and school progress toward state goals of career and college readiness. This corporation, Achieve, Inc., works to implement changes as mandated by the policymakers to improve student achievement and make teachers accountable to effectively help students learn. Although the PARCC testing implemented in 2013 was met with much resistance from parents and teachers in the media, Achieve provides alignment services for states and districts, particularly in alignment of assessments to state standards with other services, such as standards benchmarking and "augmentation" analysis of testing and standards.

Brooks and Brooks (1999) cautioned,

> The systemic thinking that frames most standards-based reform efforts is delectably logical: Develop high standards for all students; align curriculum and instruction to these standards; construct assessments to measure whether all students are meeting the standards; equate test results with student learning; and reward schools whose students score well on the assessments and sanction schools whose students don't. (p. 19)

This is the reason why Achieve, Inc. now sets forth the longitudinal data system: its vision helps states maximize their opportunities to use the elements contained within the system to increase student learning and teacher effectiveness, also helping state leaders reform strategies that will strengthen the goal of career and college readiness for all students. One asset of the system is the ability for teachers, school administrators, and district administrators to be able to use the data with detailed information provided to improve instruction.

Reform that teachers and students can understand and implement seems to come from within the schools at the district level. DiBiase, Warren, and Wagner (2002) demonstrated that the process of alignment of instruction to standards and assessment resulted in better student achievement. Moss-Mitchell's (1999) results showed the effects of alignment canceling out more traditional predictors of student achievement such as socioeconomic status, gender, race, or teacher effect. Studies have shown that aligning curriculum with standards and assessments "can level the playing field for poor or minority students and reduce the achievement gap" (Squires, 2009, p. 3). When the curriculum is aligned with the assessments and the standards, it helps all stakeholders to focus on the goals for effective student learning and achievement.

Many districts are working through a variety of different subject-specific methods to align the curriculum as one way to improve student achievement; districts typically adopt a variety of different programs and approaches.

> Teachers looking for guidance on what is most important to cover won't find answers in the textbooks because the textbooks cover "everything" once lightly. Such findings should be a warning to districts: purchasing a textbook as a vehicle to align instruction to standards and state tests will not work, at least in the United States. (Squires, 2005, p. 5)

Textbook companies give a comprehensive coverage of subject matter, but topics are many and an in-depth study is not included in any subject area; no connections are made to other subject area curriculum. The intended purpose is for each subject to be taught as an individual course and not part of an integrated curriculum for students' maximized learning potential and understanding.

When individual learning plans are in place for students, their learning potential increases. There are many factors mentioned in the literature that have an effect on the outcomes of student achievement: English Language Learners (ELLs) and economically disadvantaged students as well as cultural diversity and learning disabilities are areas that state reports project to the public. These are also areas of concern for the scope of this current research.

> Predictably, a simple and linear approach to educational reform is sinking under the weight of its own flaws. It is too similar to earlier reform approaches, and it misses the point. Educational improvement is not accomplished through administrative or legislative mandate. (Brooks & Brooks, 1999, p. 24)

The nature of learning in the classroom is something that cannot be assessed by testing alone. Teachers must use their intuitive perceptions to be able to formulate a plan of what will work best for their students. Since the students are different every year, so too must be the plan for learning.

Teachers and administrators must find ways to help insure that the curriculum is aligned with the standards and allows for learning of ideas presented in assessments. Squires (2005), a former curriculum developer and university professor, created a web-based curriculum process that helps develop and align the curriculum to state standards and state and nationally normed assessments.

Webb's (1997) Alignment Tool defined the DOK as a web-based application that helps schools by automating the process aligning between standards and assessments based on five criteria:

- Content or subject area and attributes,
- Articulation between ages and grades—not just analysis within, but also between grades,
- Address issues of equity and fairness,
- Should address pedagogical implications that may arise, and
- Provide reasonable alignment with respect to resources needed to attain the alignment.

The DOK can help districts align their curriculum with the standards and assessments to help learners reach their goals for 21st century learning (see Appendices C and D).

Science and Literacy Movement

When the focus was put on the NCLB, the science and literacy movement gained more momentum in hoping to catch the attention of curriculum designers. Perhaps learning science through the readings of nonfiction text would enhance learning of science ideas, as evidenced in the *Science for All Americans*, concepts were realized as a hope of promoting science through literacy within the structure of the classroom curriculum (Darling-Hammond, 1991). Classroom shelves began to include more nonfiction titles. In the elementary schools, more nonfiction books were introduced during instructional time to enhance student interests in science while exposing them to a wider spectrum of reading genres.

Dr. Wendy Saul (2004), Professor of Education at the University of Missouri-St. Louis, noted that providing students with the opportunity to read, write and speak as scientists; attaching purpose to the use of printed materials; and making the conventions and forms of reading, writing and speaking in science explicit, students will increase both science and literacy knowledge. She began her observations in 1998 and continued to see progress with her studies for the integration of science and literacy.

From her first-hand observations, Saul provided further evidence of increased advantages for student learning through integrated curriculum.

Project 2061's *Science for All Americans* (AAAS, 1989a, 1989b), *Benchmarks for Science Literacy* (AAAS, 1993), and the NRC's (1996) *National Science Educations Standards* all emphasized that all students should be able to describe, explain, and predict natural phenomena. The natural curiosity that children have provides the motivation for reading to find out how things work and being able to explain their understanding of science concepts through the comprehension of ideas in nonfiction literature. Significant improvement in both reading and science scores of fourth graders was found when the regular basal reading program was replaced with the reading of science materials that correlated with the science curriculum (Romance & Vitale, 1992).

For varied reasons, teachers' pedagogical approaches to integrating science and language arts has been increasing in popularity. The idea that accessing information and writing to share results are shared by both the science and literacy skills, more journaling for literacy and more nonfiction reading in the curriculum for literacy has been popping into teachers' lesson plans.

Literacy and science also provide a rationale for integration because both use the idea of constructivism in guiding reform-based teaching, share cognitive processes, and play an essential role in the work of scientist (Bradbury, 2014).

Science IDEAS (2007) provided another look at an evidence-based instructional model integrating science and literacy. The Science IDEAS model provided a 3-year, in-depth science instruction that positively impacted learning in both science and literacy. Students in Grades 3–5 showed a cumulative growth of science learning and the associated growth in literacy proficiency (Vitale & Romance, 2011). With a success story unfolding, the instructional model was extended to the K–2 curriculum. The focus became a schoolwide model, encompassing K–5 grades and motivating other school-related functions, such as assemblies, field trips, and family science events. Positive gains in both science and literacy were noted and the treatment effect was consistent with at-risk and non-at-risk students. The perspectives of the integrated instruction and the research findings offer implications for reform. "Together, they are suggestive of the means by which K-5 schools and school systems could raise their student achievement expectations in science and reading" (Vitale & Romance, 2012 p.9). From the interdisciplinary research of the NRC (2000) the concept-focused instruction provides an effective framework for considering theme-based science content as a basis for reading comprehension development (Romance & Vitale, 2001). Tables E1, E2, and E3 provide evidence of success.

Further support for the ideas of integrated curriculum come from concepts in project-based learning. Duke (2016) noted the power of project-based learning to teach informational text: "When the common core standards were implemented a lot of misconceptions and instructional mistakes were occurring while teachers were trying to rush informational text into the curriculum" (p. 3). Some of the books given to students were beyond their readability level, topics were presented that may or may not have interested the students, and writing without an authentic purpose prevailed. The advantages of project-based learning using an integrated curriculum approach produced valuable positive outcomes for the reading, writing, and development of subject area content knowledge; it enhance the standards and 21st century skills and also encourages students' self-efficacy, engagement, and motivation. As a professor of literacy, language, and culture at the University of Michigan, Duke (2016) stated, "In my 20 years of researching how children learn to read and write informational texts, I have been convinced that a project-based approach is the best overall framework for teaching literacy skills for informational texts."(para. 9)

Studies have been done to identify how effective instructional strategies can help ELLs become more accomplished learners. The constructivist teaching theory for the elementary science classroom is prominent in the instruction of culturally diverse students. When literacy and science instruction were integrated to help develop learning-style research, they proved useful resources for designing appropriate instructional learning plans for culturally diverse students. It was found that through learning styles, an integrated curriculum is a preferred way in which students' perceive, process, store, and retrieve information (Gibbons, 2004). The challenging need to acquire language proficiency and the content area curriculum to meet the growing diversity in the elementary classroom for students whose primary language was not English thus becomes a focus of many studies. Cochran-Smith (2001) also noted, "The need for dramatic change in the way teachers teach has created concern for teachers in how they educate all children well, particularly children of color, children who are poor, and those who come from diverse linguistic backgrounds" (p. 91). Literacy and language proficiency becomes enhanced when ELLs receive appropriate science instruction in a manner that allows students to construct their knowledge through learning activities, imaging, organizers, and interactive writing (Fradd & Lee, 1999).

In research at California State University in Bakersfield, Gibbons (2004) developed an evaluation instrument to aid teachers in teaching elementary science instruction to English learners. Gibbons's observations led to suggestions for how to incorporate instructional strategies that included academic language scaffolding for science vocabulary, integrated curriculum, and learning centers to manipulate science materials independently.

Sometimes the motivation to stay focused on learning wanes as students enter the upper elementary and middle school environment. Inquiry science programs using learning goals can create an environment where mistakes can be made and true learning can occur (Guthrie & Davis, 2003, Forrest, 2015). The key components of the literacy aspects—the skills of listening, writing, and speaking—are all a part of the inquiry process in learning. For students to be engaged in learning, inquiry-based science literacy skills help educators bring real-world problems to the students and increase their learning experience, helping learning to become more meaningful (Forrest, 2015). In summation, evidence of success through the integration of literacy and science through project-based learning is becoming more and more prominent, enabling teachers to utilize their instructional time to meet the expectations of the standards and increase student achievement through their learning motivation.

Interdisciplinary Mathematics & Science

Although the world is rapidly changing with technology advances enhancing our perspectives on gathering and disseminating information, the education system has remained mostly static in its approach to helping students learn. The same school schedule and format for curriculum has remained a constant since the beginning of the Sputnik era of educational reforms. The state of New Jersey has advanced in promoting a standards-based approach to curriculum, but those standards remain as nine separate disciplines to be covered in students' curriculum as expectations and mandated guidelines for the classroom teacher to cover during a given academic year. The framework for the school year remains by state averages as 180 days and approximately 6 and one half hours or 390 minutes per day for elementary school students (Achieve, Inc., 2016).

During the past century, one distinctive effort to improve science and mathematics education is an approach that recognizes commonalities between science and mathematics and seeks to appropriately and effectively integrate these two disciplines in teaching and learning (Berlin & Lee, 2005; Berlin & White, 1998; Lee, 2000; Pang & Good, 2000; AAAS, 1993). As educators work within the frameworks, there are no separate boxes for interdisciplinary connections or integration of 21st century themes and skills, nor are there modifications for special education, ELLs, students at risk of school failure, or gifted students. This is intentional, as the interdisciplinary connections of themes and skills are to be integrated throughout the frameworks. Educators should be mindful of these as they build out the frameworks and code them appropriately (NJDOE, 2013).

A number of national science and mathematics education professional associations (and recently technology education associations) are united in their support for the integration of science and mathematics teaching and learning. The national education reform documents published by the following associations recommend the integration of science and mathematics education: AAAS (1989a, 1989b, 1993, 1998), ITEA (1996, 2007), NCTM (1989, 1991, 1995, 2000a, 2000b), NRC (1989, 1990, 1996), NSTA (1992, 1997), and Berlin and Lee (2005).

In the NJCCCS for Science, the NJDOE (2016a) online information it is stated,

> Science, engineering and technology influence and permeate every aspect of modern life. Some knowledge of science and engineering is required to engage with the major public policy issues of today as well as to make informed everyday decisions such as when selecting among alternative medical treatments or when determining how to invest public funds for water supply options. In addition, understanding science and the extraordinary insights it has produced can be meaningful and relevant on a personal level, opening new worlds to explore and offering lifelong opportunities for enriching people's lives. In these contexts, learning science is important for everyone, even those who eventually choose careers in fields other than science or engineering. (para. 1)

In the elementary classroom, where a foundation is developed to build on knowledge and perceptions, the average fourth grader spends 90 minutes per day on science and social studies instruction, according to the New Jersey state average, but does this really accurately portray what learning for these disciplines actually happens in the classroom? Usually, this timeframe is in the afternoon and is sometimes replaced by assemblies, fire drills, lock-downs, character education, and so forth. With the focus on expanding 21st century skills that include collaborative learning and critical thinking skills, can science or social studies as academic disciplines be given with such a small priority?

Deidre Richardson, Coordinator for the New Jersey Core Curriculum Content Standards in Mathematics, stated, "The principles for school mathematics address the overarching themes of equity, curriculum, teaching, learning assessment and technology" (NCTM, 2000a, 2000b p. 2). Richardson justified her position: "Researchers in mathematics have recommended a more narrowed focus and coherence to help achieve more student success. Rather than making broad generalizations, standards are to help focus and narrow specific content ideas" (NCTM, 2000b, p.2). The average fourth grader is provided with 75 minutes of mathematics instruction per day, as given in the state mandates for curriculum guidelines (Achieve, Inc., 2016).

As separate parts of the curriculum, mathematics and science stand as two separate ideas which suggest to students two separate and distinct disciplines, thus the question some students ask: "When am I ever going to use this?" When some of the science and mathematics efforts are combined to show that both concepts work together from the two disciplines, illustrating that working together enables solving problems and creating innovative solutions to everyday problems, it becomes a reality to students. This is what the NGSS were created to enunciate with the combination of science and engineering concepts.

Most recently, the initiative for STEM has been developed in the NGSS (Achieve, Inc., 2013b). These newest expectations add demands for the elementary classroom teacher to become familiar with, and develop curriculum to meet these needs as well. The average length of time in New Jersey schools is 5 and one half hours for each day spent in the elementary classroom, 180 days per year (NJDOE, 2016a), remaining the same year after year. The expectations for teaching all of the social and academic demands of the curriculum have created a problem regarding how to cover all that is increasingly expected. Nothing is ever eliminated from the curriculum.

Educational leaders need to find ways to help elementary classroom educators address all of these compiled standards and meet expectations across the curriculum for each grade level to insure that student achievement continues to show improvement with the ever-changing system of testing which now holds teachers more accountable for their students' learning outcomes (Achieve, Inc., 2016). Our American public education system provides a guarantee that students have a thorough and efficient education, but the methods of reaching that goal now contain increased demands, evaluating teachers for effective teaching methods by way of measuring student achievement on high-stakes tests while adding the STEM initiatives and changing science standards to NGSS.

"Textbook companies have provided the curriculum for science and mathematics as two separate disciplines" (NCTM, 1991, p.11), In past years, for the most part, boards of education have approved a series of textbooks such as *Everyday Mathematics* or science such as Foss and STC Kits, or Scott Forsman Science to become the curriculum for their districts. With the introduction of state standards, CCCS, and NGSS, it is the textbook companies who have tried to be all- inclusive in their area of disciplines, providing such a broad spectrum of ideas that many students fail to understand any possible connections to concepts that would provide them with a big picture of their goals for career possibilities in the fields of science, engineering, or mathematics. Educators observe the trends of many students in the elementary level. At an early age, students learn to like or dislike subjects because of their limited knowledge and understanding of how subjects can be integrated to help problem-solve and shape the future. If a student finds mathematics challenging and thus lacks the motivation to pursue ways to internalize the knowledge and usefulness, he or she limits their opportunities to advance in some fields of science or engineering. There are very few elementary students that do not enjoy hands-on science activities and participate with enthusiasm when given manipulatives as part of a math lesson focused on active problem-solving. Learning to work in groups, asking questions, and creating a process to evaluate outcomes are all 21st century skills and part of the NGSS expectations that indicate science can be a great motivator for students to become engaged in more difficult tasks as they mature and develop skills. In mathematics, students can see that there is more than one way to solve a problem. Why do we not capture and nurture that spirit of success beyond the elementary level for most students? How can connections to mathematics, science, and engineering be developed into guidelines for 21st century learning in classrooms across the United States? An example of how integration may work with effective teaching guidelines is shown in (Appendix E). Table E1 shows the suggested integration for a sample Language Arts unit, Table E2 shows the suggested integration for a sample Mathematics unit and Table E3 shows the suggested integration for a sample Science unit. The samples provided display an integrated example of how teachers in one school district can effectively use an interdisciplinary approach to their teaching methods.

A hypothesis of this current research suggests the answer may lie in the CCCS being used together with integrated math, science, technology, and engineering skills. Since 2010, 45 states and the District of Columbia have adopted these standards to help raise the expectations for students across the nation. The standards-based curriculum emphasizes the individual disciplines and has largely displaced the integrated curriculums once popular in the 1980s and 1990s (Drake & Burns, 2004).

More and more programs are being developed with integrated science and mathematics themes at various universities to help teachers meet the needs of the standards through the integration of STEM or STEAM subject matter. Once teachers gain an understanding of how standards are connected, their perceptions of integrated curriculum change drastically. They are able to chunk standards together both within the subject and across disciplines (Drake & Burns, 2004).

Writing for the NCTM online, Diane Ronis (2015) provided additional support for integrated curriculum:

> Research indicates that an integrated approach to learning aligns with the way the brain naturally processes and internalizes new information. Since mathematics and science are integrated in the world outside the classroom, and technology has become a natural extension of this integration, it seems only logical that these areas are studied together inside the classroom. ("Problem-Based Learning")

As advances continue, science and mathematics seem to play a more important role in integrated learning concepts for the future. The examples of integrated curriculum highlight the potential of an integrated curriculum acting as a bridge to increase student achievement and engaging relevant curriculum (Drake & Burns, 2004).

The term *project-based learning* has also received attention from many. During a project-based learning project, the students take on the challenge of solving a local problem. Studies show that students in project-based learning go beyond the minimum effort and make connections through various subject areas to answer open-ended questions, they have lower absenteeism and fewer discipline problems, retain what they have learned, and apply learning to real-life problems (Curtis, 2002).

STEM and STEAM Movements for 21st Century Learning

Over the past two decades, the National Science Education Standards have been focused on teachers developing students' scientific literacy through student-centered, inquiry-based learning (NRC, 1996). The results of a 2012 national survey on science teaching reported that 60% of 881 K–5 elementary teachers across the United States used reform-oriented teaching (Mangiante & Moore, 2015; Trygstad, 2013). This approach allows the students to investigate and answer scientific questions with support from evidence collected during their experiments. Engineering concepts provide students with an opportunity to develop and apply their scientific knowledge with practical problems to prepare them for a future decision-making role as citizens (Mangiante & Moore, 2015).

Universities throughout the nation are focusing their educational research efforts on developing programs that will help to connect standards with the curriculum and creating initiatives to integrate concepts for math, science, engineering, and technology wherever possible. Some of the most developed and teacher-friendly examples are found using the constructivist approach of hands-on, minds-on learning. Hofstra University; the University of

California, Berkeley; and the University of Massachusetts, Boston; to name a few, have been provided research grants through the NSF (2016) to support these efforts.

The New Jersey Council of Research and Development has compiled a list of programs for the entire state that encourage STEM initiatives; many are summer programs aimed to involve children during their summer vacation time. Some are directly connected to universities and also help teachers in their professional development so they can learn to implement STEM ideas effectively when beginning to integrate their curriculums. When teachers expose students to an integrated approach to learning math and science, they develop better communication skills and are more confident and competent in these subjects; effective STEM integration provides students with opportunities to construct new knowledge and develop problem-solving skills through designing artifacts (Fortus, Krajcikb, Dershimerv, Marrx, & Mamlok-Naamand, 2005). Many research-based programs have provided approaches to integrated STEM education initiatives: design-based science (DBS; Fortus et al., 2005), Math Out of the Box (Diaz & King, 2007), Learning by Design™ (LBD; Kolodner et al., 2003), and integrated mathematics, science, and technology (IMaST; Satchwell & Loepp, 2002) provide a few examples.

The information provided in this field would make a research project in and of itself. It is mentioned in this dissertation only to acknowledge that all aspects of 21st century education in the elementary schools have been considered for integration and curriculum alignment.

Scoring Educational Efforts & International Benchmarking

Standardized testing has been used for decades to determine student performance, placement and achievement, teacher salary, school accreditation, district funding, and graduation opportunity (Smyth, 2008). The publications of *A Nation at Risk* (National Commission on Excellence in Education, 1983), *Goals 2000 Legislation,* and the impact of the NCLB have been some of the informational reports disseminated to politicians and lawmakers which have sent an alarm through the land to raise the expectations of our educational system. Every year, the NCES provides *The Condition of Education*, a report to monitor the progress of education in the American education system. Information becomes readily available for policymakers to take into account in this extensive volume of progress from year-to-year when decision-making for educational policy. The most recent test scores for NAEP Program served to evaluate the progress of the nation's students in three subject areas: mathematics, reading, and science at Grades 4, 8, and 12. The PISA reports on the performance of 15-year-olds in mathematics and science literacy in 65 countries and other education systems, including 34 OECD countries. The OECD countries are a group of the world's most advanced economies. The TIMSS is now entering into its 20th year of data collection. The TIMSS is an international assessment of mathematics and science at the fourth and eighth grades which began with the first assessments in 1995 and has continued every four years, including 1999, 2003, 2007, 2011, 2015, and 2019. For countries with data back to 1995, the TIMSS 2015 provided the sixth in a series of trend measures collected over 20 years. Approximately 60 countries have the TIMSS data, and new countries join the TIMSS in each cycle. About 70 countries were expected to participate in the TIMSS 2015 (Mullis, 2015).

The PIRLS began in 2001 to measure fourth grade students' reading achievement and is administered every 5 years. Created to complement the TIMSS assessment of fourth grade mathematics and science, over 60 countries participate in the PIRLS, measuring the reading comprehension skills and educational contexts for learning to read. The information contained in these assessments is useful for policymaking to improve reading achievement. Measuring fourth grade reading skills is an important transition point in children's development as readers, for they have learned how to read and now begin reading to learn (PISA, 2016).

The general consensus by lawmakers and other stakeholders viewing the educational system is that there needs to be accountability for providing students with a thorough and efficient education for the 21st century. Schools which receive Federal ESEA funding must make progress, known as Adequate Yearly Progress (AYP), on test scores. Schools compare scores from one year to the next, and use the difference to determine how well or poorly the students did (Hassard, 2012). Accountability for those outside the world of education is equated with standardized testing results.

> This simple, linear approach to educational renewal is badly flawed. It is virtually identical to all the other approaches to renewal that have preceded it, and it misses the point. Meaningful change is not accomplished through political pressure but, rather, through attention to the idiosyncratic, often paradoxical nature of learning. As many states are discovering, "raising the bar" by commandment results in a jump in high school dropouts, increased spending on student remediation and staff preparation for new assessments, constriction of curriculums as they are aligned with the new assessments, and loss of public confidence in schools as large numbers of students fail to meet the standards. Missing from this mix is evidence of increased student learning. (Brooks & Brooks, 1993, p. 12)

High-stakes testing has resulted in forcing teachers to teach to the test since even their performance, as well as the students' performance, is slated to be evaluated by these tests.

This creates a disadvantage to student learning which is mostly focused on learning facts and rote memory for tests: "Teaching to the test is eliminating the opportunity for teachers to teach students higher-order thinking skills" (Darling-Hammond, 2004, p.1047). Teaching to the test has the tendency to reduce teacher creativity, innovation in instruction, varied methods of reaching a diversified student population in the classroom, and motivation for lifelong learning by both the teacher and the students (Smyth, 2008). The National Center for Fair and Open Testing (2007) reported the effect of the high-stakes testing sets in motion the need for teachers to mobilize to higher performing schools. Students with the greatest need are then left behind as evidenced in a summary by Flores and Clark (2003):

> When teachers' decision making power is limited, their ability to be innovative in meeting student needs is also limited, thus leading to feelings of frustration and to a sense that their educational role has been reduced to that of a technician. Removing decision-making power from the teacher is a clear example of de-professionalization. (p. 15)

A major flaw of the current high-stakes testing program is the focus on high-stakes accountability systems and the ramifications of that focus on teachers and students. The concern for accountability and student achievement has been expressed so often in continued research, this statement from Grennon- Brooks and Brooks (1999) seems to sum up the entire situation:

> Rather than set standards for professional practice and the development of local capacity to enhance student learning, many state education departments have placed even greater weight on the same managerial equation that has failed repeatedly in the past: State Standards = State Tests; State Test Results = Student Achievement; Student Achievement = Rewards and Punishments. (p. 18)

This research has made clear the need for some changes in the process to reach effective accountability in order for progress to take place in student learning and achievement.

Research has shown that schools operating in high-stakes accountability systems typically move attention away from principles of learning, student-centered curriculum, and constructivist teaching practices. Instead, the focus is on obtaining higher test scores, despite research showing that higher test scores are not necessarily indicative of increased student learning (Brooks & Brooks, 1999).

Although testing such as the NAEP, TIMSS, PIRLS, and PISA do help us visualize U.S. progress as viewed through a window to the nation and the world, it should not be the only indicator used for decisions and policymaking. Searching for answers on trends in international testing, other nations have surpassed the United States many times, but this has only previously been addressed in reports which have led to more educational policy changes. According to

Tienken (2016), “The U.S. students have never ranked at the top of any international testing of academic skills and knowledge since the beginning of international testing in 1964” (p. 112). There are many factors that make this statement by Tienken one to consider. Some nations only allow the academically tracked students to participate in testing and some nations do not have the diversified population of students with limited language barriers or learning disabilities in their student populations to be tested as does the United States.

With the implementation of technology, programs could be established that would track students’ individual progress over time and help to develop learning goals according to individual needs and gaps in learning retention. Students could then be motivated to increase their own learning potential on an individual basis, not being assigned a number score as the only means of measuring achievement, thus stimulating individual student learning progress.

Skills for Competing in a Global Economy

As a pilot state for the federal “School-to-Work” initiative, New Jersey emphasized the importance of every student linking school-based learning with a career major and of having both school-based and work-based experiences. Since one of the goals of public education is to prepare students for the world of work, it is important that these standards be addressed through all content areas (NJDOE, 1996a). From the beginning of the standards movement, the need to prepare students for the work force has been a focus. With the introduction of technology, the emphasis on 21st century educational goals have redirected the focus for teachers to be on developing students to a global market for work force skills.

The National Academies Press (2012) stated,

> Business, political, and educational leaders are increasingly asking schools to integrate development of skills such as problem solving, critical thinking and collaboration into the teaching and learning of academic subjects. These skills are often referred to as “21st century skills” or “deeper learning.” (pp. 5–6)

A new vocabulary emerges from these terms and an understanding of their meaning becomes necessary in order to produce positive outcomes for school, work, and life.

The NRC (2012b) developed a committee consisting of educators, psychologists, and economist to define and address how to teach these skills and examine the related issues. In their work, the term *deeper learning* was clarified to mean a process where learning in one situation can be applied and transferred to new learning situations, and understanding is at a level whereby students can refine an individual subject area or discipline (NRC, 2012a, 2012b). The NRC uses the broader term, *competencies*, rather than *skills* to include both knowledge and skills for 21st century learning. In developing an organizational portfolio of these 21st century skills, the NRC committee first identified three broad domains of competence: a cognitive domain, intrapersonal domain, and interpersonal domain. The work of this NRC committee only provides a starting point and frame of reference for further research because “precise definitions of the many terms used for 21st century skills are not possible at this time, in part because there is little research to support such definitions” (NRC, 2012b, p. 186).

The cognitive domain consists of the following competencies: analysis, decision-making, adaptive learning, problem-solving, interpretation, information and communication technology, active listening, creativity, innovation, and critical thinking. The intrapersonal domain includes adaptability, integrity, appreciation for diversity, intellectual interest and curiosity, self-monitoring, continuous learning, artistic and cultural appreciation, initiative, self-evaluation, flexibility, metacognition, self-direction, physical and psychological health, work ethic and conscientiousness, grit, citizenship, perseverance, responsibility, self-reinforcement, and career orientation. The third domain, interpersonal, incorporates responsibility, social influence with others, assertive communication, leadership, empathy and perspective-taking, trust, interpersonal competencies, self-presentation, coordination, conflict resolution, service orientation, negotiation, collaboration, cooperation, and teamwork (Appendix F). Although the listed competencies or skills look overwhelming, there are many of the same skills monitored by the elementary classroom teachers in their assessments of students during progress reports or indicated on report cards (Appendix G). As grade levels increase, the skills become less and less of a verbally monitored list: in upper grades usually letter grades are reported and skills analysis for each individual student are diminished in recognized importance as the grade point average dominates importance in high school and college-level work.

The NRC committee found important areas in which goals for deeper learning and 21st century competencies overlap with the CCCS in English language arts and mathematics and the NRC Framework for K-12 Science Education. Critical thinking, nonroutine problem-solving and constructing and evaluating evidence-based arguments serve as examples (NRC, 2012a). Although the focus for the competencies may change the way teachers are prepared for their careers in education, through professional development updates and preservice courses that help to integrate curriculum, the deeper learning may already exist, but not be synthesized throughout the grade levels of a student's learning pathway (NRC, 2012a).

In summarizing the literature reviewed for this current research, many aspects of education seem to spiral in and out of the focus and framework for the system of American education. All of the reforms based on improving education seem disconnected from each other as the pieces of a puzzle no one has been able to put together to form the larger picture of what creates the best way to educate American students. As researchers write and rewrite valid and credible information, more and more emphasis and funding are placed on testing to hold those in education accountable for student achievement, not an emphasis on integrating or aligning curriculum which may only be understood by educators. Educators, the people who are working in the classrooms across America on a daily basis, report a need for a thorough and efficient way of meeting all the demands of standards and 21st century learning skills for their students. Educators who want to find a valid and professional way of making their students' achievement a valuable measure, not for the records, but for the students, are frustrated by some educational reforms, especially the high-stakes testing requirement. Researchers and educational administrators have observed the classroom, focusing on success stories, publishing and sharing their findings in the hopes that those findings will help educators in the classroom, but have not always been able to successfully link their efforts. Policymakers, far removed from the classrooms of America, do not have the big picture, the vision of how to get to where they want American education to focus and function. Zhoa (2009) addressed the essential question: Are we moving ahead or catching up with our American education ideals in the age of globalization?

Summary

The theoretical framework of this current research indicates that integration of the curriculum is of value to the students' ability to learn as it emphasizes the constructivist theory for education. Constructivism allows for the students to challenge their previously learned knowledge and build more complex understandings as they grow developmentally, attach relevance to the curriculum, formulate big ideas in learning, and continually assess their student learning from daily activities not from the mandates of a separate one-time event for testing. This system of integrating curriculum seems to help construct meaning and by scaffolding the teaching helps students reach more potential for becoming life-long learners. Chapter 3 includes details of the research methodology implemented to assess the progress made by students using an integrated curriculum map for their learning with peer students who have not used an integrated–interdisciplinary curriculum.

CHAPTER 3

METHODOLOGY

The review of literature was an exploration of many of the reform-based initiatives: standards, curriculum, and assessments, including the recently initiated PARCC high-stakes test replacing the NJASK for literacy and mathematics. The focus of the research was on the problem of whether student learning is enhanced when using an integrated–interdisciplinary curriculum by analyzing state testing data of the fourth grade students. The research questions were as follows:

1. Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC?
2. Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC?
3. Will an integrated–interdisciplinary curriculum increase academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment?

To explore answers to these research questions, a method to analyze student achievement was conducted. The nonexperimental, causal-comparative (also known as an ex post facto) research analysis was performed with information for student achievement taken from the NJDOE’s website where the scores for NJASK testing and newly initiated PARCC testing are published yearly. This method of collecting data—the nonexperimental, causal-comparative—was used to show a comparison of the curriculum, rather than a concentrated correlation study of the integration of elementary mathematics, literacy, and science curriculum; there was no direct manipulation of the independent variable, the integrated curriculum. To determine if the level of student achievement in mathematics, literacy, and science had increased as a result of using an integrated–interdisciplinary curriculum, the NJ Performance Report scores showing percentages for PARCC scores in literacy and mathematics and the student percentages for the NJASK4-Science scores were analyzed for the years 2014–2017. Gay, Miles, and Airasian (2009, pg.218) compares "differentiated correlation research from causal-comparative, explaining that the causal-comparative research approach is an attempt to determine reasons or causes for the existing conditions". The causal-comparative method is also known as the ex post facto method for analysis because the treatment occurs before the study, thus the term *experience* is used rather than treatment (Campbell & Stanley, 1963). All of the information for this present study had already been reported to the public by the NJDOE, as all results of the NJASK4-Science and PARCC tests. These tests are reported annually for each subject studied, including mathematics, literacy, and science. This researcher's utilization of state data represented a carefully controlled quasi-experimental design, and "is suggested as the only approach that allows the researcher to draw definitive conclusions about the cause-and-effect relationships" (Campbell & Stanley, 1963, p. 222).

To be more definitive about the type of study, a matched-pair design was used so the participants in the study were paired, having carefully checked curriculum for schools and districts that self-identify as having an integrated–interdisciplinary curriculum with those that do not mention the integration of curriculum at the fourth grade level for mathematics, science, and literacy (see Appendix A). A sampling of 50 schools with self-identified integrated curriculums were paired with 50 schools that do not identify as using an integrated curriculum. The assumptions for this study were that the sample data consist of matched pairs and the samples were simple random samples (Triola, 2001).

An interdisciplinary curriculum as taught by the elementary teachers was measured and analyzed for effectiveness against other public schools in a random selection from the state of New Jersey in the suggested matched-pair schools. The information needed for this study was supplied by the school district on their website and through observations and review of the curriculum guides at the elementary level for Grade 4 from the websites or from the state performance report narratives. All schools randomly selected also had their curriculum guides reviewed as made available by districts on their websites. Schools with nonintegrated curriculums were used for the matched-pair to schools with self-identified integrated curriculums.

The scores for NJASK4-Science testing and PARCC literacy and mathematics assessments are readily available to the public. This method was chosen based on the premise that the matched groups for the study would be a definitive method of determining if an integrated–interdisciplinary curriculum does affect the outcome of student learning and achievement. PARCC has not created a science test as of 2017; thus NJASK4-Science scores were analyzed using the combined percentages of the partially proficient and advanced proficient as indicated in the state information graphs.

The result of the methodology was the establishment of a 50/50 matched-pair group of elementary schools using fourth grade testing score percentages to analyze if an integrated–interdisciplinary curriculum increases student learning through an analysis of the achievement scores. The sample size for this study totaled 100 schools. The districts represented by these random matched-pair schools were viewed for their curriculum delivery of subject matter by researching district curriculum maps or guidelines as posted on districts' websites to determine if the elementary curriculums in matched-pair schools appeared to use an integrated–

interdisciplinary approach or a subject-specific approach when teaching the fourth grade curriculum.

Research Design

The similarities and differences between causal-comparative, also known as ex post facto research design, and correlation research design have been explained by several authors in educational research textbooks. Fraenkel and Wallen (2006) stressed that causal-comparative research is "intended to determine the cause for or the consequences of differences between groups of people. Using the design, groups can be compared to see if they differ in their achievement" (p. 11). An important difference between causal-comparative, also known as ex post facto, and correlational studies is that causal-comparative studies involve two or more groups of participants (matched-pair schools) and one grouping variable (integration of curriculum on student achievement). In correlational research, two or more variables are used with one group of participants (Gay et al., 2009).

Causal-comparative (or ex post facto) and correlation research have several similarities. Both are nonexperimental, lack the manipulation of an independent variable and random assignments of subjects, and neither method of research produce definitive outcomes; both may indicate relationships among variables and a direction for future research studies. The purpose of this study was to further validate or investigate whether the results of the student achievement can be attributed to an integrated–interdisciplinary curriculum.

Participants

Collecting data from the New Jersey Performance Report for the PARCC information from 2014–2017 and the accompanying NJASK4-Science allowed for the comparison of student achievement for the matched-pair schools in a random matched-pairing of elementary schools across the state. The research needed was collected publicly from the NJDOE and school district websites. It was the researcher's understanding that upon a request and approval to collect this data and provide an analysis, an exemption from the Institutional Review Board (IRB) was granted.

Setting for the Study

Taking the results from the New Jersey Performance Reports for the PARCC assessment reports from 2014–2017 for mathematics, literacy, and NJASK4-Science in Grade 4 and using the causal-comparative study (ex post facto study) for a random matched-pairing to compare student achievement randomly across the state provided the information to be collected and analyzed. Science is not tested at all grade levels for the NJASK or PARCC assessments, which was another reason for the Grade 4 focus. In addition, a science assessment was not fully implemented and operational in the new PARCC testing by the time of data collection for this research project, thus, only NJASK4-Science 2014–2017 scores could be analyzed to determine student achievement for the targeted districts in Grade 4.

Treatment–Experience

The treatment for this study had already occurred through the implementation of the integrated–interdisciplinary curriculum efforts of the matched-pair schools in the everyday delivery of classroom curriculum over the years of this study's focus: 2014–2017. Because this treatment had already occurred, rather than a treatment to be implemented by the researcher, a review of an experience that had already naturally occurred in the districts due to curriculum revisions and updates was conducted. The schools in the researcher's home district began integrating the curriculum to include combined efforts to make connections for student learning enhancement beginning with the revisions of the 2010–2011 school year curriculum reviews and provided a thorough vision of the interdisciplinary curriculum through the curriculum maps posted on its website for each grade level (see Appendix H for convenience samples).

The NJASK testing was used successfully to report elementary school student achievement for a 10-year period from 2002–2012 in Grades 3–8. The first year, 2002, was the field-testing year for NJASK; prior to this was the Elementary and School Proficiency Assessment (ESPA) testing program. NJASK was created to measure student achievement as exemplified in the NJCCCS and the initiation of the NCLB in 2002. The PARCC testing program was initiated in 2013 (field-testing year) for the first time, and scores reported for the first time to the public in 2014. Many parents, teachers, and members of the general public have voiced their opinions over this test. It has met with public resistance, subsequently modified to take less time and tweaked to provide a better picture of 21st century skills. The PARCC continues to evolve and, as such, must be viewed with its limitations in mind. For the above reasons, the PARCC testing, if it remains in effect during the newly elected governor's administration, leaves options for future research.

Research Methods

Data Collection

As a starting point, schools were randomly paired after having been determined to have a self-identified integrated curriculum with schools not identified as using integrated curriculums. This determination was made by the researcher through reading and reviewing the schools' websites for posted curriculum based on the criteria checklist found in the Appendix A. The next step was to explore the New Jersey Performance Reports for all the score averages for each school. The reports can span a limited amount of testing information when schools were found to house primary students from PK–2 as they are not developmentally ready for performing in lengthy testing periods, only approximately 12 pages per report, but good for determining if the district had a self-identified, integrated curriculum. Elementary schools averaged a report of 26–30 pages each and K–8 schools could have up to 40 pages of information. All scores for Grade 4 students were searched out and entered for analysis in Excel spreadsheets (Appendices I, J, and K) to help manage the study for the researcher as a starting point; later this information was transferred to the SPSS format.

Variables

The independent variable was the use of an integrated, also known as interdisciplinary, curriculum to measure the growth of student achievement. The dependent variable was the schools' percentile scores for the subject areas of mathematics, literacy, and science. The statistical analysis was completed using SPSS Version 24 software programmed to calculate the matched-pair outcomes. The data were collected to determine if the null hypothesis of no difference in student achievement scores was apparent in the self-identified integrated–interdisciplinary curriculum.

Sampling

The student population for the 100 elementary schools was used without exclusion of any groups such as special-needs or ELL students. The school districts and schools in this study were randomly selected. For future years, implementing a continuation of the PARCC testing scores would provide an opportunity to look for upward trends to be anticipated, as the testing is implemented annually with the implementation of 21st century skills, including the use of computers by the students to take the assessment rather than using pencil and paper; this variable should be noted and taken into consideration. The districts would differ according to the implementation of the computer-based instruction and testing program. Rapidly changing expectations of student assessments are the norm in our ever-changing educational system striving to catch up to the 21st century demands.

The data collected for the study were only collected from the NJDOE's database of scores for the PARCC and NJASK testing. Subsequent matched-pair school information was gathered publicly through the NJDOE's database and district websites as well. Approval for conducting this research included an exemption from the IRB, as all of the documents used were in the public domain and only school-level data were used.

Instrumentation

The PARCC tests are designed to measure student achievement in language arts literacy, mathematics, and NJASK4-Science as obtained from the NJCCCS. These PARCC and NJASK tests were administered to Grades 3–8 and aligned to meet the requirements outlined in the NCLB. The NJDOE provides results by general education, gender, race, ethnicity, special education classification, and economic status. This dissemination of information began with the 2001 administration of the ESPA (NJDOE, 2008).

The NJASK tests were designed to measure the student progress under the NJCCCS. These standards originated in 1996 to define the framework of what students should know and be able to do at the end of their K-12 educational experience. Several revisions over time were developed into a newly revised and modified version in 2016 and entitled the New Jersey Standards for Student Learning. A new set of testing instruments—the PARCC—were devised to meet the 21st century learning expectations and the needs for college and career preparedness. Achieve, Inc. had created testing for New Jersey based on the newly mandated standards revisions and updated skills needs; it finished a field-testing year in 2013 and 3 years of test results for 2014–2015, 2015–2016, and 2016–2017. This new testing was known as the PARCC tests. The PARCC test results were included as part of this study as per the committee recommendation.

In working with the PARCC for literacy and mathematics scores and the NJASK4-Science tests as the instrument for use in the data analysis, the reliability and validity of this study was steady and assured. The methods for data analysis also provided increased validity and reliability through the use of the random matched-pair study and analysis to further assure that interpretations of data by both descriptive and inferential analysis were not just a chance difference due to a possible sampling error. The hypothesis that integrated–interdisciplinary curriculum increases student achievement and the null hypothesis that there is no difference in student achievement by the delivery of curriculum, whether integrated or whether the literacy, math and science are taught separately (subject-specific) as subjects independent of each other, was proved or disproved by the use of this study’s thorough method of data analysis.

Procedures

Testing information for the PARCC and NJASK4-Science tests was downloaded from the NJDOE and district websites into an Excel program. Information was reviewed for relevancy and downloaded from the NJDOE for PARCC and NJASK4-Science for the years 2014–2017 for each of schools in the matched-pair study to draw comparisons for the study. The plan included analysis of the data using an SPSS Version 24 software program to determine the mean value of the differences (*d*) for the population of paired data. The hypothesis test based calculations on the differences (*d*) between the pairs of data. The first part of the SPSS implementation provided a descriptive statistical analysis using frequencies and a *t* test for the means and standard deviations.

Methods of Data Analysis

The researcher used a descriptive statistical analysis through a single test because the paired differences have a normal distribution from the collected data. "If the variance between the groups was much greater that the variance within groups (i.e., greater than would be expected by chance), the ratio would be larger and a significant effect would thus be apparent; however, if the variance between groups and within groups did not differ more than would be expected by chance, then the ratio would be small and the groups would not be significantly different" (Gay et al., 2009, p. 342).

Discussion of Controls

The creation of the new standards and testing also brought the development of new and improved technology to help generate fair comparisons in the new tests. Grade levels provided age-level appropriate information and comparisons.

The main question, whether the differences among the means represent true, significant differences or the differences are by chance, perhaps due to sampling error, was answered in a further study by using an analysis of variance (ANOVA) in which an *F* ratio was computed. This analysis alleviated statistical problems concerning any distortion of the probability of an error. As Gay et al. (2009) indicated, an ANOVA test is more efficient and keeps the error rate low.

Step-By-Step Procedures

The following steps were conducted in this study:

1. *Gaining the permission to do the study.* Gaining the permission for this study to be conducted was paramount. Many attempts for studies fail to gain acceptance, leading to failure (Madsen, 1992). The research for this study was conducted

without using information of a sensitive nature; instead, the researcher used publicized general and educational information from the NJDOE website to provide information for each school. This information is accessible to the public and gathered from the state performance reports and individual school website information accessible to the public. The Institutional Review Board did not have to review this proposal.

2. *Identify the schools to be included in the study.* The schools were selected randomly until 50 schools were found to have self-identified an integrated curriculum and 50 schools were found that did not have an integrated curriculum determined by information from the NJ Performance Reports and school curriculum websites. This made a total of 100 elementary schools for the sampling of this research. Then the schools were paired by grade level configuration of their school populations (e.g., K–4, Grades 3–6, K–8). No other considerations were taken into account in the pairing.
3. *Collection of the NJASK4-Science and the PARCC 2014–2017 test data.* All data were collected from the New Jersey state performance reports for the schools. This information was easily obtained through the NJDOE website's archived information.
4. *Statistical analysis using SPSS Version 24 software and Excel spreadsheets to gather information in an organized fashion.* The fourth step was to establish and complete the data bank with the information necessary to complete the causal-comparative study for the data analysis. Individual school matched-pairs of 50 groups were generated for the NJASK 4-Science and the PARCC literacy and

mathematics tests for 2014–2017 using SPSS software for Excel spreadsheets. When the independent variable of the integrated curriculum and the dependent variable testing (NJASK) were measured on a ratio scale, the point-biserial correlation coefficient was used (Hinkle, Wiersma, & Jurs, 2003). This, as indicated, further strengthened the study.

5. *Discussion*. Lastly, the data were analyzed and conclusions drawn concerning the integration of literacy, mathematics, and science curriculum and this was reported in the summary included in Chapter 5 of this research report.

CHAPTER 4

DATA ANALYSIS

Overview

The purpose of the study was to investigate the possible influence of an integrated–interdisciplinary elementary curriculum in comparison to the traditional subject-specific curriculum taught in elementary schools. The study utilized matched-pairing of 100 schools across the state of New Jersey; pairing one school using integrated–interdisciplinary curriculum with one school using a subject-specific curriculum.

Schools were researched through website narratives and the NJ State Performance Report narratives to select 50 schools that self-identified as having an integrated–interdisciplinary curriculum. A checklist to qualify schools as integrated–interdisciplinary curriculum schools is found in Appendix A. After finding 50 schools with the criteria for an integrated–interdisciplinary curriculum, the remaining 50 schools were researched to find no mention of an integrated–interdisciplinary curriculum and were then paired to a school with a self-identified, integrated–interdisciplinary curriculum. In determination of the random selection, none of the subject-specific schools had any of the criteria listed in Appendix A. This criteria was specific to the integrated–interdisciplinary schools identified for the study. When pairing the schools, the only consideration taken was the grade level configuration of the school population (e.g., K–4, Grades 3–6, K–8), to keep the pairing population of students similar during the matching of the groups. Socioeconomics as well as ELLs, and students disabilities were not noted factors in the pairing of schools, but were factors that might be important for the outcome of any educational study and are to be considered for another research study. With the state mandating that all public schools in the state of New Jersey follow the CCCS, it was assumed that the students should be learning nearly the same curriculum at each grade level across the state. It is important to note that the traditional subject-specific elementary schools made no mention of providing an integrated–interdisciplinary approach to the teaching of those standards in their school curriculum narratives or in any informational narratives provided on school websites or through NJ State Performance Reports.

Student achievement scores for the schools were collected from the New Jersey Performance Reports provided by the NJDOE on their website. The initial study data were collected using an Excel spreadsheet to gather and organize the information for each school. Scores for mathematics, language arts, and science were collected for a period of 3 years: 2014–2015, 2015–2016, and 2016–2017. The study encompassed a 3-year period of time because the newly introduced (in 2014) PARCC testing as a tool for measuring student achievement was controversial and received much public scrutiny at its inception. In the past, district group factors were considerations in comparing schools for student achievement measures of success. As a result of this knowledge, also taken into the consideration for the study, were the demographics collected about each school. Since the elementary schools were scattered across the state, data about socioeconomics, students with disabilities, and ELLs were collected and became a part of the information entered on the Excel spreadsheets for the same 3-year period of time.

As previously noted, the study utilized the results of the state-mandated PARCC test for Grade 4 as a tool for this nonexperimental, quantitative, explanatory study to explore the possible influence of an integrated–interdisciplinary curriculum when compared with subject-specific instruction of curriculum. The statistical analysis software SPSS Version 24 was used for the data analysis. The research questions and the resulting null hypotheses were analyzed and explained. In addition to the main focus of academic achievement, a third tier of the study could include analysis of the critical educational factors of socioeconomic status, ELLs, and students with disabilities for each of the school districts. Although these factors are not a taught academic discipline, they do seem to play a part in any education system and, as a result, could add a valuable analysis for another study. This study design creates a view of everything looked over and nothing being overlooked when considering curriculum design that may help increase student learning and achievement.

In summation, the purpose of this chapter is to present the results of this study with descriptive statistical analysis using a general linear model and regression models. Data were entered into the SPSS Version 24 software program to compare the sample means of students taught in schools that self-identified as using an integrated–interdisciplinary curriculum with those schools that did not use an integrated–interdisciplinary curriculum method for teaching and student learning, thus the subject-specific group. This New Jersey state study and data contain 3 years of information for language arts and mathematics based on the 2015–2017 PARCC test scores and for science based on the 2015–2017 NJASK scores (at the time of this research there was no science test created for PARCC). This might raise the question of consistency for the testing, but the NJASK4-Science tests have been used in prior years and serve as a continued measure of student science achievement. All scores were focused on the elementary fourth grade level.

Research Questions

Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC?

Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC?

Will an integrated–interdisciplinary curriculum increase achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment?

Null Hypotheses

There is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC.

There is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC.

There is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment.

Summary of the Method of Analysis

If the variance between groups and within groups do not differ more than would be expected by chance, then the ratio would be small and the groups would not be significantly different (Gay et al., 2009, p. 342). The analysis was used to look for trends either upward or downward in the core academic subjects of language arts, mathematics and science for the 3-year period of time from 2014 to 2017.

Student achievement for language arts scores were measured by the mean scores ranging from 22%–94% in 2014–15, 21%–94% in 2015–2016, and 23%–93% in 2016–2017 from the PARCC achievement tests. Student achievement for mathematics scores were measured by mean scores ranging from 0%–87% in 2014–2015, 11%–94% in 2015–2016, and 16%–88% in 2016–2017 from the PARCC achievement tests. Student achievement for science scores were measured by mean scores ranging from 0%–100% in 2014–2015, 79%–100% in 2015–2016, and 76%–100% in 2016–2017, using the NJASK4-Science achievement tests.

Organization of the Chapter

This chapter is organized by first providing descriptive information on the key variables, followed by a presentation of the findings pertinent to each of the research questions. Descriptive statistics are presented for the two groups of school curriculums and for individual subject areas (see Table 1). Both integrated–interdisciplinary and subject-specific mean scores slightly increased over the 3-year period of time for language arts and mathematics, and for the first two years in science, but a slight decrease was noted for student achievement in science in the year 2016–2017. In language arts, 72%, 74%, and 76% mean scores for integrated–interdisciplinary curriculum were noted as always above the mean score for the subject-specific curriculum with mean scores of 56%, 57%, and 62% for all 3 years of the study. In mathematics, 63%, 71%, and 71% mean scores for integrated–interdisciplinary curriculum were noted as always above the mean score for the subject-specific curriculum with mean scores of 43%, 50%, and 52% for all 3 years of the study. In science, 95%, 95%, and 94% mean scores for integrated–interdisciplinary curriculum were noted as always above the mean score for the subject-specific curriculum with mean scores of 93%, 94% and 92%. The standard deviations for the integrated–interdisciplinary schools also indicated less variance for each subject, including language arts, mathematics, and science, when noting academic performance among the integrated–interdisciplinary schools as compared to the subject-specific curriculum schools.

Table 1

Descriptive Statistics by Curriculum, Subject, and Year

Subject	Curriculum	2014–2015		2015–2016		2016–2017	
		M	*SD*	*M*	*SD*	*M*	*SD*
Language arts[a]	Total sample	64.11	18.00	65.39	17.12	68.96	15.70
	Integrated	72.30	9.98	74.22	8.76	76.40	9.50
	Subject-specific	55.90	20.32	56.56	18.87	61.52	17.21
Mathematics[a]	Total sample	53.01	19.50	60.41	19.80	61.62	17.40
	Integrated	63.22	11.87	70.80	10.69	71.30	9.89
	Subject-specific	42.80	20.38	50.02	21.46	51.94	17.98
Science[b]	Total sample	94.50	10.60	95.4	4.49	93.61	5.90
	Integrated	96.42	3.24	96.78	3.07	95.24	4.47
	Subject-specific	92.56	14.44	94.02	5.23	91.98	6.72

[a]Language Arts and Mathematics achievement for 4th grade as measured by PARCC test.
[b]Science achievement for fourth grade as measured by NJASK.
NJDOE: 2014-15 Performance Reports. Retrieved: www.nj.gov/education/pr/1415/
NJDOE: 2015-16 Performance Reports. Retrieved: rc.doe.state.nj.us/ReportsDatabase1516.aspx
NJDOE: 2016-17 Performance Reports. Retrieved: rc.doe.state.nj.us/ReportsDatabase1617.aspx

The demographic characteristics for the two types of schools are presented for the following variables: socioeconomic status, ELL, and students with disabilities were measured by the sample populations and curriculum (see Table 2). Defining the populations of ELLs, both types of school curriculum were similar (3.66% integrated with 3.5% subject-specific in 2014–2015; 4.12% integrated with 3.88% subject-specific in 2015–2016; 4.5% integrated with 3.86% subject-specific in 2016–2017). Students with disabilities showed little disparity in the percentage of students between integrated–interdisciplinary curriculum when compared with the subject-specific curriculum (15.56% integrated with 15.44% subject-specific in 2014–2015; 17.32% integrated with 18.08% subject-specific in 2015–2016; 17.04% integrated with 19.06%

subject-specific in 2016–2017). There is a noted larger difference in the socioeconomic variable of 12.44% integrated with 27.52% subject-specific in 2014–2015, 12.3% integrated with 27.06% subject-specific in 2015–2016 and 12.54% integrated with 27.32% subject-specific in 2016-17.

Table 2

Distribution of Student Characteristics by Curriculum and Year

		2014–2015		2015–2016		2016–2017	
Student characteristic	Curriculum	*N*	Percent	*N*	Percent	*N*	Percent
Socioeconomic[a]	sample pop.	100	19.92	100	19.67	100	19.9
	Integrated	50	12.44	50	12.3	50	12.54
	Subject-specific	50	27.52	50	27.06	50	27.32
ELLs		100	3.66	100	4.05	100	4.28
	Integrated	50	3.64	50	4.12	50	4.50
	Subject-specific	50	3.5	50	3.88	50	3.86
Students with disabilities		100	15.52	100	17.73	100	18.06
	Integrated	50	15.56	50	17.32	50	17.04
	Subject-specific	50	15.44	50	18.08	50	19.06

[a]Socioeconomic is measured by the percent of students on free and reduced lunches.

Findings for Research Question 1

Research Question 1 was as follows: Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC?

Effect of Curriculum on Language Arts Scores

Table 3 shows the mean and standard deviations for academic achievement for each of the years examined in this study. The means and standard deviations are reported separately for the schools with an integrated curriculum and those without.

Table 3

Descriptive Statistics for Language Arts 2015, 2016, and 2017

	Curriculum	*N*	Mean	Std. deviation	Std. error mean
2015 Language arts	Subject-specific	50	55.92%	20.321%	2.874%
	Integrated	50	72.30%	9.976%	1.411%
2016 Language arts	Subject-specific	50	56.56%	18.875%	2.669%
	Integrated	50	74.22%	8.758%	1.239%
2017 Language arts	Subject-specific	50	61.52%	17.213%	2.434%
	Integrated	50	76.40%	9.534%	1.348%

Language arts: 2015. As a first step in the analysis, an independent sample *t* test was conducted to determine if a statistically significant difference was apparent in the mean scores for the language arts test. The 50 integrated–interdisciplinary curriculum schools had a mean score of 72.30% with a standard deviation of 9.97%; the 50 subject-specific curriculum schools had a mean score of 55.92% with a standard deviation of 20.32%. Since Levene's test for equality of variances indicated that variances for the integrated–interdisciplinary curriculum 2015 language arts scores differed significantly from each other (F = 42.29, p < .001), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean language arts test scores between the two curriculum groups, t (71.32) = -5.116, p < .001. The mean difference between the two means -16.38% (SE = 3.20, CI of the difference [-22.76% lower; - 9.99% upper]) indicated that students at schools using the integrated curriculum scored, on average, 16.38% higher than did the students at schools using subject-specific curriculum.

Language arts: 2016. The 50 integrated–interdisciplinary curriculum schools had a mean score of 74.22% with a standard deviation of 8.75%; the 50 subject-specific curriculum schools had a mean score of 56.56% with a standard deviation of 18.87%. Since Levene's test for equality of variances indicated that variances for the integrated–interdisciplinary curriculum 2016 language arts scores differed significantly from each other ($F = 37.10$, $p < .001$), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean language arts test scores between the two curriculum groups, t (69.16) = -6.001, $p < .001$. The mean difference between the two means -17.66% ($SE = 2.94$, CI of the difference [-23.53% lower; - 11.78% upper]) indicated that students at schools using the integrated curriculum scored, on average, 17.66% higher than did the students at schools using subject-specific curriculum.

Language arts: 2017. The 50 integrated–interdisciplinary curriculum schools had a mean score of 76.40% with a standard deviation of 9.53%; the 50 subject-specific curriculum schools had a mean score of 61.52% with a standard deviation of 17.21%. Since Levene's test for equality of variances indicated that variances for the integrated–interdisciplinary curriculum 2017 language arts scores differed significantly from each other ($F = 22.57$, $p < .001$), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean language arts test scores between the two curriculum groups, t (76.47) = -5.347, $p < .001$. The mean difference between the two means -14.88% ($SE = 2.78$, CI of the difference [-20.42% lower; - 9.33% upper]) indicated that students at schools using the integrated curriculum scored, on average, 14.88% higher than did the students at schools using subject-specific curriculum.

Predicting 2015 Language Arts Achievement With Student Predictors and Curriculum

In this second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was integrated–interdisciplinary type of curriculum (Model 1). The *R* square was .211, indicating 21% of the variance in language arts achievement was explained by this variable. Along with the type of curriculum, the second model introduced, socioeconomic, ELLs, and students with disabilities as control variables. In this model, an *R*-square change = .474 which was significantly better than the model using curriculum alone, F (3, 95) = 47.547, $p < 0.001$. This meant that the second model improved the percent of variance of language arts scores in 2015 determined by predictors from 21% to 69%.

The first model of predicting language arts from only curriculum was significant, F (1, 98) = 26.18, $p < 0.001$. When the student characteristics are added as predictors, the second model was also significant, F (4, 95) = 51.53, $p < 0.001$. In evaluating each of the independent variables: curriculum was significant at $p = .002$, socioeconomic was significant at $p = .000$, ELL was significant at $p = .036$; disability, however, was not as significant at $p = .064$. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2015 language arts with a $B = 7.082$ as indicated in Table 4. The unstandardized difference in academic performance between integrated and nonintegrated schools was 7.08 percentage points in favor of the integrated curriculum schools.

Table 4

Hierarchical Multiple Regression Analysis Summary, Predicting 2015 Language Arts

Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	16.38**	3.20	.46	.21	.21
Constant	55.92**	2.26			
Model 2					
Integrated curriculum	7.08**	2.23	.20	.69	.47
Socioeconomic	.61**	.06	-.77		
ELL	.52*	.24	.14		
Disability	-.33	.17	-.11		
Constant	76.02**	3.26	-		

*$p < 0.05$. **$p < 0.01$.

Predicting 2016 Language Arts Achievement With Student Predictors and Curriculum

In this second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The *R* square was .269, indicating 27% of the variance in language arts achievement was explained by this variable. Along with type of curriculum, the second model introduced socioeconomic, ELL, and students with disabilities as control variables. In this model, an *R*-square change = .346 which was significantly better than the model using curriculum alone, F (3, 95) = 28.370, $p < 0.001$. This meant that the second model improved the percent of variance of language arts scores in 2016 determined by predictors from 27% to 61%.

The first model of predicting language arts from only curriculum was significant, F (1, 98) = 36.02, $p < 0.001$. When the student characteristics are added as predictors the second model was also significant, F (4, 95) = 37.83, $p < 0.001$. In evaluating each of the independent variables: curriculum was significant at $p = .000$, socioeconomic was significant at $p = .000$, ELL at $p = .330$ and disability at $p = .408$ were not significant. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2016 language arts with a *B* = 9.833 as indicated in Table 5. The unstandardized difference in academic performance between the integrated and non-integrated schools is 9.83 percentage points in favor of the integrated curriculum schools.

Table 5

Hierarchical Multiple Regression Analysis Summary, Predicting 2016 Language Arts Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	17.66**	2.94	.52	.27	.27
Constant	56.56**	2.08			
Model 2					
Integrated curriculum	9.83**	2.38	.29	.61	.35
Socioeconomic	-.52**	.06	-.66		
ELL	.26*	.27	.08		
Disability	-.14	.17	-.05		
Constant	72.20**	3.80	-		

*$p < 0.05$. **$p < 0.01$.

Predicting 2017 Language Arts Achievement With Student Predictors and Curriculum

In this second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The *R* square was .226, indicating 23% of the variance in language arts achievement was explained by this variable. Along with type of curriculum, the second model introduced socioeconomic, ELL, and students with disability as control variables. In this model an *R*-square change = .426 which was significantly better than the model using curriculum alone, F (3, 95) = 38.735, $p < 0.001$. This meant that the second model improved the percent of variance of language arts scores in 2017 determined by predictors from 23% to 65%.

The first model of predicting language arts from only curriculum was significant, F (1, 98) = 28.59, $p < 0.001$. When the student characteristics are added as predictors the second model was also significant, F (4, 95) =44.46, $p < 0.001$. In evaluating each of the independent variables: curriculum was significant at $p = .002$, socioeconomic was significant at $p = .000$, ELL was not significant at $p = .273$, and disability was not as significant at $p = .085$. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2017 language arts with a $B = 6.837$ as indicated in Table 6. The unstandardized difference in academic performance between the integrated and nonintegrated schools is 6.84 percentage points in favor of the integrated curriculum schools.

Table 6

Hierarchical Multiple Regression Analysis Summary, Predicting 2017 Language Arts Achievement From Socio-Economic, ELL, Disability and Integrated/ Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	14.88**	2.78	.48	.23	.23
Constant	61.52**	1.97			
Model 2					
Integrated curriculum	6.84**	2.10	.22	.65	.43
Socioeconomic	.50**	.05	-.72		
ELL	.27*	.25	.08		
Disability	-.26	.15	-.11		
Constant	79.05**	3.34	-		

*$p < 0.05$. **$p < 0.01$.

Summary of Findings Research Question 1

A significant difference was found to indicate that an integrated–interdisciplinary curriculum increased fourth grade students' academic achievement in language arts as measured by the New Jersey PARCC. Therefore, the null hypothesis is rejected as there is a statistical significance of fourth grade language arts scores as measured by New Jersey PARCC of students who followed an integrated–interdisciplinary curriculum as compared to those who followed a subject-specific curriculum.

Findings for Research Question 2

Research Question 2 was as follows: Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC?

Effect of Curriculum on Mathematics Scores

Table 7 shows the mean and standard deviations for academic achievement for each of the years examined in this study. The means and standard deviations are reported separately for the schools with an integrated curriculum and those with a subject-specific curriculum.

Table 7

Descriptive Statistics for Mathematics 2015, 2016 and 2017

	Curriculum	N	Mean	Std. deviation	Std. error mean
2015 Mathematics	Subject-specific	50	42.80%	20.379%	2.882%
	Integrated	50	63.22%	11.872%	1.679%
2016 Mathematics	Subject-specific	50	50.02%	21.460%	3.035%
	Integrated	50	70.80%	10.696%	1.513%
2017 Mathematics	Subject-specific	50	51.94%	17.978%	2.542%
	Integrated	50	71.30%	9.888%	1.398%

Mathematics: 2015. As a first step in the analysis, an independent sample *t* test was conducted to determine if a statistically significant difference was apparent in the mean scores for the mathematics test. The 50 integrated–interdisciplinary curriculum schools had a mean score of 63.22% with a standard deviation of 11.87%; the 50 subject-specific curriculum schools had a mean score of 42.80% with a standard deviation of 20.37%. Since Levene's test for equality of variances indicated that variances for the integrated–interdisciplinary curriculum 2015 mathematics scores differed significantly from each other (F = 22.30, p < .001), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean mathematics test scores between the two curriculum groups, t (78.82) = -6.122, p < .001. The mean difference between the two means -20.42% (*SE* =3.33, CI of the difference [-27.05% lower; -13.78% upper]) indicated that students at schools using the integrated curriculum scored, on average, 20.42% higher than did the students at schools using subject-specific curriculum.

Mathematics: 2016. The 50 integrated–interdisciplinary curriculum schools had a mean score of 70.80% with a standard deviation of 10.69%; the 50 subject-specific curriculum schools had a mean score of 50.02% with a standard deviation of 21.467%. Since Levene's test for equality of variances indicated that variances for integrated–interdisciplinary curriculum 2016 mathematics scores differed significantly from each other (F = 31.09, p < .001), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean mathematics test scores between the two curriculum groups, t (71.93) = -6.128, p < .001. The mean difference between the two means -20.78% (*SE* =3.39, CI of the difference [- 27.54% lower; - 14.01% upper]) indicated that students at schools using the integrated curriculum scored, on average, 20.78% higher than did the students at schools using subject-specific curriculum.

Mathematics: 2017. The 50 integrated–interdisciplinary curriculum schools had a mean score of 71.30% with a standard deviation of 9.88%; the 50 subject-specific curriculum schools had a mean score of 51.94% with a standard deviation of 17.97%. Since Levene's test for equality of variances indicated that variances for integrated–interdisciplinary curriculum 2017 mathematics scores differed significantly from each other (F = 26.39, p < .001), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean mathematics test scores between the two curriculum groups, t (76.15) = -6.672, p < .001. The mean difference between the two means -19.36% (*SE* =2.90, CI of the difference (- 25.413% lower; - 13.58% upper]) indicated that students at schools using the integrated curriculum scored, on average, 19.36% higher than did the students at schools using subject-specific curriculum.

Predicting 2015 Mathematics Achievement With Student Predictors and Curriculum

In the second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The R square was .277, indicating 28% of the variance in mathematics achievement was explained by this variable. The second model introduced, along with type of curriculum, socioeconomic, ELL, and students with disabilities as control variables. In this model, an R-square change = .349 which was significantly better than the model using curriculum alone, F (3, 95) = 29.559, p < 0.001. This meant that the second model improved the percent of variance of mathematics scores in 2015 determined by predictors from 28% to 63%.

The first model of predicting mathematics from only curriculum was significant, F (1, 98) = 37.48, p < 0.001. When the student characteristics are added as predictors the second model was also significant, F (4, 95) =39.73, p < 0.001. In evaluating each of the independent variables: curriculum was significant at p = .000, socioeconomic was significant at p = .000, ELL was significant at p = .056; disability, however, was not as significant at p = .0188. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2015 mathematics with a B = 11.618 as indicated in Table 8. The unstandardized difference in academic performance between the integrated and nonintegrated schools is 11.62 percentage points in favor of the integrated curriculum schools.

Table 8

Hierarchical Multiple Regression Analysis Summary, Predicting 2015 Mathematics Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	20.42**	3.34	.53	.28	.28
Constant	42.80**	2.36			
Model 2					
Integrated curriculum	11.62**	2.64	.30	.63	.35
Socioeconomic	-.58**	.07	-.67		
ELL	.56*	.29	.14		
Disability	-.27	.21	-.08		
Constant	61.02**	3.86	-		

*p < 0.05. **p < 0.01.

Predicting 2016 Mathematics Achievement With Student Predictors and Curriculum

In the second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The R square was .277, indicating 28% of the variance in mathematics achievement was explained by this variable. Along with type of curriculum, the second model introduced socioeconomic, ELL, and students with disabilities as control variables. In this model an R-square change = .31 which was significantly better than the model using curriculum alone, *F* (3, 95) = 23.248, $p < 0.001$. This meant that the second model improved the percent of variance of mathematics scores in 2016 determined by predictors from 28% to 58%.

The first model of predicting mathematics from only curriculum was significant, *F* (1, 98) = 37.55, $p < 0.001$. When the student characteristics are added as predictors the second model was also significant, *F* (4, 95) =33.22, $p < 0.001$. In evaluating each of the independent variables: curriculum was significant at $p = .000$, socioeconomic was significant at $p = .000$, ELL was not significant at $p = .309$, and disability was not as significant at $p = .301$. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2016 mathematics with a $B = 12.142$ as indicated in Table 9. The unstandardized difference in academic performance between the integrated and nonintegrated schools is 12.14 percentage points in favor of the integrated curriculum schools.

Table 9

Hierarchical Multiple Regression Analysis Summary, Predicting 2016 Mathematics Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	20.78**	3.39	.53	.28	.28
Constant	50.02**	2.40			
Model 2					
Integrated curriculum	12.14**	2.87	.31	.58	.31
Socioeconomic	-.57**	-.57	-.63		
ELL	.33*	.33	.08		
Disability	-.22	-.22	-.07		
Constant	68.08**	4.58	-		

*$p < 0.05$. **$p < 0.01$.

Predicting 2017 Mathematics Achievement With Student Predictors and Curriculum

In the second analysis, a control for school-level characteristics was presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The *R* square was .312 indicating 31% of the variance in mathematics achievement was explained by this variable. Along with type of curriculum, the second model introduced socioeconomic, ELL, and students with disability as control variables. In this model an *R*-square change = .391 was significantly better than the model using curriculum alone, F (3, 95) = 41.618, $p < 0.001$. This meant that the second model improved the percent of variance of mathematics scores in 2017 determined by predictors from 31% to 70%.

The first model of predicting mathematics from only curriculum was significant, F (1, 98) = 44.518, $p < 0.001$. When the student characteristics are added as predictors the second model was also significant, F (4, 95) =56.181, $p < 0.001$. In evaluating each of the independent variables: curriculum was significant at $p = .000$, socioeconomic was significant at $p = .000$; disability, however, was not as significant at $p = .066$; and ELL was not significant at $p = .117$. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2017 mathematics with a $B = 10.605$ as indicated in Table 10. The unstandardized difference in academic performance between the integrated and nonintegrated schools is 10.61 percentage points in favor of the integrated curriculum schools.

Table 10

Hierarchical Multiple Regression Analysis Summary, Predicting 2017 Mathematics Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	19.36**	2.90	.56	.31	.31
Constant	51.94**	2.05			
Model 2					
Integrated curriculum	10.61**	2.15	.31	.70	.39
Socioeconomic	-.54**	.06	-.69		
ELL	.39*	.25	.11		
Disability	-.29	.154	-.11		
Constant	70.51**	3.41	-		

*$p < 0.05$. **$p < 0.01$.

Summary of Findings Research Question 2

A significant difference was found to indicate that an integrated–interdisciplinary curriculum increased fourth grade students' academic achievement in mathematics as measured by the New Jersey PARCC. Therefore, the null hypothesis is rejected as there is a statistical significance of fourth grade mathematic scores as measured by the New Jersey PARCC of students who followed an integrated–interdisciplinary curriculum as compared to those who followed a subject-specific curriculum.

Findings for Research Question 3

Research Question 3 was as follows: Will an integrated–interdisciplinary curriculum increase academic achievement in science in fourth grade students as measured by the New Jersey ASK4 Science assessment?

Effect of Curriculum on Science Scores

Table 11 shows the mean and standard deviations for academic achievement for each of the years examined in the study. The means and standard deviations are reported separately for the schools with an integrated curriculum and those without.

Table 11

Descriptive Statistics for Science 2015, 2016, and 2017

	Curriculum	*N*	Mean	Std. deviation	Std. error mean
2015 Science	Subject-specific	50	92.56%	14.443%	2.043%
	Integrated	50	96.42%	3.239%	0.458%
2016 Science	Subject-specific	50	94.02%	5.231%	0.740%
	Integrated	50	96.78%	3.066%	0.434%
2017 Science	Subject-specific	50	91.98%	6.717%	0.950%
	Integrated	50	95.24%	4.475%	0.633%

Science: 2015. As a first step in the analysis, an independent sample *t* test was conducted to determine if a statistically significant difference was apparent in the mean scores for the science test. The 50 integrated–interdisciplinary curriculum schools had a mean score of 96.42% with a standard deviation of 3.23%; the 50 subject-specific curriculum schools had a mean score of 92.56% with a standard deviation of 14.44%. Since Levene's test for equality of variances indicated that variances for the integrated–interdisciplinary curriculum 2015 science scores differed significantly from each other ($F = 4.17$, $p < .001$), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean science test scores between the two curriculum groups, $t\ (53.91) = -1.844$, $p < .001$. The mean difference between the two means -3.86% (*SE* =2.09, CI of the difference [- 8.01% lower; - 0.33% upper]) indicated that students at schools using the integrated curriculum scored, on average, 3.86% higher than did the students at schools using subject-specific curriculum.

Science: 2016. The 50 integrated–interdisciplinary curriculum schools had a mean score of 96.78% with a standard deviation of 3.06%; the 50 subject-specific curriculum schools had a mean score of 94.02% with a standard deviation of 5.23%. Since Levene's test for equality of variances indicated that variances for integrated–interdisciplinary curriculum 2016 science scores differed significantly from each other ($F = 8.27$, $p < .001$), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean science test scores between the two curriculum groups, t (79.10) = -3.219, $p < .001$. The mean difference between the two means -2.76% (*SE* =0.85, CI of the difference [- 4.46% lower; -1.05% upper]) indicated that students at schools using the integrated curriculum scored, on average, 2.76% higher than did the students at schools using subject-specific curriculum.

Science: 2017. The 50 integrated–interdisciplinary curriculum schools had a mean score of 95.24% with a standard deviation of 4.47%; the 50 subject-specific curriculum schools had a mean score of 91.98% with a standard deviation of 6.71%. Since Levene's test for equality of variances indicated that variances for integrated–interdisciplinary curriculum 2017 science scores differed significantly from each other ($F = 11.38$, $p < .001$), the assumption of the homogeneity of variance had been violated. There was a significant difference in the mean science test scores between the two curriculum groups, t (85.33) = -2.856, $p < .001$. The mean difference between the two means -3.26% (*SE* =1.14, CI of the difference [- 5.52% lower; -0.99% upper]) indicated that students at schools using the integrated curriculum scored, on average, 3.26% higher than did the students at schools using subject-specific curriculum.

Predicting 2015 Science Achievement With Student Predictors and Curriculum

In the second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The R square was .034, indicating 3.4% of the variance in science achievement was explained by curriculum. Along with type of curriculum, the second model introduced socioeconomic, ELL, and students with disabilities as control variables. In this model, an R-square change = .246, which was significantly better than the model using curriculum alone, F (3, 95) = 10.789, $p < 0.001$. This meant that the second model improved the percent of variance of science scores in 2015 determined by predictors from 3.4% to 28%.

The first model of predicting science from only curriculum was significant, F (1, 98) = 3.40, $p = .068$. When the student characteristics were added as predictors, the second model was also significant, F (4, 95) =9.196, $p < 0.001$. In evaluating each of the independent variables, curriculum was not significant at $p = .989$, socioeconomic was significant at $p = .000$, ELL was significant at $p = .033$; disability, however, was not as significant at $p = .076$. In examining which predictor was the strongest, socioeconomic was analyzed to be the strongest negative impact for 2015 science with a $B = -0.256$ as indicated in Table 12. The unstandardized difference in academic performance between the integrated and nonintegrated schools was not significant; however, the socio economic variable negatively impacted the schools by -.25 percentage points.

Table 12

Hierarchical Multiple Regression Analysis Summary, Predicting 2015 Science Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	3.86**	2.09	.18	.03	.03
Constant	92.56**	1.48			
Model 2					
Integrated curriculum	-0.027**	1.99	-.001	.28	.25
Socioeconomic	-.256**	.049	-.54		
ELL	.47*	.212	.21		
Disability	-.27	-.158	-.16		
Constant	102.23**	2.91	-		

*$p < 0.05$. **$p < 0.01$.

Predicting 2016 Science Achievement With Student Predictors and Curriculum

In the second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. Using the predictor of the first model, the only independent variable was type of curriculum (Model 1). The *R* square was .096, indicating 9.6% of the variance in science achievement was explained by this variable. Along with type of curriculum, the second model introduced socioeconomic, ELL, and students with disabilities as control variables. In this model, an *R*-square change = .311 which was significantly better than the model using curriculum alone, F (3, 95) = 16.634, $p < 0.001$. This meant that the second model improved the percent of variance of science scores in 2016 determined by predictors from 9.6% to 41%.

The first model of predicting science from only curriculum was significant, F (1, 98) = 10.36, $p < 0.001$. When the student characteristics are added as predictors the second model was also significant, F (4, 95) =16.31, $p < 0.001$. In evaluating each of the independent variables, curriculum was not significant at *p* = .152, socioeconomic was significant at *p* = .000, ELL was not significant at *p* = .39; disability, however, was not as significant at *p* = .11. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2016 science with a *B* = 1.118 as indicated in Table 13. The unstandardized difference in academic performance between the integrated and nonintegrated schools was 1.12 percentage points in favor of the integrated curriculum schools.

Table 13

Hierarchical Multiple Regression Analysis Summary, Predicting 2016 Science Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	2.76**	0.86	.31	.10	.10
Constant	94.02**	.61			
Model 2					
Integrated curriculum	1.12**	.77	.13	.41	.31
Socioeconomic	-.11**	.02	-.53		
ELL	-.08*	.09	-.08		
Disability	-.09	.06	-.13		
Constant	98.86**	1.24	-		

*$p < 0.05$. **$p < 0.01$.

Predicting 2017 Science Achievement With Student Predictors and Curriculum

In the second analysis, a control for school-level characteristics is presented. There were two models in the hierarchical regression. In the first model, the only independent variable was type of curriculum (Model 1). The *R* square was .08, indicating 8% of the variance in science achievement was explained by this variable. Along with the curriculum, the second model introduced socioeconomic, ELL, and students with disabilities as control variables. In this model, an *R*-square change = .436 which was significantly better than the model using curriculum alone, *F* (3, 95) = 28.368, *p* < 0.001. This meant that the second model improved the percent of variance of science scores in 2017 determined by predictors from 8% to 51%.

The first model of predicting science from only curriculum was significant, *F* (1, 98) = 8.157, *p* < 0.001. When the student characteristics were added as predictors, the second model was also significant, *F* (4, 95) =25.024, *p* < 0.001. In evaluating each of the independent variables, curriculum was not significant at *p* = .641, socioeconomic was significant at *p* = .000, ELL was not significant at *p* = .978, and disability was not as significant at *p* = .0178. In examining which predictor was the strongest, curriculum was analyzed to be the strongest for 2017 science with a *B* = .438 as indicated in Table 14. The unstandardized difference in academic performance between the integrated and nonintegrated schools was .438 percentage points in favor of the integrated curriculum schools.

Table 14

Hierarchical Multiple Regression Analysis Summary, Predicting 2017 Science Achievement From Socioeconomic, ELL, Disability, and Integrated–Interdisciplinary Curriculum

Variable	B	SEB	β	R^2	ΔR^2
Model 1					
Integrated curriculum	3.26**	1.14	.28	.08	.08
Constant	91.98**	.81			
Model 2					
Integrated curriculum	.438**	.94	.04	.51	.44
Socioeconomic	-.18**	.02	-.69		
ELL	.003*	.11	.002		
Disability	-.09	.07	-.09		
Constant	98.58**	1.48	-		

*p < 0.05. **p < 0.01.

Summary of Findings Research Question 3

A slight significant difference was found to indicate that an integrated–interdisciplinary curriculum increased fourth grade students' academic achievement in science as measured by the New Jersey ASK4-Science assessment. Therefore, the null hypothesis is rejected as there is a slight statistical significance of fourth grade science scores as measured by New Jersey ASK4-Science assessment of students who followed an integrated–interdisciplinary curriculum as compared to those who followed a subject-specific curriculum.

Summary of the Total Data Research Results

An integrated–interdisciplinary curriculum appears to have some effect on the scores for language arts, mathematics, and science, as indicated in the first analysis in the study. The influence of the integrated–interdisciplinary curriculum over time shows a slight increase in scores for language arts and mathematics, but a slight decrease in science scores (see Appendix L). The predictor characteristics of socioeconomic, ELLs, and students with disabilities indicated that the predictors do have an influence on the scores for language arts, mathematics, and science; especially the socioeconomic predictor.

The hierarchical regressions indicated the following results for language arts with the predictors of socioeconomic, ELL, and students with disabilities: The integrated–interdisciplinary curriculum displayed a moderately positive correlation when used alone as a predictor in all 3 years of the study. When the predictors of socioeconomic, ELL, and students with disabilities were analyzed with the curriculum, the socioeconomic predictor was significant for all 3 years of the study; ELL was significant in 2015, but not significant in 2016 and 2017; and students with disabilities was not significant as a predictor in any of the 3 years of the study.

In all 3 years of the study, the curriculum was the strongest predictor of language arts student achievement scores.

The hierarchical regressions indicated the following results for mathematics with the predictors of socioeconomic, ELL, and students with disabilities: The integrated–interdisciplinary curriculum displayed a moderately positive correlation when used alone as a predictor in all 3 years of the study. When the predictors of socioeconomic, ELL, and students with disabilities were analyzed with the curriculum, the socioeconomic predictor was significant for all 3 years of the study; ELL was not significant for any of the 3 years of the study; and students with disabilities were not as significant as a predictor of mathematics achievement in 2015 and 2016, and only slightly significant in the year 2017. In all 3 years of the study, the curriculum was the strongest predictor of mathematics student achievement scores.

The hierarchical regressions indicated the following results for science with the predictors of socioeconomic, ELL, and students with disabilities: The integrated–interdisciplinary curriculum indicated a moderately positive correlation when used alone as a predictor in all 3 years of the study. When the predictors of socioeconomic, ELL, and students with disabilities were analyzed with the curriculum, the socioeconomic predictor was significant for all 3 years of the study, students with disabilities as a predictor was not significant for the 3 years of the study; and ELL was significant in 2015, but was not a significant predictor in 2016 and 2017. In 2015, the strongest predictor of science achievement was negatively impacted by the socioeconomic predictor, but in 2016 and 2017, the curriculum was the strongest predictor of science student achievement scores.

Summary of Research Questions and Answers

Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC? There is significant evidence from this research to support a positive increase in student achievement for language arts when using an integrated–interdisciplinary curriculum.

Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC? There is significant evidence from this research to support a positive increase in student achievement for mathematics when using an integrated–interdisciplinary curriculum.

Will an integrated–interdisciplinary curriculum increase academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment? There is a slight increase in student achievement for science when using an integrated–interdisciplinary curriculum.

Summary of Null Hypotheses and Answers

The null hypothesis that there is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC is rejected.

The null hypothesis that there is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC is rejected.

The null hypothesis that there is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment is rejected.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

As a problem that has long existed for teachers over the years, curriculum has seen many educational changes made in the name of the standards reform movement. Fitting into this movement, "yet based historically in much earlier events, exists the concept of interdisciplinary education" (Hurley, 2001, p. 259). Having taught in schools for 32 years, my colleagues and I have had many conversations over the years about the increasing demands of the elementary curriculum. As Furner and Kumar (2007) stated,

> More and more educators are coming to realize that one of the fundamental problems in schools today is the "separate subject" or "layer cake" approach to knowledge and skills. The separate subject curriculum can be viewed as a jigsaw puzzle without any picture. (p. 185)

With the increase in mandated curriculum additions such as anti-bullying and other initiatives increasing demands on our educators, we are increasing the layers on the cake or providing more jigsaw pieces without giving any picture to all the students. As we hope to teach and make the meaningful connections to provide increased student achievement; sometimes the only focus in lesson planning seems to be on achieving a checklist of mandated, individualized curriculum goals by subject area.

The purpose of this research study was to explore the possibility of an effect when integrating or using an interdisciplinary approach to the teaching of state-mandated CCCS. In order to be able to meet all the demands of the curriculum in the amount of time allotted for the teaching of concepts at each grade level, given the 180 days prescribed by the state, this research served to explore for a viable solution to teaching a "jam-packed" curriculum of expectations with only a subject-specific curriculum approach. The study provided a random sampling of 50 self-identified integrated–interdisciplinary schools paired with 50 schools that made no mention of integration or an interdisciplinary approach to the teaching of their curriculum. The measure used to evaluate the effect of the curriculum was the state-mandated PARCC test for language arts and mathematics and the NJASK4-Science test for a 3 year period: 2014–2017. Schools for the study were selected by finding 50 schools that self-identified as using an integrated–interdisciplinary approach to teaching curriculum as described in the NJ Performance Reports and individual school websites. Then, 50 schools were randomly selected from across the state with similar grade configurations (e.g., K–4, K–8, Grades 3–5) and paired for their student populations, but these schools made no mention of an integrated–interdisciplinary approach to teaching. The same search for curriculum was explored through reading the NJ Performance Reports and the individual school websites. A criteria checklist was used to be consistent (Appendix A). Thus the pairing of 50 schools with an integrated–interdisciplinary curriculum and 50 schools with a subject-specific curriculum was begun for this research study.

Design of the Study

The study began with causal-comparative (also known as ex post facto) research design. Fraenkel and Wallen (2006) stressed that causal-comparative research is "intended to determine the cause for or the consequences of differences between groups of people. Using the design groups can be compared to see if they differ in their achievement" (p. 11).

The research involved analyzing the outcomes of an integrated–interdisciplinary curriculum when compared with subject-specific curriculum for a sample population of 100 elementary schools randomly selected from across the state of New Jersey. Reviewed achievement scores were analyzed through the information available from the NJDOE. When the initial results for the PARCC test to measure student achievement in language arts and mathematics, and the NJASK4-Science test were collected in an Excel spreadsheet for fourth grade elementary schools selected for the matched-pair school study, there was a manageable system for analyzing the grouping variables. Using the SPSS Version 24 software to explore the outcomes of the data served to produce the following summary of results for the means, standard deviations for each year and subject, as well as the grouping variables of socioeconomic, ELLs, and students with disabilities.

Summary of the Findings

Major Findings

An integrated–interdisciplinary curriculum appears to have some effect on the scores for language arts, mathematics, and science as was indicated in the first analysis in the study comparing means and standard deviations for the 3 years of the study. The influence of the integrated–interdisciplinary curriculum over time shows a slight increase in scores for language arts and mathematics, but a slight decrease in science scores as indicated in the graphs (Appendix L). The predictor characteristics of socioeconomic, ELLs, and students with disabilities indicated that the predictors do have an influence on the scores for language arts, mathematics and science, especially the socioeconomic predictor.

Findings for Research Question 1. Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC? There is significant evidence from this research to support a positive increase in student achievement for language arts when using an integrated–interdisciplinary curriculum. The null hypothesis is rejected as there was a statistical significance of fourth grade language arts scores as measured by New Jersey PARCC assessment of students who followed an integrated–interdisciplinary curriculum as compared to those who were following a subject-specific curriculum.

The hierarchical regressions indicated the following results for language arts with the predictors of socioeconomic, ELLs, and students with disabilities: The integrated–interdisciplinary curriculum displayed a moderately positive correlation when used alone as a predictor in all 3 years of the study. When the predictors of socioeconomic, ELLs, and students with disabilities were analyzed with the curriculum, the socioeconomic predictor was significant for all 3 years of the study; ELLs was significant in 2015, but not significant in 2016 and 2017; students with disabilities was not significant as a predictor in any of the 3 years of the study. In all 3 years of the study, the curriculum was the strongest predictor of language arts student achievement scores.

Findings for Research Question 2. Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC? There is significant evidence from this research to support a positive increase in student achievement for mathematics when using an integrated–interdisciplinary curriculum. The null hypothesis is rejected as there was a statistical significance of fourth grade mathematics scores as measured by New Jersey PARCC assessment of students who were in an integrated–interdisciplinary curriculum and those who were not.

The hierarchical regressions indicated the following results for mathematics with the predictors of socioeconomic, ELLs, and students with disabilities: The integrated–interdisciplinary curriculum displayed a moderately positive correlation when used alone as a predictor in all 3 years of the study. When the predictors of socioeconomic, ELLs, and students with disabilities were analyzed with the curriculum, the socioeconomic predictor was significant for all 3 years of the study, ELL was not significant for any of the 3 years of the study and students with disabilities was not as significant as a predictor of mathematics achievement in

2015 and 2016 and only slightly significant in the year 2017. In all 3 years of the study, the curriculum was the strongest predictor of mathematics student achievement scores.

Findings for Research Question 3. Will an integrated–interdisciplinary curriculum increase academic achievement in science in fourth grade students as measured by the New Jersey ASK4-Science assessment? There is slight significant evidence from this research to support a positive increase in student achievement for science when using an integrated–interdisciplinary curriculum. The null hypothesis is rejected as there was a slight statistical significance of fourth grade science scores as measured by New Jersey ASK4-Science assessment of students who followed an integrated–interdisciplinary curriculum as compared to those who were following a subject-specific curriculum.

The hierarchical regressions indicated the following results for science with the predictors of socioeconomic, ELLs, and students with disabilities: The integrated–interdisciplinary curriculum indicated a moderately positive correlation when used alone as a predictor in all 3 years of the study. When the predictors of socioeconomic, ELLs, and students with disabilities were analyzed with the curriculum, the socioeconomic predictor was significant for all 3 years of the study, students with disabilities as a predictor was not significant for the 3 years of the study; and ELL was significant in 2015, but was not a significant predictor in 2016 and 2017. In 2015, the socioeconomic predictor was the strongest, but in 2016 and 2017, the strongest predictor was curriculum for both years.

An analysis of the findings for policy and practice in the field of education have indicated that there should be further study into the possible influences of integrated–interdisciplinary curriculum in the elementary curriculum since the results of this study investigated and discovered that the integrated–interdisciplinary curriculum was the strongest predictor of the student achievement scores for this study. Further study would be needed to determine the extent of integration. One example to consider is the integration just by way of technology or are teachers personalizing the curriculum by using their creativity to intertwine the concepts into various subjects taught throughout the day?

Research Analysis

1. Will an integrated–interdisciplinary curriculum increase academic achievement in language arts in fourth grade students as measured by the New Jersey PARRC?
   ANSWER: From the results of this study, curriculum integration does indicate an increase in academic achievement for students who have experienced an integrated–interdisciplinary approach to the learning as measured by language arts achievement scores. The Null Hypothesis that there is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in language arts in fourth grade students as measured by the New Jersey PARCC is rejected.
2. Will an integrated–interdisciplinary curriculum increase academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC?
   ANSWER: From the results of this study, curriculum integration does indicate an increase in academic achievement for students who have experienced an integrated–interdisciplinary approach to the learning as measured by mathematics achievement scores. The Null Hypothesis that there is no significant difference that an integrated–interdisciplinary curriculum has on increasing academic achievement in mathematics in fourth grade students as measured by the New Jersey PARCC is rejected.
3. Will an integrated–interdisciplinary curriculum increase academic achievement in science in fourth grade students as measured by the New Jersey ASK Science

Assessment? ANSWER: From the results of this study, curriculum integration does indicate a slight increase in academic achievement for students who have experienced an integrated–interdisciplinary approach to the learning as measured by science achievement scores. However in the 2017 year of the study, science scores for achievement in groups, integrated/ interdisciplinary curriculum and subject-specific curriculum decreased. A speculated reason might be the increased emphasis for higher expectations on the achievement scores for the language arts and mathematics given the high-stakes testing of the PARCC; that may have left less time for instruction and hands-on activities in science education. The Null Hypothesis that there is no significant difference that an integrated/ interdisciplinary curriculum has on increasing academic achievement in science in fourth grade students as measured by the New Jersey ASK4 Science Assessment is rejected.

Discussion and Conclusions

What has been learned from the study? This research study took commitment and long-term organization. Although the collection of data would seem like an easy and straightforward task, the actual distribution of scores and analyses of data was a challenge when comparing 3 years in the study. The state continues to change the format for their reports and findings from year to year. The PARCC tests, which began in 2014 after a pilot year in 2013, were not well-received by parents or teachers when first introduced to the state; the PARCC was perceived as a high-stakes test. In many places across the state, teachers' salaries and evaluations were to reflect the progress or lack of progress as reported in the student achievement scores for the PARCC. As such, there was much controversy about some teachers perhaps teaching to the test. Using scores from the public domain always run such a risk when the researcher does not know the individual pressures to show progress or success for test scores. Using the NJASK4-Science test to anticipate the science outcomes brought to mind the socioeconomic variable in using random schools across the state. With the PARCC test creating high stakes for testing results, a question of whether the subject of science would even be taught with the same amount of time and care, if the anticipated need was to raise the scores for student achievement in the areas of language arts and mathematics. When the science scores appeared to slightly decline in 2017, the speculation was that lack of time for teaching and the preparation given to science instruction might be the cause. The high-stakes testing of the PARCC implementation was focused only on the subjects of language arts and mathematics.

Every school in each of the states' 656 school districts can be using a different textbook series to help deliver its curriculum. Some schools rely only on textbook instruction, some schools have teachers using online sources to enhance textbook instruction, and some teachers use their experience and knowledge of what works from prior years to enhance lessons. Every school can also have different priorities when trying to educate their students for success. The focus is based on the needs of the student population. Many schools' websites included their needs in a mission statement. Student disabilities and services vary greatly in need and execution. Some lessons for remedial students are one-on-one, some are small group instruction, and some are in-class support. Resources dwindle as funding is decreased in state aid. Is technology one-on-one, or is there a computer lab that students visit on a rotating cycle? Do the science and mathematics classes provide for manipulatives and hands-on materials to teach concepts? So, although there are state-mandated CCCS for expectations at each grade level, the delivery of those standards may come in many different ways by the capacity of resources and the creativity of the educators that the students encounter. Because of the different priorities and amounts of funding in each district, the solution of presenting learning ideas to students through an integrated–interdisciplinary approach seems to present possibilities for increasing student achievement. The potential for saving time and helping students and teachers focus on the learning objectives to help deliver a thorough and efficient education guaranteed by the state constitution is the possibility of an integrated–interdisciplinary curriculum.

The results of this study would indicate the need for further research and study in the area of integrated–interdisciplinary curriculum. How is it done? What are the concepts at a grade level that could be combined without sacrificing the needed repetitive skills and foundations to advance learning? What would be the best method of delivery for implementing an integrated–interdisciplinary curriculum? There is no known textbook currently available that combines subject-matter learning ideas; it must come from the experience and background training of the teachers. If painting a big picture for the students helps to solidify learning concepts and shows the importance and interconnectivity of subject matter, student achievement scores should increase, as indicated by the positive results of this study. Learning concepts would be retained not for a test-score performance, but because students have an understanding and a foundation to build on for life-long learning. Student misconceptions would also be addressed and corrected, as is the basis of providing a constructivist framework. Also, project-based learning is gaining an enthusiasm for instruction in the classroom, using applications learned in real-life situations. Motivation is thus provided for implementation.

Other possible interpretations and conclusions might be that the number of schools in the study was not sufficient to measure the full extent of an integrated–interdisciplinary curriculum. The NJ Performance Reports were all written very differently, perhaps to take on the personality of the individual schools, and the mission statements were all different in describing the goals of the school community. There did not seem to be a format or template for these reports to keep information consistent. It is possible that some schools might be using an integrated curriculum, but did not mention it in their written report. When doing this research, many different interpretations integrated–interdisciplinary curriculum became apparent. For example, the integration of technology into the classroom was mentioned with pride in many reports, but did that include integrating subject matter or was the report meant to convey the use of technology to reinforce a skill level taught? Because this was nonexperimental research with no intervention or opportunity to ask questions, the answer cannot be provided here.

In light of the limitations, considering this research design did not allow for interaction in the classroom or observation of students and the amount or extent of integration, the next steps would be to actually observe integration in the classroom, to survey teachers on their use of integration–interdisciplinary curriculum, and to learn how professional development groups can work to implement integrated curriculum. A second check for understanding of the role of student achievement would be developing a new study to examine the state assessment using other grade levels and determine if there is increased student achievement when progressing to higher grade levels. Another approach would be to follow identified integrated–interdisciplinary curriculum groups during their elementary years for the purpose of analyzing if the achievement of a control group would continue through academic years into high school. Perhaps a study of schools using the same textbooks for their curriculum-building, the amount textbooks are used versus the use of technology, and the level of formative assessments used in the classroom instead of the annual state-mandated test would also provide valued information.

Recommendations for Policy and Practice

Many textbook companies sell curriculum by subject-specific categories such as mathematics, reading, writing, science, and social studies. Whenever possible, integrated–interdisciplinary ideas need to be incorporated into the ways that companies market their sales to school districts since it appears from this study to influence student achievement scores. This would help teachers be enabled to teach curriculum to their students by consolidating and maximizing emphasis on concepts for student learning in the given timeframe to any districts using the programs regardless of student characteristics for the district. This would also allow for the review of concepts, as certain topics of study in a given grade level would lend themselves to reconnecting and repeating main ideas for better learning retention. Developing learning connections through an integrated–interdisciplinary curriculum presents more than one perspective on ways that all parts of the curriculum are important by using cycles of learning to connect the main ideas of the curriculum. More professional development would be required to enable elementary teachers to integrate concepts of mathematics and science as they may only have received a methods course in their own coursework and certification.

The anticipated outcome of an integrated–interdisciplinary curriculum would help with the differentiation of instruction as well as being able to scaffold lessons and learning for differentiation. Project-based learning would increase motivation because students would be using real-life situations and not textbook examples through which they find themselves distanced from learning with enthusiasm. Concepts are revisited as learning spirals to reinforce outcomes. Although the idea of integrated curriculum is not new (over 900 previous studies have been done), it is mostly used in combining mathematical and science concepts, a natural fit for many topics, and usually only presented to middle school and high school students. A theme-based approach to integrating subject matter would seem the most logical and has met with success in the past, but always the emphasis on high-stakes testing seems to create a barrier to continued success of an integrated program. With all of the outside distractions given today's society, starting younger to combine and intertwine the concepts for curriculum learning seems like a viable solution to help teachers and students feel more assured that students are succeeding at learning as the demands of the curriculum are constantly increasing to include all societal needs as reinforced by the new social-emotional learning emphasis. Policymakers, in particular, should reevaluate the amount of time allotted for each subject area and balance the needs according to the current emphasis on STEM and STEAM learning requirements to reach 21st century skills and goals.

Suggestions for Future Research

- Conduct studies using elementary students to discover the extent that the socioeconomic levels might be influenced by the integration of technology for student achievement. Will the use of computers level the playing field for student achievement?
- How does a theme-based curriculum for an integrated approach have an influence on student achievement in the elementary level, studying a cohort of students from K–4 or K–5 in comparison to subject-specific learning?
- What are the successful components for developing an integrated approach to learning and avoiding misconceptions while learning?
- How does the extent of textbook usage as a main source of learning, as a resource for learning, or online extension of the textbook help to guide teachers in the implementation of an integrated–interdisciplinary curriculum?

- Measuring student achievement is good and necessary, but creating high-stakes testing seems to be putting a wrong emphasis on the outcomes for testing; should not the real purpose for testing be to encourage growth and individual learning through a summative assessment, pointing out strengths and weaknesses so that the formula for learning at the next level is focused on improvements and increased growth?

Emphasizing language arts and mathematics achievement at the cost of other academic disciplines does not insure that we are reaching all the needs of differentiated instruction for students, finding ways to integrate curriculum thus meets more instructional needs of all students.

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APPENDIX A

CRITERIA CHECKLIST FOR SELF-IDENTIFIED INTERDISCIPLINARY–INTEGRATED CURRICULUM DETERMINATION

County: ____

District: ____

School: ____

If more than one of the following conditions is checked, the school is considered as self-identified for interdisciplinary/integrated curriculum to use for this research project.

Interdisciplinary/Integrated Curriculum identified within school's website in curriculum maps or guides for grade 4 curriculum.	
Interdisciplinary/ Integrated Curriculum identified for individual schools within the description of the school's narrative on each school website.	
New Jersey Performance Report identifies school's integration of curriculum in highlights or curriculum section of the individual school in narrative of the report.	
Integration of curriculum is identified and highlighted on school website by emphasizing 1:1 computer technology ratio for students.	
Implementation of STEM/STEAM initiative identified on school website as an approach to integrated–interdisciplinary curriculum.	

Project-Based Learning Methodology is identified and implemented within the school as described on school website.	
Constructivist Methodology is identified and emphasized in description of curriculum on school website.	

*Created by author for research gathering.

APPENDIX B

STATE AND COMMON CORE CURRICULUM

Table 1

State and Common Core Curriculum

New Jersey Standards and Explanations from NJ Department of Education New Jersey Cross Content Readiness Workplace Standards All students will develop career planning and workplace readiness skills. All students will use technology, information, and other tools. All students will use critical thinking, decision-making, and problem-solving skills. All students will demonstrate self-management skills. All students will apply safety principles.
The essential results expected for students using recommendations resulted into 56 standards covering the following seven academic content areas: Visual and Performing Arts Comprehensive Health and Physical Education Language Arts/Literacy Mathematics Science Social Studies World Languages
Evidence of support for integration of curriculum: "Other parts of the educational system and the larger community can be used to

deliver an integrated curriculum. For example, career education should be incorporated into all seven content areas as well as into occupational education programs. Language arts and literacy skills are key to success in all areas of learning. Science is an important part of health education and represents an important part of the historical record. Mathematics skills are tools for problem-solving in science and can be reinforced in vocational-technical areas. Technology education teachers can show the application of problem-solving techniques which bring physics principles to life. Family and consumer sciences (home economics) draw on health and science in preparing students for family living. The visual and performing arts provide an avenue for the understanding of science, social studies, language arts, world languages, and design technology."

*Adapted from Common Core Presentations: state.nj.us/education/archive/sca/ppt/gears/

Table 2

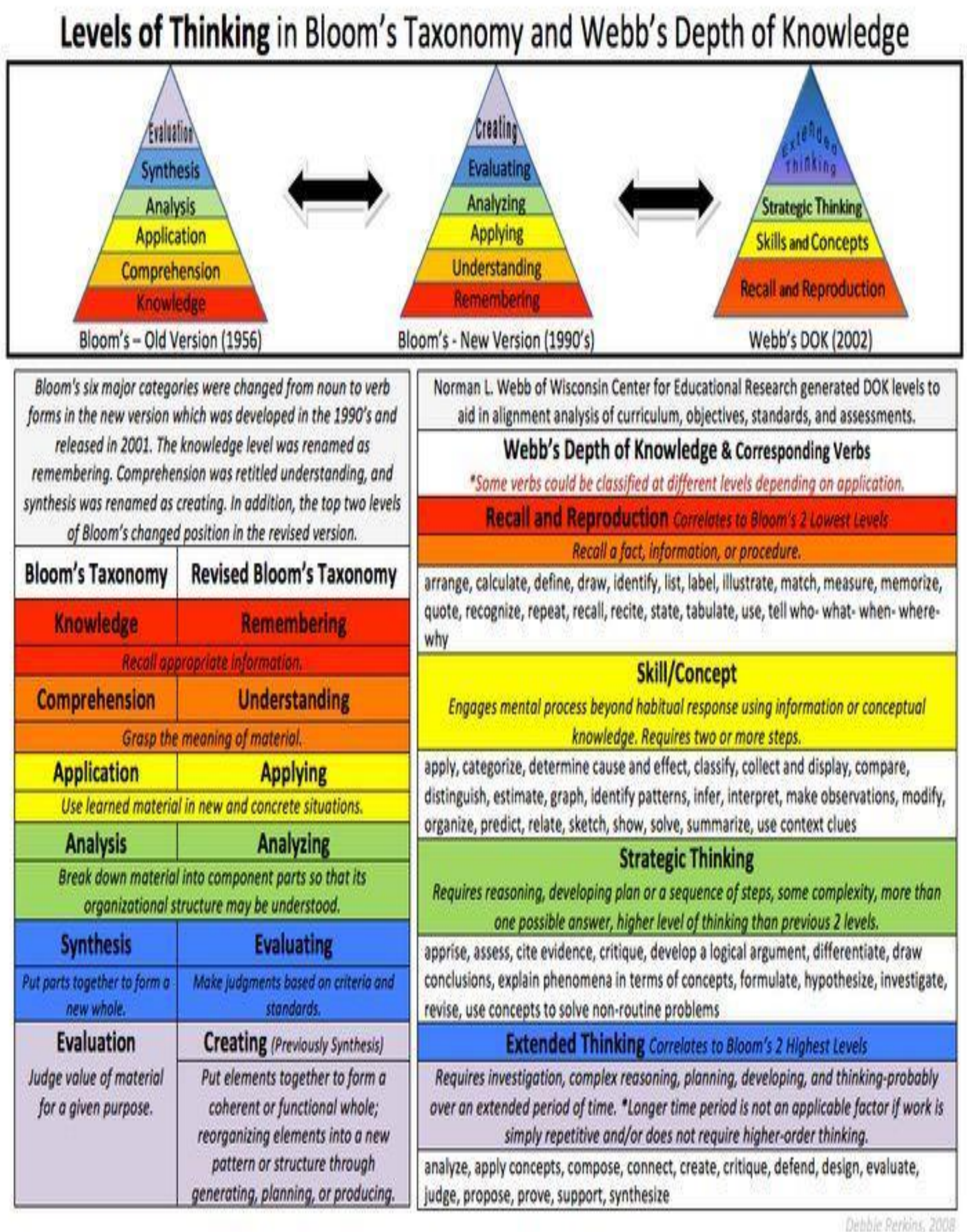
What Changed With the Common Core Standards Initiative?

The Fundamental Shifts for the Common Core Standards
Balance Literacy and Informational Text
Build Knowledge on the Disciplines
Build a Scaffold of Text Complexity
Text-Based Answers
Write From Various Sources
Build Academic Vocabulary

*Common Core Presentations:state.nj.us/education/archive/sca/ppt/gears/

APPENDIX C

BLOOM'S TAXONOMY AND WEBB'S DEPTH OF KNOWLEDGE



APPENDIX D

HESS'S COGNITIVE RIGOR MATRIX AND CURRICULAR EXAMPLES

Hess' Cognitive Rigor Matrix & Curricular Examples: Applying Webb's Depth-of-Knowledge Levels to Bloom's Cognitive Process Dimensions – *M-Sci*

Revised Bloom's Taxonomy	**Webb's DOK Level 1 Recall & Reproduction**	**Webb's DOK Level 2 Skills & Concepts**	**Webb's DOK Level 3** Strategic Thinking/ Reasoning	**Webb's DOK Level 4 Extended Thinking**
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	○ Recall, observe, & recognize facts, principles, properties ○ Recall/ identify conversions among representations or numbers (e.g., customary and metric measures)			
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion (such as from examples given), predict, compare/contrast, match like ideas, explain, construct models	○ Evaluate an expression ○ Locate points on a grid or number on number line ○ Solve a one-step problem ○ Represent math relationships in words, pictures, or symbols ○ Read, write, compare decimals in scientific notation	○ Specify and explain relationships (e.g., non-examples/examples; cause-effect) ○ Make and record observations ○ Explain steps followed ○ Summarize results or concepts ○ Make basic inferences or logical predictions from data/observations ○ Use models /diagrams to represent or explain mathematical concepts ○ Make and explain estimates	○ Use concepts to solve non-routine problems ○ Explain, generalize, or connect ideas using supporting evidence ○ Make and justify conjectures ○ Explain thinking when more than one response is possible ○ Explain phenomena in terms of concepts	○ Relate mathematical or scientific concepts to other content areas, other domains, or other concepts ○ Develop generalizations of the results obtained and the strategies used (from investigation or readings) and apply them to new problem situations
Apply Carry out or use a procedure in a given situation; carry out (apply to a familiar task), or use (apply) to an unfamiliar task	○ Follow simple procedures (recipe-type directions) ○ Calculate, measure, apply a rule (e.g., rounding) ○ Apply algorithm or formula (e.g., area, perimeter) ○ Solve linear equations ○ Make conversions among representations or numbers, or within and between customary and metric measures	○ Select a procedure according to criteria and perform it ○ Solve routine problem applying multiple concepts or decision points ○ Retrieve information from a table, graph, or figure and use it solve a problem requiring multiple steps ○ Translate between tables, graphs, words, and symbolic notations (e.g., graph data from a table) ○ Construct models given criteria	○ Design investigation for a specific purpose or research question ○ Conduct a designed investigation ○ Use concepts to solve non-routine problems ○ Use & show reasoning, planning, and evidence ○ Translate between problem & symbolic notation when not a direct translation	○ Select or devise approach among many alternatives to solve a problem ○ Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, find coherence, deconstruct	○ Retrieve information from a table or graph to answer a question ○ Identify whether specific information is contained in graphic representations (e.g., table, graph, T-chart, diagram) ○ Identify a pattern/trend	○ Categorize, classify materials, data, figures based on characteristics ○ Organize or order data ○ Compare/ contrast figures or data ○ Select appropriate graph and organize & display data ○ Interpret data from a simple graph ○ Extend a pattern	○ Compare information within or across data sets or texts ○ Analyze and draw conclusions from data, citing evidence ○ Generalize a pattern ○ Interpret data from complex graph ○ Analyze similarities/differences between procedures or solutions	○ Analyze multiple sources of evidence ○ analyze complex/abstract themes ○ Gather, analyze, and evaluate information
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique			○ Cite evidence and develop a logical argument for concepts or solutions ○ Describe, compare, and contrast solution methods ○ Verify reasonableness of results	○ Gather, analyze, & evaluate information to draw conclusions ○ Apply understanding in a novel way, provide argument or justification for the application
Create Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, construct, produce	○ Brainstorm ideas, concepts, or perspectives related to a topic	○ Generate conjectures or hypotheses based on observations or prior knowledge and experience	○ Synthesize information within one data set, source, or text ○ Formulate an original problem given a situation ○ Develop a scientific/mathematical model for a complex situation	○ Synthesize information across multiple sources or texts ○ Design a mathematical model to inform and solve a practical or abstract situation

Provided with the permission of:
Hess' Cognitive Rigor Matrix & Curricular Examples: Applying Webb's Depth-of-Knowledge Levels to Bloom's Cognitive Process Dimensions – *M-Sci*

APPENDIX E

CURRICULUM MAPS

Table 1

Language Arts and Literacy Curriculum Map

Evidence of Theme-Based Content for Reading Comprehension

Language Arts/Literacy Curriculum Map

*Adapted from Grade 4 District Curriculum of Six Elementary Schools in the HTPS District.
Integrated–interdisciplinary Control Group Curriculum

Unit 1 Building a Literacy Community Narrative - 20 Days

Essential Questions	Enduring Understandings	CCR	Standard	Learning Targets	Assessment Formative and Summative	Inter-disciplinary Connection	21st Century Connection
What do good readers do? Am I clear about what I just read? How do I know?	Students who are college and career ready read and interpret a variety of complex texts with confidence and independence.	Read and comprehend complete literary and informational texts independently and proficiently.	RL.4.10 By the end of the year, read and comprehend literature, including stories dramas and poetry in grades 4-5 text complexity band proficiently with scaffolding as needed at the high end of the range.	Use reading strategies to understand difficult complex text (e.g. ask questions, make connections , take notes, make inferences, visualize, and re-read).	Formative- Individual Teacher/ student conferences and notes. Summative- District Reading Inventory Assessment	6.1.4.A.1 Explain how rules and laws created by community, state and national governments protect the rights of people, help resolve conflicts, and promote the common good. 6.3.4.A.1 Evaluate what makes a good rule or law.	9.1.4.A.3 Determine when the use of technology is appropriate to solve problems. 9.1.4.E.3 Distinguish how digital media are used by individuals, groups, and organizations for varying purposes. 9.1.4.E.4 Explain why some uses of media are unethical. 9.1.4.F.1 Explain the meaning of productivity and accountability and describe situations in which productivity and accountability are important in home, school and community. 9.1.4.F.2 Establish and follow performance goals to guide progress.

Table 2

Mathematics: Sample Curriculum Map Integrated–Interdisciplinary Connections

Essential Questions	**Enduring Understandings**	**Domain**	**Cluster**	**Standard**	**Learning Targets**	**Assessments Formative & Summative**	**Interdisciplinary Connections**	**21st Century Connections**
What makes a computational strategy both effective and efficient?	Computational fluency includes understanding the meaning and the appropriate use of numerical operations.	Numbers and Operations in Base Ten Measurement and Data SMP 2- Reason abstractly and quantitatively. SMP 4- Model with mathematics. SMP 6- Attend to precision.	Use place value understanding and properties of operations to perform multi-digit arithmetic. Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	**4. NBT.5 –** Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculations by using equations, rectangular arrays and/or area models. 4. MD.3 – Apply the area and perimeter formulas for rectangles in real world and mathematical problems.	Review rectangular arrays and explore patterns in square numbers. Develop a formula for area of a rectangle. Find factor pairs. Explore how factors and multiples are related. Classify numbers as prime or composite. Create and solve multiplicative comparison statements and equations. Use rules to complete "What's My Rule/" tables. {For example, find the width of a rectangular room given the area of the flooring and the length, by viewing the area formula as a multiplication equation with an unknown factor.}	*Written Assessment* *Open Response Question* Identify factor pairs. Identify patterns of square numbers. Write equations for arrays. For a given number, list factors and tell whether it is prime or composite. Write an equation to represent multiplicative comparisons. Create a "What's My Rule" table and have a partner describe its pattern.	RI.4.7.- Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs diagrams, timelines, animations or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.	9.1.4. D.1 – Use effective oral and written communication in face-to-face and online interactions and when presenting to an audience.

*Adapted from Grade 4 Control Group - Six Elementary Schools in the HTPS District

Table 3

Science Unit: Structure, Function, and Information Processing (Plants)

Pacing 25 Days September- Mid October

*Adapted from Grade 4 District Curriculum of Six Elementary Schools in the HTPS District. Integrated–interdisciplinary Control Group Curriculum

NGSS Performance Expectations	3-Dimensional Learning Components	Anchoring Phenomena Essential Questions	Enduring Understandings	Learning Targets	Assessments- Formative & Summative	Interdisciplinary Connections
4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. 4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival growth, behavior and reproduction. 4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.	Science and Engineering Practice: Developing and Using Models: Develop a model to describe phenomena (4-PS$-2). Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2) Engage in an argument from evidence Engaging in argument from evidence in 3-5 builds on experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. Construct an argument with evidence data, and/or a model. (4-LS1-1) **Crosscutting Concepts**: Cause and Effect relationships re routinely identified. (4-PS4-2) Systems and system Models: a system can be described in terms its components and their interactions. (4-LS1-1);	How do we classify living things? How can we compare natural and classroom habitats? How does a plant meet its basic needs for survival? How do plant structures work together for plant survival? How do plants respond to changes in temperature ? How do different types of plants respond to changes in the seasons? Phenomena: Venus Fly Trap eating bugs.	2.3 – Plant Structures and Survival Plants have internal and external structures that help them to survive, grow and reproduce. 2.4 Plant and Animal Responses Plants and animals are suited to living in their own particular habitat where they can meet their basic needs for survival. These basic needs are met through a combination of physical structures and behaviors. Sometimes an environment or habitat changes. The change may be part of a seasonal cycle. The temperature and availability of food and water change with the seasons. Both plants and animals have adaptations, physical and behavioral patterns, which allow them to respond to seasonal changes. The purpose of this lesson is for students to understand how plants and animals respond to seasonal changes through adaptations, thus allowing them to survive.	Investigate how the physical structures of plants (roots, stems, leaves, flowers and fruits) support their basic needs. Analyze and interpret how the physical structures op plants connect to their specific functions and construct an explanation of how these structures work together as a system in a plant. Observe and compare characteristics of plant structures in a variety of plants. Draw evidence from literacy or informational text to support analysis, reflection, and research. Plant and Animal Seasonal Responses Construct an explanation for how adaptations of plants allow them to respond to seasonal changes. Carry out a guided inquiry about the effects of temperature on plants. Construct an explanation for how adaptations	2.3 Plant Structures and Survival **Formative-** Journal Entry- How does a plant meet its basic needs for survival? **Summative-** Draw a plant and label its physical structures. Explain how these structures help the plant survive. 2.4- Plant and Seasonal Responses **Formative-** Journal Entry – give examples of how plants respond to seasonal change. **Summative-** Choose a plant that you learned about to interview. Write at least four questions for a plant and responses for that plant regarding how it responds to change in seasons.	**Mathematics:** MP.4 Model with mathematics (4-PS4-2) 4.G.A.1 Draw points, lines ,line segments, rays angles,(right, obtuse acute) and perpendicular and parallel lines. Identify these in two- dimensional figures. (4-PS$-2) 4. G.A.3. Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. **ELA/Literacy:** RI.01 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. RI.04 Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area. RI.07 Interpret information presented visually, orally or qualitatively (e.g. in charts, graphs,

	(4-LS1-2) **Disciplinary Core Ideas:** P34.B Electromagnetic Radiation- An object can be seen when light reflected from the surface enters the eye.(4-PS4-2) LS1.A Structure and function plants and animals have both internal and external structures that serve various functions in growth survival, behavior and reproduction. (4-LS1-1) LS1.D Information processing are specialized for particular kinds of information which then may be processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS!-2).			of animals allow them to respond to seasonal changes. Compare seasonal behaviors of migration, hibernation and staying active. Carry out a guided inquiry about the effects of temperature on animals. Recognize and understand that conducting science investigations requires safe practices. Draw evidence from nonfiction reading texts.		diagrams, timelines, animations or interactive elements, on Web pages) and explain how the information contributes to an understanding of the text in which it appears. W.4.1 Write opinion pieces on topics and text, supporting a point of view with reasons and information. (4-LS-1). SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. (4-PS4-2), (4-LS1-2) **Technology:** 8.2.5.D.3 Follow step by step Directions to assemble a product or solve a problem.

APPENDIX F

NATIONAL RESEARCH COUNCIL: ORGANIZATION OF 21ST CENTURY SKILLS

(Report Brief: Education for Life and Work:nap.edu/resource/13398/dbasse_070895.pdf)

Cognitive Domain	**Intrapersonal Domain**	**Interpersonal Domain**
Analysis	Adaptability	Responsibility
Decision making	Integrity	Social Influence with Others
Adaptive Learning	Appreciation for Diversity	Assertive Communication
Problem Solving	Intellectual Interest and Curiosity	Leadership
Interpretation	Self-Monitoring	Empathy/Perspective-taking
Information	Continuous Learning	Trust
Communication Technology	Artistic and Cultural Appreciation	Interpersonal Competencies
Active Listening	Initiative	Self-Presentation
Creativity	Self-Evaluation	Coordination
Innovation	Flexibility	Teamwork
Critical Thinking	Metacognition	
	Self-Direction	
	Physical and Psychological Health	
	Work Ethic/ Conscientiousness	
	Grit	
	Citizenship	
	Perseverance	
	Responsibility	
	Self-Reinforcement	
	Career Orientation	

APPENDIX G

EXAMPLE ELEMENTARY PROGRESS REPORT: GRADE 4 EXPECTATIONS

Language Arts - Reading	**Uses reading skills and strategies** **Uses comprehension skills** **Participates in discussions** **Writes in response to literature**
Language Arts - Literacy	**Writing Rubric** **Writes on Topic** **Expresses ideas clearly and logically in paragraph form** **Revises writing for content and organization** **Spells appropriately in daily work** **Learns assigned spelling words**
Mathematics Strands	**Numeration** **Operations and computation** **Patterns, Relationships, and Functions** **Measurement** **Geometry** **Statistics, Data Analysis and Probability** **Problem Solving / Analytical Reasoning** **Maintains secure skills**
Science	**Shows Understanding of unit and applies knowledge** **Exhibits appropriate understanding of science process skills** **Uses appropriate science vocabulary** **Demonstrates problem solving strategies** **Communicates ideas and data in an appropriate manner**

*Adapted from Hillsborough Township Public Schools, Grade 4 – Progress Report 2017

APPENDIX H

CHARACTERISTICS OF A CURRICULUM AND ASSESSMENT PLAN

The following seven characteristics of a curriculum and assessment plan were developed using standards linking.	
Characteristic	Description
Explicit	Expresses clear targets for learning drawn from the identified standards.
Coherent	Organizes content (concepts, skills, and processes) to show increasingly rigorous expectations as students move to higher grades.
Dynamic	Supports rich interactions among the standards, learner strengths and needs, effective instruction, and multidimensional assessment.
Practical	Provides a clear, well-organized, user-friendly format.
Comprehensive	Incorporates all subject areas that are part of the curriculum.
Coherent	Uses consistent organizational approaches and language across subject areas throughout the document.
Manageable	Represents not only what *all* students can learn but also what any *one* student can be expected to learn.
Source: The Center for Curriculum Renewal, 1998	

APPENDIX I

EXCEL SPREADSHEET OF SCHOOLS IN STUDY: 2015

School	County	District	Grade Span	Curriculum	2015#grade 4 students	2015 Soc./Ec.	2015 ELL	2015 Disability	2015 Total Population	2015 Language Arts	2015 Math	2015 Science
Amsterdam Elementary	Somerset	Hillsborough	KH-04	integrated	111	3%	2%	14%	511	78%	63%	99%
Lyncrest Elem School	Bergen	Fair Lawn Boro	KH-05	subject-specific	40	17%	12%	15%	229	75%	78%	98%
Hillsborough Elementary	Somerset	Hillsborough	KH-04	integrated	104	10%	5%	17%	517	70%	69%	99%
Warren Point Elementary	Bergen	Fair Lawn Boro	KH-05	subject-specific	63	14%	7%	19%	398	72%	66%	97%
Sunnymead Elementary	Somerset	Hillsborough	3H-04	integrated	82	18%	8%	12%	415	80%	65%	96%
William H. Ross III School	Atlantic	Margate	3H-04	subject-specific	46	10%	0%	15%	228	50%	42%	100%
Triangle Elementary	Somerset	Hillsborough	PK-04	integrated	75	9%	11%	28%	370	77%	71%	94%
Bayberry School	Somerset	Watchung	PK-04	subject-specific	67	2%	1%	2%	363	78%	68%	100%
Woodfern Elementary	Somerset	Hillsborough	KH-04	integrated	77	14%	5%	21%	388	52%	62%	97%
Barley Sheaf Elementary	Hunterdon	Flemington	KF-04	subject-specific	75	2%	0%	14%	353	77%	70%	98%
Woods Road Elementary	Somerset	Hillsborough	3H-04	integrated	85	4%	3%	28%	471	77%	62%	99%
Brookdale Ave. School	Essex	Verona	KH-04	subject-specific	22	2%	0%	13%	120	68%	21%	100%
Community Park School	Mercer	Princeton	3H-05	integrated	52	19%	10%	15%	324	68%	60%	100%
Wanamassa Elementary	Monmouth	Ocean Township	3H-04	subject-specific	66	11%	5%	23%	306	73%	65%	100%
Johnson Park School	Mercer	Princeton	3H-05	integrated	48	24%	4%	20%	355	70%	60%	91%
North End Elementary	Essex	Cedar Grove	3F-04	subject-specific	61	4%	4%	14%	307	77%	64%	92%
Littlebrook School	Mercer	Princeton	3H-05	integrated	64	8%	8%	15%	352	92%	79%	98%
Tewksberry Elementary	Hunterdon	Tewksberry Twshp	3H-04	subject-specific	66	1%	0%	15%	310	68%	60%	100%
Riverside School	Mercer	Princeton	3H-05	integrated	30	18%	5%	24%	286	64%	67%	86%
Ridge Ranch Elementary	Bergen	Paramus	KF-04	subject-specific	48	5%	6%	17%	295	82%	64%	95%
Franklin Elementary	Bergen	Bergenfield	KF-05	integrated	45	35%	5%	13%	323	58%	40%	96%
Hamilton Primary School	Somerset	Bridgewater	KH-04	subject-specific	128	2%	0%	7%	475	89%	82%	98%
Hoover Elementary	Bergen	Bergenfield	KF-05	integrated	26	54%	10%	12%	214	61%	48%	93%
South End School	Essex	Cedar Grove	KF-04	subject-specific	62	2%	2%	1%	301	76%	51%	95%

Jefferson Elementary	Bergen	Bergenfield	KF-05	integrated	48	28%	5%	10%	254	49%	27%	97%
Frederic N. Brown School	Essex	Verona	KH-04	subject-specific	45	5%	4%	14%	205	58%	21%	93%
Lincoln Elementary	Bergen	Bergenfield	3H-05	integrated	48	28%	6%	34%	401	58%	52%	91%
Mt.Horeb School	Somerset	Warren	3H-05	subject-specific	47	1%	7%	26%	269	67%	59%	98%
Washington Elementary	Bergen	Bergenfield	KF-05	integrated	46	39%	6%	9%	306	51%	44%	95%
Woodland School	Somerset	Warren	KF-05	subject-specific	61	0%	4%	7%	285	65%	65%	94%
Central School	Camden	Haddonfield	3H-05	integrated	65	2%	0%	21%	404	78%	72%	94%
Hopewell Elementary	Mercer	Hopewell Valley	3H-05	subject-specific	60	2%	1%	18%	419	68%	48%	94%
Elizabeth Haddon School	Camden	Haddonfield	3H-05	integrated	51	0%	0%	6%	340	82%	69%	100%
Bear Tavern Elementary	Mercer	Hopewell Valley	3H-05	subject-specific	91	4%	1%	19%	392	82%	68%	98%
J.Fithian Tatem School	Camden	Haddonfield	3H-05	integrated	77	2%	0%	21%	455	72%	68%	96%
Hilltop Elementary	Morris	Mendham	3H-04	subject-specific	77	2%	0%	13%	305	80%	64%	99%
Stony Brook School	Somerset	Branchburg	GR 04-05	integrated	177	6%	0%	19%	350	69%	62%	96%
Memorial Elementary	Bergen	Montvale	3H-04	subject-specific	107	1%	2%	12%	559	83%	51%	96%
Village Elementary	Somerset	Montgomery	GR 03-04	integrated	351	5%	1%	17%	648	76%	68%	96%
Laning Ave. School	Essex	Verona	3H-04	subject-specific	43	0%	0%	20%	274	94%	64%	96%
Sea Girt Elementary	Monmouth	Sea Girt Boro	3H-08	integrated	15	0%	0%	10%	161	93%	60%	100%
Loudenslager Elementary	Gloucester	Paulsboro Boro	GR 03-06	subject-specific	71	75%	1%	23%	303	22%	0%	68%
Robertsville Elementary	Monmouth	Marlboro Township	GR 01-05	integrated	101	9%	6%	18%	507	78%	55%	96%
Good Intent Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	57	45%	6%	17%	352	59%	49%	96%
Asher Holmes Elementary	Monmouth	Marlboro Township	GR 01-05	integrated	115	4%	4%	16%	615	59%	50%	100%
Lake Tract Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	95	40%	0%	13%	513	43%	44%	96%
Frank DeFino Central Elem	Monmouth	Marlboro Township	GR 01-05	integrated	125	5%	3%	15%	541	80%	72%	99%
Dane Barse Elementary	Cumberland	Vineland City	KF-05	subject-specific	51	83%	13%	13%	329	34%	36%	97%
Frank J. Dugan Elementary	Monmouth	Marlboro Township	GR 01-05	integrated	130	4%	3%	20%	605	58%	55%	98%
Eleanor Rush Intermediate	Burlington	Cinnaminson Twp	GR 03-05	subject-specific	179	18%	0%	17%	523	61%	49%	96%
Marlboro Elementary	Monmouth	Marlboro Township	GR 01-05	integrated	105	3%	2%	18%	509	76%	69%	99%
Dr. William Mennies Elem	Cumberland	Vineland City	KF-05	subject-specific	92	3%	10%	11%	595	44%	21%	97%
Knollwood School	Monmouth	Fair Haven Boro	GR 04-08	integrated	107	1%	0%	16%	592	64%	47%	95%
Roosevelt School	Hudson	Kearny Town	4H-06	subject-specific	59	38%	0%	13%	485	38%	32%	98%
Cedar Hill School	Somerset	Bernards Township	KF-05	integrated	101	3%	0%	15%	610	72%	77%	94%

Gloria M. Sabater Elem.	Cumberland	Vineland City	KF-05	subject-specific	115	93%	37%	12%	799	26%	14%	93%
Liberty Corner School	Somerset	Bernards Township	KF-05	integrated	99	2%	0%	16%	556	78%	76%	98%
Florence Riverfront School	Burlington	Florence Township	GR 04-08	subject-specific	152	32%	1%	15%	710	36%	42%	89%
Mount Prospect Elem.	Somerset	Bernards Township	3H-05	integrated	112	1%	4%	18%	687	85%	84%	98%
Oak Valley Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	84	35%	0%	26%	424	44%	36%	95%
Oak Street School	Somerset	Bernards Township	KF-05	integrated	98	4%	1%	13%	579	85%	77%	96%
Robert L. Horbert Elem.	Ocean	Barnegat Township	KF-05	subject-specific	79	37%	2%	14%	444	34%	38%	96%
H.W.Monty Elem.	Monmouth	Spring Lake Boro	3F-08	integrated	29	0%	0%	15%	213	81%	85%	100%
Oldsman Township School	Salem	Oldsman Township	3H-08	subject-specific	27	31%	0%	6%	265	38%	33%	91%
Forrestdale School	Monmouth	Rumson Boro	GR 04-08	integrated	14	0%	0%	13%	483	70%	63%	98%
Anna L. Klein School	Hudson	Gutenburg Town	4H-08	subject-specific	97	78%	13%	8%	975	40%	18%	95%
Brooks Crossing Elem	Middlesex	South Brunswick	KF-05	integrated	145	14%	3%	6%	735	81%	66%	99%
Joseph T. Donahue	Ocean	Barnegat Township	KF-05	subject-specific	46	30%	0%	33%	262	38%	23%	89%
Brunswick Acres Elem.	Middlesex	South Brunswick	KF-05	integrated	81	15%	5%	10%	512	69%	60%	97%
Central School	Somerset	Warren Township	KF-05	subject-specific	58	2%	3%	11%	313	94%	81%	100%
Cambridge Elem.	Middlesex	South Brunswick	KF-05	integrated	100	7%	1%	10%	552	78%	72%	99%
John H. Winslow Elem.	Cumberland	Vineland City	KF-05	subject-specific	75	56%	4%	16%	511	42%	27%	86%
Constable Elementary	Middlesex	South Brunswick	KF-05	integrated	57	15%	5%	12%	484	73%	63%	98%
Dr.Joyanne D. Miller Elem	Atlantic	Egg Harbor Twnship	GR 04-05	subject-specific	591	49%	1%	13%	1175	41%	24%	91%
Greenbrook Elementary	Middlesex	South Brunswick	KF-05	integrated	67	26%	6%	16%	435	69%	66%	98%
Alpha Borough School	Warren	Alpha Boro	4H-08	subject-specific	20	37%	0%	16%	224	37%	21%	100%
Indian Fields Elementary	Middlesex	South Brunswick	3H-05	integrated	102	9%	5%	12%	589	63%	69%	99%
Franklin Elementary	Hudson	Kearny Town	3H-06	subject-specific	168	64%	8%	12%	1092	33%	23%	90%
Monmouth Junction Elem.	Middlesex	South Brunswick	3H-05	integrated	70	2%	1%	7%	341	85%	87%	98%
MacFarland Intermediate	Burlington	Bordentown Reg.	GR 04-05	subject-specific	180	20%	3%	21%	405	49%	34%	94%
Bartle Elementary	Middlesex	Highland Park Boro	GR 02-05	integrated	103	42%	6%	12%	473	68%	57%	87%
Shady Lane Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	78	53%	0%	17%	409	25%	34%	90%
Bowne-Munro Elem.	Middlesex	East Brunswick	3H-05	integrated	42	22%	1%	13%	214	74%	51%	96%
Cecil S. Collins Elementary	Ocean	Barnegat Township	3H-05	subject-specific	59	22%	1%	23%	419	57%	30%	100%
Central Elementary	Middlesex	East Brunswick	3H-05	integrated	60	15%	9%	19%	439	67%	61%	90%
Garfield Elementary	Hudson	Kearny Town	4H-06	subject-specific	78	63%	2%	14%	557	27%	21%	85%

Chittick Elementary	Middlesex	East Brunswick	3H-05	integrated	63	17%	0%	14%	416	74%	43%	92%
Maude M Wilkins Elem	Burlington	Maple Shade	3H-04	subject-specific	161	47%	1%	34%	402	39%	14%	93%
Frost Elementary	Middlesex	East Brunswick	3H-05	integrated	74	7%	5%	11%	425	86%	77%	99%
Hamilton Intermediate	Hudson	Harrison Town	GR 04-05	subject-specific	144	79%	3%	23%	302	45%	23%	0%
Irwin Elementary	Middlesex	East Brunswick	3H-05	integrated	72	23%	9%	9%	468	80%	67%	96%
Washington Elementary	Hudson	Kearny Town	4H-06	subject-specific	75	80%	3%	17%	621	31%	19%	94%
Lawrence Brook Elem.	Middlesex	East Brunswick	3H-05	integrated	58	21%	8%	18%	385	75%	58%	98%
Huber St. No. 3	Hudson	Secaucus Town	3H-05	subject-specific	73	29%	2%	8%	690	64%	45%	91%
Memorial Elementary	Middlesex	East Brunswick	3H-05	integrated	76	15%	0%	19%	477	76%	68%	94%
Clarendon No. 4	Hudson	Secaucus Town	3H-05	subject-specific	89	26%	1%	15%	582	37%	29%	85%
Warnsdorfer Elementary	Middlesex	East Brunswick	3H-05	integrated	79	5%	0%	12%	463	69%	64%	98%
Thelma L. Sandmeier Elem	Union	Springfield Townshp	GR-03-05	subject-specific	91	10%	0%	14%	246	78%	59%	96%
Center Grove School	Morris	Randolph Township	3H-05	integrated	83	5%	1%	19%	478	67%	54%	99%
James Caldwell Elem. Sch.	Union	Springfield Twnship	GR 03-05	subject-specific	87	14%	4%	13%	245	58%	50%	96%

*****Information gathered from Performance Reports 2014-15:nj.gov/education/pr/1415

APPENDIX J

EXCEL SPREADSHEET OF SCHOOLS IN STUDY: 2016

School	County	District	Grade Span	Curriculum	2016#grade 4 students	2016 Soc./Ec.	2016 ELL	2016 Disability	2016 Total Population	2016 Language Arts	2016 Math	2016 Science
Amsterdam Elementary	Somerset	Hillsborough	KH-04	Integrated	108	4%	4%	17%	532	72%	77%	100%
Lyncrest Elem School	Bergen	Fair Lawn Boro	KH-05	subject-specific	33	12%	6%	13%	233	74%	88%	92%
Hillsborough Elementary	Somerset	Hillsborough	KH-04	integrated	119	10%	6%	20%	501	71%	79%	99%
Warren Point Elementary	Bergen	Fair Lawn Boro	KH-05	subject-specific	62	14%	10%	21%	416	74%	74%	100%
Sunnymead Elementary	Somerset	Hillsborough	3H-04	integrated	85	21%	6%	15%	451	76%	81%	97%
William H. Ross III School	Atlantic	Margate	3H-04	subject-specific	40	13%	1%	24%	205	75%	70%	98%
Triangle Elementary	Somerset	Hillsborough	PK-04	integrated	78	8%	7%	31%	378	80%	82%	100%
Bayberry School	Somerset	Watchung	PK-04	subject-specific	72	2%	1%	2%	354	79%	55%	100%
Woodfern Elementary	Somerset	Hillsborough	KH-04	integrated	78	13%	6%	23%	366	66%	68%	99%
Barley Sheaf Elementary	Hunterdon	Flemington	KF-04	subject-specific	69	4%	0%	16%	333	81%	80%	100%
Woods Road Elementary	Somerset	Hillsborough	3H-04	integrated	80	3%	2%	29%	489	82%	82%	98%
Brookdale Ave. School	Essex	Verona	KH-04	subject-specific	23	0%	0%	13%	114	35%	35%	96%
Community Park School	Mercer	Princeton	3H-05	integrated	46	21%	10%	17%	321	67%	58%	92%
Wanamassa Elementary	Monmouth	Ocean Township	3H-04	subject-specific	54	14%	5%	29%	294	60%	70%	97%
Johnson Park School	Mercer	Princeton	3H-05	integrated	47	26%	5%	25%	348	81%	81%	100%
North End Elementary	Essex	Cedar Grove	3F-04	subject-specific	57	4%	5%	22%	303	88%	63%	95%
Littlebrook School	Mercer	Princeton	3H-05	integrated	58	9%	9%	14%	334	84%	82%	100%
Tewksberry Elementary	Hunterdon	Tewksberry Twshp	3H-04	subject-specific	75	3%	0%	21%	302	77%	52%	100%
Riverside School	Mercer	Princeton	3H-05	integrated	37	17%	6%	23%	266	91%	83%	97%
Ridge Ranch Elementary	Bergen	Paramus	KF-04	subject-specific	70	3%	6%	20%	326	70%	68%	98%
Franklin Elementary	Bergen	Bergenfield	KF-05	integrated	64	33%	5%	11%	346	72%	58%	93%
Hamilton Primary School	Somerset	Bridgewater	KH-04	subject-specific	138	3%	0%	10%	481	78%	74%	98%
Hoover Elementary	Bergen	Bergenfield	KF-05	integrated	35	58%	10%	19%	206	72%	54%	90%

South End School	Essex	Cedar Grove	KF-04	subject-specific	69	2%	2%	13%	285	75%	73%	96%
Jefferson Elementary	Bergen	Bergenfield	KF-05	integrated	44	29%	7%	12%	263	71%	61%	93%
Frederic N. Brown School	Essex	Verona	KH-04	subject-specific	44	0%	3%	20%	199	68%	27%	95%
Lincoln Elementary	Bergen	Bergenfield	3H-05	integrated	51	31%	9%	34%	426	56%	66%	92%
Mt.Horeb School	Somerset	Warren	3H-05	subject-specific	43	0%	6%	22%	266	57%	55%	93%
Washington Elementary	Bergen	Bergenfield	KF-05	integrated	63	36%	9%	10%	312	56%	55%	100%
Woodland School	Somerset	Warren	KF-05	subject-specific	36	2%	5%	18%	261	81%	78%	100%
Central School	Camden	Haddonfield	3H-05	integrated	76	2%	0%	18%	414	85%	79%	96%
Hopewell Elementary	Mercer	Hopewell Valley	3H-05	subject-specific	74	5%	1%	17%	445	71%	62%	96%
Elizabeth Haddon School	Camden	Haddonfield	3H-05	integrated	48	0%	0%	19%	355	73%	53%	98%
Bear Tavern Elementary	Mercer	Hopewell Valley	3H-05	subject-specific	71	4%	1%	15%	422	91%	85%	97%
J.Fithian Tatem School	Camden	Haddonfield	3H-05	integrated	73	1%	0%	22%	444	74%	62%	95%
Hilltop Elementary	Morris	Mendham	3H-04	subject-specific	53	2%	0%	18%	278	85%	83%	100%
Stony Brook School	Somerset	Branchburg	GR 04-05	integrated	146	5%	1%	13%	322	75%	76%	95%
Memorial Elementary	Bergen	Montvale	3H-04	subject-specific	112	4%	4%	14%	519	71%	68%	98%
Village Elementary	Somerset	Montgomery	GR 03-04	integrated	333	5%	3%	16%	649	74%	75%	97%
Laning Ave. School	Essex	Verona	3H-04	subject-specific	51	0%	0%	26%	265	62%	62%	95%
Sea Girt Elementary	Monmouth	Sea Girt Boro	3H-08	integrated	16	0%	0%	9%	154	63%	75%	100%
Loudenslager Elementary	Gloucester	Paulsboro Boro	GR 03-06	subject-specific	63	34%	2%	26%	286	27%	24%	82%
Robertsville Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	100	7%	5%	18%	556	63%	48%	96%
Good Intent Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	50	43%	10%	23%	359	45%	52%	96%
Asher Holmes Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	135	3%	2%	20%	587	71%	68%	99%
Lake Tract Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	90	37%	0%	15%	509	49%	41%	94%
Frank DeFino Central Elem	Monmouth	MarlboroTwnshp	GR 01-05	integrated	112	5%	4%	17%	507	80%	77%	100%
Dane Barse Elementary	Cumberland	Vineland City	KF-05	subject-specific	53	78%	7%	19%	339	41%	37%	98%
Frank J. Dugan Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	131	3%	1%	20%	572	84%	75%	100%
Eleanor Rush Intermediate	Burlington	Cinnaminson Twp	GR 03-05	subject-specific	167	14%	1%	16%	537	57%	46%	98%
Marlboro Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	120	3%	1%	17%	473	75%	67%	100%
Dr. William Mennies Elem	Cumberland	Vineland City	KF-05	subject-specific	88	75%	7%	13%	622	33%	31%	93%
Knollwood School	Monmouth	Fair Haven Boro	GR 04-08	integrated	107	1%	0%	17%	588	62%	67%	97%
Roosevelt School	Hudson	Kearny Town	4H-06	subject-specific	56	34%	1%	15%	474	29%	31%	92%

Cedar Hill School	Somerset	Bernards Township	KF-05	integrated	101	3%	1%	17%	611	81%	82%	99%
Gloria M. Sabater Elem.	Cumberland	Vineland City	KF-05	subject-specific	136	96%	37%	15%	760	21%	11%	79%
Liberty Corner School	Somerset	Bernards Township	KF-05	integrated	88	2%	2%	16%	535	72%	72%	98%
Florence Riverfront Sch	Burlington	Florence Township	GR 04-08	subject-specific	146	26%	1%	19%	737	49%	40%	91%
Mount Prospect Elem.	Somerset	Bernards Township	3H-05	integrated	114	1%	5%	20%	677	83%	84%	97%
Oak Valley Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	60	30%	0%	23%	395	36%	46%	97%
Oak Street School	Somerset	Bernards Township	KF-05	integrated	106	3%	1%	13%	547	75%	81%	98%
Robert L. Horbert Elem.	Ocean	Barnegat Township	KF-05	subject-specific	63	36%	3%	12%	417	34%	21%	85%
H.W.Monty Elem.	Monmouth	Spring Lake Boro	3F-08	integrated	20	1%	0%	21%	214	94%	94%	100%
Oldsman Township School	Salem	Oldmans Township	3H-08	subject-specific	33	30%	0%	11%	285	71%	87%	100%
Forrestdale School	Monmouth	Rumson Boro	GR 04-08	integrated	99	0%	0%	12%	560	85%	80%	99%
Anna L. Klein School	Hudson	Gutenburg Town	4H-08	subject-specific	110	79%	19%	9%	1015	28%	18%	88%
Brooks Crossing Elem	Middlesex	South Brunswick	KF-05	integrated	153	12%	4%	7%	714	81%	79%	98%
Joseph T. Donahue	Ocean	Barnegat Township	KF-05	subject-specific	36	31%	2%	39%	261	55%	32%	92%
Brunswick Acres Elem.	Middlesex	South Brunswick	KF-05	integrated	99	13%	6%	8%	528	71%	64%	97%
Central School	Somerset	Warren Township	KF-05	subject-specific	60	5%	7%	11%	314	72%	67%	100%
Cambridge Elem.	Middlesex	South Brunswick	KF-05	integrated	92	7%	1%	12%	548	72%	67%	98%
John H. Winslow Elem.	Cumberland	Vineland City	KF-05	subject-specific	58	51%	0%	18%	468	48%	36%	97%
Constable Elementary	Middlesex	South Brunswick	KF-05	integrated	77	14%	4%	11%	460	73%	61%	94%
Dr.Joyanne D. Miller Elem	Atlantic	Egg Harbor Twnsh	GR 04-05	subject-specific	527	47%	1%	14%	1156	51%	36%	92%
Greenbrook Elementary	Middlesex	South Brunswick	KF-05	integrated	80	25%	8%	18%	432	56%	51%	94%
Alpha Borough School	Warren	Alpha Boro	4H-08	subject-specific	29	29%	1%	19%	200	35%	31%	85%
Indian Fields Elementary	Middlesex	South Brunswick	3H-05	integrated	98	10%	3%	15%	646	71%	66%	97%
Franklin Elementary	Hudson	Kearny Town	3H-06	subject-specific	159	61%	12%	5%	1147	42%	27%	91%
Monmouth Junction Elem.	Middlesex	South Brunswick	3H-05	integrated	72	2%	2%	13%	357	84%	81%	100%
MacFarland Intermediate	Burlington	Bordentown Reg.	GR 04-05	subject-specific	188	10%	3%	22%	397	55%	51%	93%
Bartle Elementary	Middlesex	Highland Park Bor	GR 02-05	integrated	122	38%	9%	11%	468	62%	58%	94%
Shady Lane Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	85	51%	0%	25%	425	31%	29%	79%
Bowne-Munro Elem.	Middlesex	East Brunswick	3H-05	integrated	36	18%	1%	15%	212	82%	76%	98%
Cecil S. Collins Elementary	Ocean	Barnegat Township	3H-05	subject-specific	54	25%	0%	27%	422	51%	23%	94%
Central Elementary	Middlesex	East Brunswick	3H-05	integrated	81	14%	6%	22%	421	68%	54%	97%

Garfield Elementary	Hudson	Kearny Town	4H-06	subject-specific	81	62%	0%	16%	527	37%	36%	95%
Chittick Elementary	Middlesex	East Brunswick	3H-05	integrated	75	20%	1%	19%	395	73%	61%	90%
Maude M Wilkins Elem	Burlington	Maple Shade	3H-04	subject-specific	155	44%	1%	38%	422	44%	26%	91%
Frost Elementary	Middlesex	East Brunswick	3H-05	integrated	66	7%	5%	15%	447	89%	81%	99%
Hamilton Intermediate	Hudson	Harrison Town	GR 04-05	subject-specific	134	78%	9%	19%	286	45%	21%	90%
Irwin Elementary	Middlesex	East Brunswick	3H-05	integrated	74	23%	12%	11%	462	70%	72%	92%
Washington Elementary	Hudson	Kearny Town	4H-06	subject-specific	81	81%	5%	20%	621	44%	40%	89%
Lawrence Brook Elem.	Middlesex	East Brunswick	3H-05	integrated	54	24%	14%	25%	432	73%	72%	94%
Huber St. No. 3	Hudson	Secaucus Town	3H-05	subject-specific	77	29%	3%	12%	654	60%	52%	95%
Memorial Elementary	Middlesex	East Brunswick	3H-05	integrated	80	15%	1%	22%	507	64%	67%	88%
Clarendon No. 4	Hudson	Secaucus Town	3H-05	subject-specific	89	23%	2%	17%	562	46%	43%	90%
Warnsdorfer Elementary	Middlesex	East Brunswick	3H-05	integrated	82	4%	1%	13%	480	77%	83%	97%
Thelma L. Sandmeier Elem	Union	Springfield Township	GR-03-05	subject-specific	80	10%	1%	16%	262	85%	86%	95%
Center Grove School	Morris	Randolph Township	3H-05	integrated	63	5%	1%	24%	488	79%	65%	98%
James Caldwell Elem. Sch.	Union	Springfield Township	GR 03-05	subject-specific	86	13%	3%	16%	281	55%	58%	96%

*Information gathered from Performance Reports: rc.doe.state.nj.us/ReportsDatabase1516.aspx

APPENDIX K

EXCEL SPREADSHEET OF SCHOOLS IN STUDY: 2017

School	County	District	Grade Span	Curriculum	2017#grade 4 students	2017 Soc./Ec.	2017 ELL	2017 Disability	2017 Total Population	2017 Language Arts	2017 Math	2017 Science
Amsterdam Elementary	Somerset	Hillsborough	KH-04	integrated	123	6%	5%	17%	558	75%	73%	97%
Lyncrest Elem School	Bergen	Fair Lawn Boro	KH-05	subject-specific	46	9%	10%	14%	232	74%	64%	92%
Hillsborough Elementary	Somerset	Hillsborough	KH-04	integrated	92	8%	4%	18%	484	66%	76%	100%
Warren Point Elementary	Bergen	Fair Lawn Boro	KH-05	subject-specific	77	10%	10%	20%	427	71%	70%	94%
Sunnymead Elementary	Somerset	Hillsborough	3H-04	integrated	78	20%	5%	15%	442	91%	86%	97%
William H. Ross III School	Atlantic	Margate	3H-04	subject-specific	46	10%	2%	23%	200	80%	74%	100%
Triangle Elementary	Somerset	Hillsborough	PK-04	integrated	62	9%	6%	31%	364	69%	66%	98%
Bayberry School	Somerset	Watchung	PK-04	subject-specific	93	2%	3%	2%	367	89%	62%	100%
Woodfern Elementary	Somerset	Hillsborough	KH-04	integrated	77	12%	9%	22%	355	76%	72%	97%
Barley Sheaf Elementary	Hunterdon	Flemington	KF-04	subject-specific	77	4%	0%	14%	337	81%	71%	100%
Woods Road Elementary	Somerset	Hillsborough	3H-04	integrated	88	3%	2%	28%	495	88%	82%	99%
Brookdale Ave. School	Essex	Verona	KH-04	subject-specific	33	0%	0%	12%	135	76%	52%	97%
Community Park School	Mercer	Princeton	3H-05	integrated	55	18%	7%	17%	375	72%	72%	97%
Wanamassa Elementary	Monmouth	Ocean Township	3H-04	subject-specific	63	15%	5%	31%	315	83%	71%	98%
Johnson Park School	Mercer	Princeton	3H-05	integrated	62	27%	7%	25%	380	83%	76%	97%
North End Elementary	Essex	Cedar Grove	3F-04	subject-specific	59	3%	5%	26%	279	65%	70%	93%
Littlebrook School	Mercer	Princeton	3H-05	integrated	60	9%	11%	13%	330	73%	78%	97%
Tewksberry Elementary	Hunterdon	Tewksberry Twshp	3H-04	subject-specific	59	3%	0%	21%	279	77%	64%	97%
Riverside School	Mercer	Princeton	3H-05	integrated	42	19%	5%	23%	290	92%	85%	100%
Ridge Ranch Elementary	Bergen	Paramus	KF-04	subject-specific	66	4%	6%	20%	333	70%	67%	97%
Franklin Elementary	Bergen	Bergenfield	KF-05	integrated	46	32%	9%	13%	353	61%	65%	89%
Hamilton Primary School	Somerset	Bridgewater	KH-04	subject-specific	126	2%	0%	9%	493	80%	80%	99%
Hoover Elementary	Bergen	Bergenfield	KF-05	integrated	41	57%	9%	24%	214	47%	40%	76%
South End School	Essex	Cedar Grove	KF-04	subject-specific	54	1%	3%	16%	294	87%	74%	100%
Jefferson Elementary	Bergen	Bergenfield	KF-05	integrated	39	28%	7%	12%	265	80%	58%	98%

Frederic N. Brown School	Essex	Verona	KH-04	subject-specific	35	0%	6%	22%	213	69%	44%	93%
Lincoln Elementary	Bergen	Bergenfield	3H-05	integrated	51	27%	10%	35%	442	74%	60%	92%
Mt.Horeb School	Somerset	Warren	3H-05	subject-specific	41	0%	3%	25%	240	63%	74%	89%
Washington Elementary	Bergen	Bergenfield	KF-05	integrated	66	39%	8%	12%	312	64%	62%	95%
Woodland School	Somerset	Warren	KF-05	subject-specific	54	0%	3%	17%	251	83%	65%	98%
Central School	Camden	Haddonfield	3H-05	integrated	68	2%	0%	16%	399	80%	87%	96%
Hopewell Elementary	Mercer	Hopewell Valley	3H-05	subject-specific	70	3%	0%	20%	454	85%	65%	99%
Elizabeth Haddon School	Camden	Haddonfield	3H-05	integrated	74	1%	0%	23%	377	81%	71%	97%
Bear Tavern Elementary	Mercer	Hopewell Valley	3H-05	subject-specific	84	2%	0%	21%	408	85%	74%	98%
J.Fithian Tatem School	Camden	Haddonfield	3H-05	integrated	65	1%	0%	21%	444	77%	68%	92%
Hilltop Elementary	Morris	Mendham	3H-04	subject-specific	60	3%	0%	16%	272	80%	76%	93%
Stony Brook School	Somerset	Branchburg	GR 04-05	integrated	176	5%	2%	15%	331	70%	67%	93%
Memorial Elementary	Bergen	Montvale	3H-04	subject-specific	99	2%	3%	12%	511	76%	66%	99%
Village Elementary	Somerset	Montgomery	GR 03-04	integrated	321	5%	4%	17%	657	77%	78%	96%
Laning Ave. School	Essex	Verona	3H-04	subject-specific	44	0%	0%	31%	254	70%	56%	96%
Sea Girt Elementary	Monmouth	Sea Girt Boro	3H-08	integrated	22	0%	0%	7%	141	91%	86%	100%
Loudenslager Elementary	Gloucester	Paulsboro Boro	GR 03-06	subject-specific	58	82%	2%	32%	278	34%	26%	79%
Robertsville Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	135	8%	5%	18%	577	76%	70%	97%
Good Intent Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	86	40%	10%	21%	367	42%	43%	94%
Asher Holmes Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	138	3%	1%	19%	592	81%	73%	98%
Lake Tract Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	111	39%	0%	20%	482	44%	39%	95%
Frank DeFino Central Elem	Monmouth	MarlboroTwnshp	GR 01-05	integrated	98	4%	4%	15%	457	86%	74%	99%
Dane Barse Elementary	Cumberland	Vineland City	KF-05	subject-specific	69	77%	10%	19%	349	51%	43%	96%
Frank J. Dugan Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	110	3%	2%	19%	546	78%	68%	95%
Eleanor Rush Intermediate	Burlington	Cinnaminson Twp	GR 03-05	subject-specific	186	14%	2%	20%	541	65%	50%	99%
Marlboro Elementary	Monmouth	MarlboroTwnshp	GR 01-05	integrated	90	3%	2%	16%	471	81%	72%	100%
Dr. William Mennies Elem	Cumberland	Vineland City	KF-05	subject-specific	87	72%	1%	13%	578	45%	29%	89%
Knollwood School	Monmouth	Fair Haven Boro	GR 04-08	integrated	108	0%	0%	15%	591	79%	80%	97%

Roosevelt School	Hudson	Kearny Town	4H-06	subject-specific	73	35%	1%	14%	445	50%	21%	87%
Cedar Hill School	Somerset	Bernards Township	KF-05	integrated	124	2%	1%	17%	594	76%	78%	97%
Gloria M. Sabater Elem.	Cumberland	Vineland City	KF-05	subject-specific	124	94%	31%	15%	763	32%	24%	77%
Liberty Corner School	Somerset	Bernards Township	KF-05	integrated	93	2%	2%	13%	554	79%	81%	98%
Florence Riverfront Sch	Burlington	Florence Township	GR 04-08	subject-specific	150	30%	1%	16%	719	39%	39%	86%
Mount Prospect Elem.	Somerset	Bernards Township	3H-05	integrated	103	1%	5%	20%	643	85%	88%	99%
Oak Valley Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	79	30%	0%	25%	380	57%	56%	97%
Oak Street School	Somerset	Bernards Township	KF-05	integrated	100	3%	1%	12%	520	77%	74%	94%
Robert L. Horbert Elem.	Ocean	Barnegat Township	KF-05	subject-specific	56	33%	2%	12%	397	59%	52%	94%
H.W.Monty Elem.	Monmouth	Spring Lake Boro	3F-08	integrated	15	0%	0%	18%	199	86%	60%	100%
Oldsman Township School	Salem	Oldmans Township	3H-08	subject-specific	35	26%	0%	11%	269	57%	66%	100%
Forrestdale School	Monmouth	Rumson Boro	GR 04-08	integrated	120	0%	0%	11%	600	93%	84%	99%
Anna L. Klein School	Hudson	Gutenburg Town	4H-08	subject-specific	108	80%	16%	9%	1022	45%	37%	87%
Brooks Crossing Elem	Middlesex	South Brunswick	KF-05	integrated	106	10%	4%	7%	663	76%	68%	92%
Joseph T. Donahue	Ocean	Barnegat Township	KF-05	subject-specific	40	36%	2%	33%	239	41%	25%	83%
Brunswick Acres Elem.	Middlesex	South Brunswick	KF-05	integrated	78	18%	6%	8%	538	66%	62%	91%
Central School	Somerset	Warren Township	KF-05	subject-specific	46	2%	3%	11%	302	87%	73%	95%
Cambridge Elem.	Middlesex	South Brunswick	KF-05	integrated	86	7%	2%	9%	543	77%	76%	96%
John H. Winslow Elem.	Cumberland	Vineland City	KF-05	subject-specific	68	49%	0%	23%	460	65%	55%	93%
Constable Elementary	Middlesex	South Brunswick	KF-05	integrated	85	13%	6%	9%	482	61%	61%	92%
Dr.Joyanne D. Miller Elem	Atlantic	Egg Harbor Twnsh	GR 04-05	subject-specific	558	50%	2%	15%	1162	58%	42%	85%
Greenbrook Elementary	Middlesex	South Brunswick	KF-05	integrated	65	27%	7%	19%	424	74%	60%	92%
Alpha Borough School	Warren	Alpha Boro	4H-08	subject-specific	25	27%	0%	19%	193	23%	23%	81%
Indian Fields Elementary	Middlesex	South Brunswick	3H-05	integrated	115	9%	4%	14%	699	62%	60%	92%
Franklin Elementary	Hudson	Kearny Town	3H-06	subject-specific	125	57%	10%	18%	1000	48%	35%	80%
Monmouth Junction Elem.	Middlesex	South Brunswick	3H-05	integrated	72	2%	2%	13%	357	84%	81%	100%
MacFarland Intermediate	Burlington	Bordentown Reg.	GR 04-05	subject-specific	165	2%	2%	26%	386	57%	52%	92%
Bartle Elementary	Middlesex	Highland Park Bor	GR 02-05	integrated	126	41%	10%	13%	478	58%	52%	84%
Shady Lane Elementary	Gloucester	Deptford Township	GR 02-06	subject-specific	97	53%	1%	29%	432	34%	26%	77%

Bowne-Munro Elem.	Middlesex	East Brunswick	3H-05	integrated	42	18%	0%	17%	210	85%	74%	98%
Cecil S. Collins Elementary	Ocean	Barnegat Township	3H-05	subject-specific	71	25%	0%	27%	443	58%	47%	95%
Central Elementary	Middlesex	East Brunswick	3H-05	integrated	70	14%	6%	20%	426	82%	71%	98%
Garfield Elementary	Hudson	Kearny Town	4H-06	subject-specific	73	60%	5%	15%	499	50%	42%	87%
Chittick Elementary	Middlesex	East Brunswick	3H-05	integrated	69	22%	9%	21%	432	77%	59%	91%
Maude M Wilkins Elem	Burlington	Maple Shade	3H-04	subject-specific	156	47%	4%	34%	437	39%	16%	87%
Frost Elementary	Middlesex	East Brunswick	3H-05	integrated	88	11%	7%	14%	465	75%	71%	96%
Hamilton Intermediate	Hudson	Harrison Town	GR 04-05	subject-specific	148	82%	9%	17%	283	51%	36%	85%
Irwin Elementary	Middlesex	East Brunswick	3H-05	integrated	89	21%	12%	13%	445	75%	66%	95%
Washington Elementary	Hudson	Kearny Town	4H-06	subject-specific	97	75%	11%	19%	594	39%	25%	79%
Lawrence Brook Elem.	Middlesex	East Brunswick	3H-05	integrated	63	27%	15%	23%	467	80%	80%	96%
Huber St. No. 3	Hudson	Secaucus Town	3H-05	subject-specific	94	24%	2%	15%	595	62%	61%	90%
Memorial Elementary	Middlesex	East Brunswick	3H-05	integrated	70	18%	1%	24%	506	59%	62%	90%
Clarendon No. 4	Hudson	Secaucus Town	3H-05	subject-specific	60	27%	3%	18%	448	65%	43%	95%
Warnsdorfer Elementary	Middlesex	East Brunswick	3H-05	integrated	90	6%	0%	10%	462	85%	81%	94%
Thelma L. Sandmeier Elem	Union	Springfield Twnship	GR-03-05	subject-specific	81	12%	0%	16%	271	67%	68%	89%
Center Grove School	Morris	Randolph Township	3H-05	integrated	85	6%	1%	21%	490	80%	71%	89%
James Caldwell Elem. Sch.	Union	Springfield Twnship	GR 03-05	subject-specific	104	13%	4%	19%	268	68%	64%	94%

*Information gathered from Performance Reports: rc.doe.state.nj.us/ReportsDatabase1617.aspx

APPENDIX L

GRAPHS FOR STUDY OUTCOMES

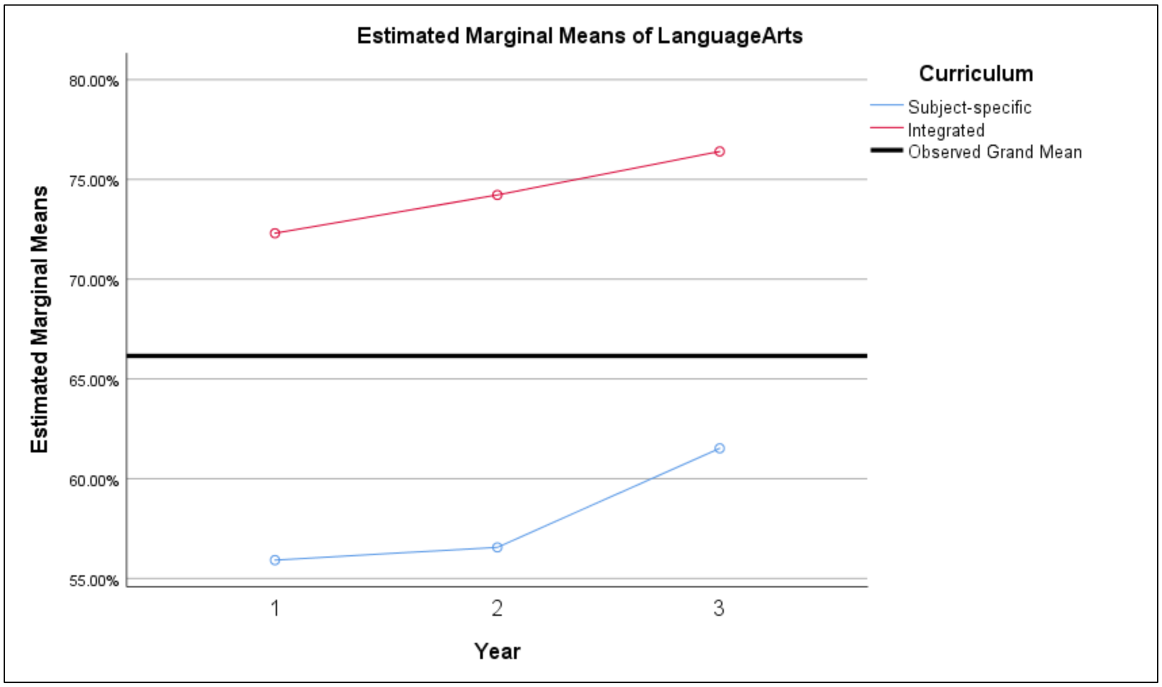


Figure 1. Estimated marginal means for language arts.

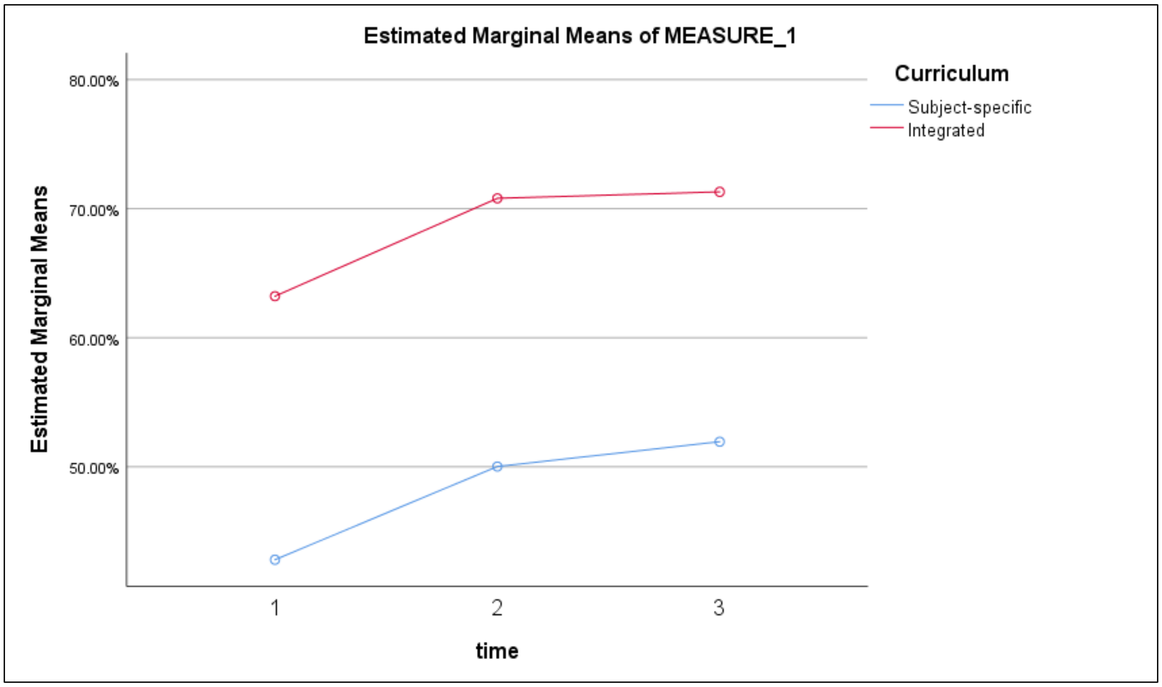


Figure 2. Estimated marginal means for mathematics.

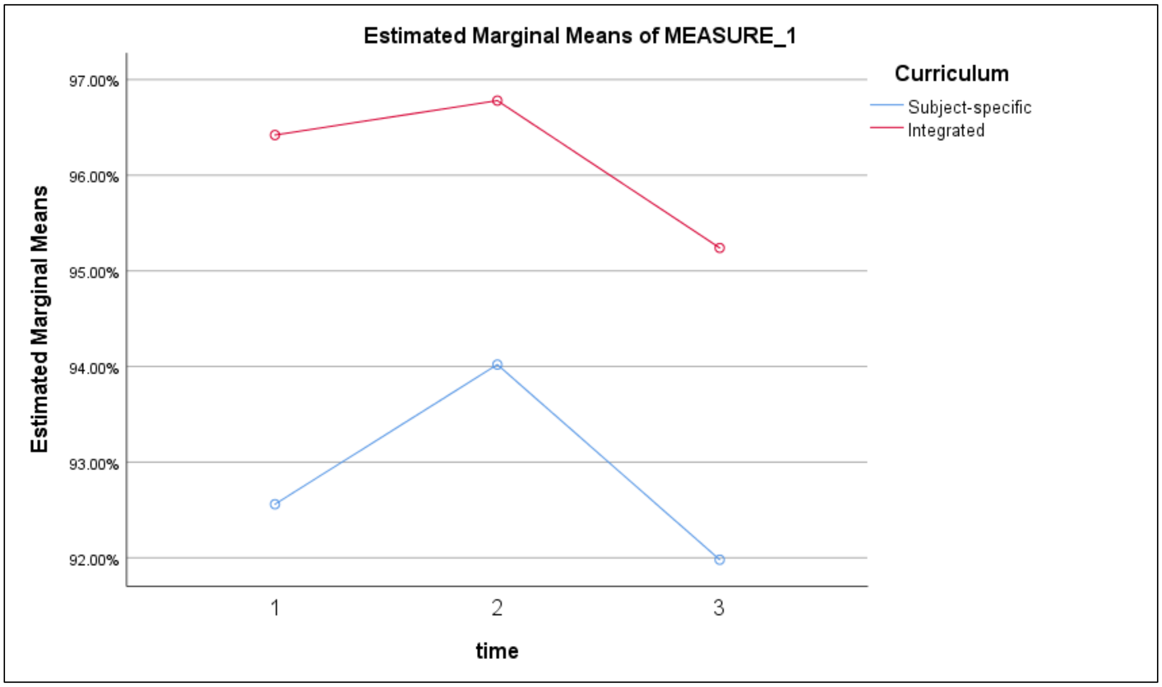


Figure 3. Estimated marginal means for science.

APPENDIX M

EMPHASIS ON PROCESS OF COMPREHENSION IN READING CURRICULUM

Grade 4	Grade 4	Grade 4	Grade 4	Grade 3	Grade 2	Grade 1
Focus on Retrieving Stated Information	Making Inferences	Interpret and Integrate Ideas and Information	Examining and Evaluating Content Language and Factual Elements	Reading Comprehension Skills	Reading Comprehension Skills	Reading Skills
Identifying Specific Ideas	Evaluating Cause & Effect	Discerning Overall Message or Theme	Interpreting a Real World Application of Text Information	Describing Style and Structure of the Text	Identifying Main Idea of the Text	Knowing Letters of the Alphabet
Searching for Definitions of Words or Phrases	Determining Referent of Pronoun	Describing Relationship between Two Characters	Evaluating Whether Events Described Could Really Happen	Identifying Main Idea of the Text	Explaining Supporting Understanding of the Text	Knowing Letter Sound Relationships
Finding Topic Sentences or Main Idea	Identifying Generalizations	Comparing and Contrasting Text Information	Judging Completeness or Clarity of Information	Explaining Supporting Understanding of the Text	Comparing Text with Personal Experience	Reading Words
	Summarizing Main Point	Inferring Story Mood or Tone	Determining an Author's Perspective	Comparing Text with Personal Experience	Comparing Different Texts	Reading Isolated Sentences
				Comparing Different Texts	Making Generalizations and Inferences Based on Text	Reading Connected Text
				Making Generalizations and Inferences Based on Text	Making Predictions-What Will Happen Next in the Text	Making Predictions-What Will Happen Next in the Text

*Table 1 -Emphasis on Process of Comprehension in Reading Curriculum
Adapted from the PIRLS 2006 – International Report from information in
Chapter 5 School Curriculum and Organization for the Teaching of Reading pgs.187-224.

APPENDIX N

INTEGRATION FOR ELL PROVIDING COGNITIVE LEARNING

Integrated Curriculum for English Language Learners **Provides** **Cognitive Views of Learning**
Redistributing authority and redefining classroom responsibilities
Cultivating and Nurturing Positive Attitudes by Connecting to students' life at home
Scaffolding content and supporting student awareness of metacognitive processes in learning
Developing students' capacity to think independently, critically, and creatively
Encourage real, active, and engaged conversations
Extending and connecting content and relationships beyond the classroom

Note. Adapted from *Teaching Science to Culturally and Linguistically Diverse Elementary Students*, by A. Cox-Petersen, L. M. Melber, and T. Patchen, 2012, Boston, MA: Pearson Education.

APPENDIX O

RESEARCH DESIGNED FREQUENCY TABLES

Table 1

Tabulated Frequency Tables for Fourth Grade Student Scores: 2014–2015

Subject	Score Range	Mean Score	Above Mean Score	Below Mean Score	Ratio of Scores	Integrated(I) Subject-Specific (S)	Dominant Curriculum
Language Arts	22% - 94%	63.9%	43 I 20 S	29 S 8 I	+43:20 -29:8	I S	Integrated/ Interdisciplinary
Mathematics	0% - 87%	52.8%	41 I 16 S	34 S 9 I	+41:16 - 34:9	I S	Integrated/ Interdisciplinary
Science	0% - 100%	94.4%	38 I 30 S	20 S 11 I	+38:30 -20:11	I S	Integrated/ Interdisciplinary
Socio-Economic	0% - 93%	19.92%	39 I 25 S	25 S 11 I	+39:25 -25:11	I S	Integrated/ Interdisciplinary
English Language Learners (ELL)	0%- 37%	3.66%	33 S 25 I	25 I 17 S	+33:25 -25:17	S I	Subject-Specific
Students with Disability	1%- 34%	15.52%	29 S 28 I	23 I 20 S	+29:28 -23:20	S I	Subject-Specific

Table 2

Tabulated Frequency Tables for Fourth Grade Student Scores: 2015–2016

Subject	Score Range	Mean Score	Above Mean Score	Below Mean Score	Ratio of Scores	Integrated(I) Subject-Specific (S)	Dominant Curriculum
Language Arts	21% - 94%	65.2%	42 I 19 S	31 S 8 I	+42:19 - 31:8	I S	Integrated/ Interdisciplinary
Mathematics	11% - 94%	60.2%	41 I 18 S	32 S 9 I	+41:18 - 32:9	I S	Integrated/ Interdisciplinary
Science	79% 100%	95.4%	33 I 26 S	25 S 16 I	+33:26 -26:16	I S	Integrated/ Interdisciplinary
Socio-Economic	0% - 96%	19.67%	37 I 25 S	24 S 13 I	+37:25 -24:13	I S	Integrated/ Interdisciplinary
English Language Learners	0% - 37%	4.05%	33 S 28 I	23 I 16 S	+33:28 -23:16	S I	Subject-Specific
Students with Disability	2% - 39%	17.73%	27 I 25 S	25 S 23 I	+27:25 -25:23	I S **	Integrated/ Interdisciplinary

** Indicates very slight difference in curriculum choice.

Table 3

Tabulated Frequency Tables for Fourth Grade Student Scores: 2016–2017

Subject	Score Range	Mean Score	Above Mean Score	Below Mean Score	Ratio of Scores	Integrated(I) Subject-Specific (S)	Dominant Curriculum
Language Arts	23% - 93%	68.9%	40 I 19 S	32 S 10 I	+40:19 -32:10	I S	Integrated/ Interdisciplinary
Mathematics	16% - 88%	61.3%	39 I 21 S	29 S 10 I	+39:21 - 20:10	I S	Integrated/ Interdisciplinary
Science	76% - 100%	93.6%	35 I 27 S	23 S 14 I	+35:27 -23:14	I S	Integrated/ Interdisciplinary
Socio-Economic	0% - 94%	19.9%	38 I 25 S	25 S 12 I	+38:25 -25:12	I S	Integrated/ Interdisciplinary
English Language Learners (ELL)	0%-31%	4.28%	35 S 26 I	24 I 15 S	+35:26 -24:15	S I	Subject-Specific
Students with Disability	2%-35%	18.06 %	31 I 25 S	25 S 19 I	+31:25 -25:19	I S	Integrated/ Interdisciplinary

*Tables 1, 2, &3 in Appendix O were created by author as an initial source of gathering Ginformation in order to determine if this study was of any importance in delivering curriculums in the classroom.