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The New Jersey Core Curriculum Content Science Standards Influence On The Scope And Sequence Of The High School Science Curriculum

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THE NEW JERSEY CORE CURRICULUM CONTENT SCIENCE STANDARDS
INFLUENCE ON THE SCOPE AND SEQUENCE OF THE HIGH SCHOOL SCIENCE CURRICULUM

BY

TENA R. WRIGHT

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DEDICATION

This study is dedicated to my family; my children Alyssa and Aaron Wright; my mother Norma Brown; my sister Hannah Brodsky, my brother-in-law Larry Brodsky, and my nephew Ian Brodsky for their understanding and unfailing commitment to all my endeavors. Their love anchored me through some very rough water.
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CHAPTER I

INTRODUCTION

Background

Science reform has been part of the political landscape since World War II, only to be heightened after the successful launch of Sputnik I in 1957 (Yee & Kirst, 1994). Indeed, the scope and sequence of secondary science education has been discussed and debated since the Committee of Ten in 1893 (Bybee & DeBoer, 1994). Similarly, the tenacious nature of secondary science education has been documented repeatedly in the case studies of Cuban (1984); Stake & Easley Jr. (1978), and Tobin, Kahle, & Fraser, (1990). Discussions about the dullness of the curriculum, the heavy reliance on texts, and the need for rigorous study of subject matter has been part of the debate of science education since the 1890s (Bybee & DeBoer, 1994).

The current science reform movement is incorporated in the present standards movement. Before World War II, science curriculum was considered a local issue. After World War II, the pace of scientific knowledge escalated rapidly leaving many high school students unprepared for college. University scientists became concerned with students’ lack of background and instituted a series of reform movements that were further heightened after the successful launch of Sputnik I in 1957 (Anderson, R. D., Anderson, B. L. Varanka-Martin, M.A., Romagnano, L., Bielenberg, J., Flory M.,
Mieras, B., and Whitworth, J., 1994). The focus of the high school science curriculum as a training ground for future scientists is reflective of the type of reform that permeated high school science reform (Bybee & DeBoer, 1994; DeBoer, 1991). Yet, such reform efforts brought little change to the science classroom (Cuban, 1984).

Lacking financial support and success, reform efforts from the post-World War II era slowed down to a virtual stand still by the 1980s. Much time was spent assessing the needs, problems, and status of science in the United States. During this time frame, the United States economy took a severe downturn.

The seminal work in 1983 of A Nation at Risk (National Commission of Excellence in Education, 1983) was prompted by the realization that the United States was not competing well in the international economic arena (Yee & Kirst, 1994). Once again the economic survival of the United States was linked to excelling in science and mathematics.

A Nation At Risk sparked a wealth of studies. Each study found students lacking a deep understanding of the natural laws of science (LaPointe, A. E., Mead, N.A., & Phillips, G.W., 1989). Professional science organizations such as the American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA) became concerned.

The focal point of this reform movement however, was egalitarian, directed toward science literacy rather than science careers (Raizen, 1998). Studies conducted by the results of the 1995 Third International Mathematics and Science Study (TIMSS) and of comparable national assessments, e.g., the National Assessment of Educational
Progress (NAEP) found that students in the United States lacked a deep understanding of the fundamental laws of science.

Efforts to address science literacy is exemplified by the first work of Project 2061, initiated in 1986 by the AAAS and entitled *Science for All Americans* (Rutherford & Allegran, 1989). In 1993, Project 2061 released *Benchmarks for Science Literacy*, which established minimum goals for what students should know and be able to do at various grade levels. In 1995 the National Research Council (NRC) published the *National Science Education Standards (NSES)*. Similar reform efforts were simultaneously being acted out at the state level.

The New Jersey standards effort mirrored that of the nation. From 1992 to 1995, panels of educators, business people and community members developed draft standards in science and other academic areas. These standards are:

1. Visual and Performing Arts
2. Comprehensive Health and Physical Education
3. Language Arts Literacy
4. Mathematics
5. Science
6. Social Studies
7. World Languages

Drafts of standards were shared with local interest groups, refined, and finalized. In May 1996 the New Jersey State Board of Education adopted the *New Jersey Core Curriculum Content Standards (NJCCCS)*. Each standard delineates benchmarks of knowledge at grades 4, 8, and 12. The benchmarks are called cumulative progress
indicators (CPIs). The state then used these CPIs to develop assessments that measured student progress at grades 4, 8, and 12. A comprehensive set of tests was developed with a timeline for implementation. For the first time, science would be assessed and linked to state assessments. It was deemed important enough to be included in the first group of tests.

High stakes tests, i.e., the High School Proficiency Test (HSPT), and the Grade 8 Early Warning Test (EWT) were redesigned to align to the new standards. A new 4th grade test would be developed. The timeline for these new tests: the Elementary School Proficiency Assessment (ESPA, Grade 4), the Grade Eight Proficiency Assessment (GEPA), and the High School Proficiency Assessment (HSPA) were developed.

During the summer of 1996, a committee of 9 elementary school teachers, 5 science supervisors, and a testing specialist met and developed the test specifications for the science portion of ESPA (New Jersey Department of Education, 1998a). In August 1996, another committee of 32 New Jersey science educators and a testing specialist met to define the test specifications for GEPA and HSPA (New Jersey Department of Education, 1998b). Both committees continue to meet regularly to assess field test questions and review item analyses of test items.

Timelines for each test were developed and disseminated statewide. The first test to be field-tested and operational would be the ESPA, which would include mathematics, literacy, and science benchmarks. In the following years GEPA and HSPA would be field-tested and then become operational. The target date for an operational HSPA exam to include science is expected to be May 2003.
The Science Testing Committees for ESPA, GEPA, and HSPA articulated the test specifications for the NJCCCS in science, drawing heavily upon *Benchmarks for Science Literacy* and the *NSES* to further delineate CPIs, specifying the knowledge and skills students would be responsible for mastering. The standards have been rated as excellent by outside organizations (Lerner, 1998; Finn & Petrilli, 2000).

During this time period, New Jersey educators were examining their science programs, identifying deficiencies, and implementing curricular changes. Simultaneously, national organizations such as the NSTA, the National Science Foundation (NSF), AAAS, and the NRC were developing programs and guidelines for implementing thoughtful science curriculum.

Throughout this time, there was much discussion among New Jersey Science Supervisors over ways to modify their high school science programs. The timeline for the HSPA was to be in the spring of students’ junior year. So, although the CPIs benchmark Grade 12, students would be evaluated on this high-stakes test in the spring of their junior year. The new standards and test specifications indicated that the types of questions students would be asked would be higher order thinking skills requiring writing and reflection.

This was problematic since most New Jersey high schools, reflected the typical American curriculum, i.e., providing full year courses in each of the major science disciplines; earth science, biology, chemistry, and physics (Aldridge, 1992a; Bybee & DeBoer, 1994; Chemoclogy, 1991; National Science Teachers Association, 1992). The issue became how to cram four content areas of science into three years of schooling.
The high school science curriculum has long been dominated by colleges, in both form and substance (DeBoer, 1991). As such, high socio-economic districts, that pride themselves on their college admissions and high science enrollments, were reluctant to make significant changes. Less wealthy districts, which have traditionally low-performing students, were concerned about students passing.

The issues facing the secondary curriculum required changing the curriculum. Studies in the 1970s by Stake and Easley (1978) and later in 1990 by Tobin, Kahle, and Fraser (1990) point out the conservative nature of high school. Thus, it is no surprise that many secondary science supervisors moved cautiously in implementing any change to their curriculum. It is the intent of this research project to determine if those changes were within the traditional layer cake paradigm or reflected more recent thought on developing interdisciplinary science courses.

Research Problem

The premise of the standards movement is to improve student learning. As Loucks-Horsely and Bybee (1999) point out, "The phenomenon of educational standards has caught on and, at least for the foreseeable future, their use to improve education will continue" (p.3).

The use of standards to leverage an improved educational system would entail changes at the state, district, and classroom level. Gardner, in his seminal work, *The Unschooled Mind: How Children Think and How Schools Should Teach* (1991) uses the science misconceptions of students enrolled in the Massachusetts Institute for
Technology to suggest that the present learning system does not support a fundamental understanding of science. Interviews of Harvard graduates and their faculty in the Smithsonian video, *A Private Universe* (Shapiro, Whitney, Sadler, & Schneps, 1987) further illustrate that being a graduate of a venerable institution of higher learning does not guarantee science literacy. Statistical analyses of TIMSS and NAEP show that high school students continue to maintain a tenuous understanding of science (Campbell, Hombo, & Mazzeo, 2000; Hoffer, Quinn, & Suter, 1996; Johnson & Owen, 1998).

Schmidt, McKnight and Raizen (1997) and others that have interpreted the results of the TIMSS data, describe our curriculum as unfocused and too broad. Increasingly, over the past decade the issue of providing a scientifically literate society has become of paramount importance (Rutherford & Ahlgren, 1989). All of these issues have an impact on existing and developing science curriculum.

It is of interest to science educators throughout the state to see the impact that the New Jersey Core Content Science Standards have had on the curriculum. Scientists, educational researchers, and cognitive psychologists suggest that integrating science would promote science literacy, a deeper understanding of scientific concepts, and an understanding of the nature of science (Aldridge, 1992a; Dempster, 1992; Rutherford & Ahlgren, 1989; Schmidt, McKnight & Raizen, 1997).

If the standards-reform movement is to make a difference, curriculum will reflect that difference by being interdisciplinary and less broad. It will not continue to reflect the typical United States model of secondary schools science, i.e., the “layer cake” model. Little change will confirm the findings of Stake and Easley (1978) and Tobin, Kahle, and Fraser (1990) that high school science resists change.
This research proposes to describe influence of the NJCCCS in science on the scope and sequence of high school curriculum.

The first subsidiary problem disaggregates curricular reform efforts by a district's socioeconomic status, which in New Jersey is categorized as district factor grouping (DFG). If the standards movement is designed to leverage student improvement then districts with poor student test scores may be more receptive to change than those with higher test scores. Gardner (1991) notes that efforts to bring about educational change are paradoxical; most Americans, while critical of education in general, are satisfied with their own schools. They typically feel that their own schools are of good quality and that the failure of a student to perform well is a lack of academic ability within the student. Thus, wealthier districts with higher test scores may have less motivation to revise curriculum while poorly performing districts may not. This research will disaggregate information about curricular changes and compare changes by socio-economic status, which in New Jersey is categorized as a district factor group (DFG).

The second subsidiary research problem delves deeper into issue of curriculum reform. Schools that participate in systemic reform have had increased opportunities in professional development and curriculum analysis provided by the universities and colleges associated with the state's NSF funded systemic initiative. These seven regional centers provide a variety of professional development programs, technical assistance and planning services to help districts implement standards-based curriculum programs in mathematics, science, and technology (New Jersey Statewide Systemic Initiative, http://dimacs.rutgers.edu/~nissiweb/, 2000). According to a 1997 study by the Consortium for Policy Research in Education, standards-based systemic reform has made
impressive gains in recent years, despite the difficulties of implementing change at a
statewide level (Massell, Kirst, Hoppe, 1997).

This research proposes to describe how participating in the New Jersey Statewide
Systemic Initiative (NJSSI) has influenced curriculum changes in high schools.

Primary and Subsidiary Research Questions

The primary research question asks: How have the New Jersey Core Curriculum
Science Standards influenced the scope and sequence of the high school science
curriculum? The hypothesis predicted is that there will be little significant change in the
scope and sequence of high school science curriculum as a result of the adoption of the
NJCCCS science standards.

The first subsidiary question asks: Is there a relationship between a district’s
District Factor Grouping (DFG) and revising its curriculum? The hypothesis proposed is
that those schools with a lower DFG, i.e., poorer districts, will have made greater changes
to their curriculum than high schools in wealthier districts.

The second subsidiary question posed is: What impact did participating in the
New Jersey Statewide Systemic Initiative have on the scope and sequence of secondary
science? The hypothesis is that high schools participating in NJSSI will have
significantly more change in the scope and sequence of their curriculum than those high
schools that did not participate in NJSSI.
Importance of Study

The present science reform movement differs from others in the past in both structure and intent. The reform effort of the 1960s was on expanding the scientific talent pool. Today’s efforts are aimed at all students.

The premise of the standards movement is to improve student understanding of science. Scientific misconceptions demonstrated in the video *A Private Universe* (Shapiro et al, 1987) and explained by Gardner (1991) eloquently speak to changing the way we teach science. Changing instruction calls for changes in curriculum. The TIMSS study shows that United States students get less physical science than their international counterparts; and that their level of understanding of the physical sciences is poor at best (Schmidt & Wang, 1999). National tests such as NAEP support those findings (Selden, Clark, & Raizen, 2000). If American students are to be scientifically literate, they need opportunities to learn the nature of science and all of the disciplines of science. The present model of science education in this state does not promote participation in the physical science, particularly physics. For that to happen the scope of courses will reflect all of the disciplines. Furthermore, the sequence of required courses of students should reflect an increase in physical science.

The present science curriculum is seen as unsatisfactory for it does not prepare students to deal with the personal and professional realities of today’s society. Contemporary science is more holistic in concept than traditional science and operates in broader contexts (Hurd, 1995). Curriculum must change to reflect that change. It should reflect the need for science literacy by helping students practice and hone critical thinking skills; it must focus on the future, rather than the past; and will match the nature of
contemporary science with its emphasis on interdisciplinary, strategic research. The curriculum should reflect the unity of the various science disciplines rather than their isolation. In short, the current text-based, discipline-based "layer cake" curriculum must be altered.

If the New Jersey Core Curriculum Content Standards in Science are to make a difference, they will leverage such curriculum changes. Those changes need to take place in all of our schools and for students of all socioeconomic status. The effectiveness of the statewide systemic initiative to support curricular reform will provide a means of implementing that change.

This study will describe how the scope of secondary school science has changed and whether or not the sequence of course offerings has changed.

Study Delimitations

The study will involve a sample of New Jersey high schools of varying DFGs. Each high school will include grades 9-12. It will examine the scope and sequence of the college preparatory science curriculum. It will not examine curricular changes in the honors or general tracks. Nor will it provide detailed descriptions of the curricular changes that have been identified.

The survey is self-reported; therefore results are dependent upon the integrity of the answers supplied by respondents.

District factor groups were determined through the New Jersey 2000 Report Card data base available online from the New Jersey Department of Education. Addresses for
the school districts were provided through another online state database. The second
database did not identify the school district, rather the town address. A total of 285
districts were identified. Surveys were mailed to all 285 school districts, percentages are
calculated from the state’s School Report Card 2000 database.

Definition of Terms

Scope is defined as the extent or range of disciplines in the science curriculum. A
curriculum’s scope will be examined for its interdisciplinary nature.

Sequence is defined as the order in which students are able to take science.
Traditionally, American high school students take a series of year long courses in each
science. Generally the vast majority of students enroll in biology, chemistry, and physics
Mervis, 1998; Aldridge, 1992a).

The term curriculum is complex and known to have scores of definitions
(Henderson and Hawthorne, 2000). For the purpose of this study, curriculum will be
defined as a course of study.

District Factor Grouping (DFG) is a term coined by the state of New Jersey to
classify districts by the economic demographics. The range of District Factor Groups
goes from A to J, with J being the wealthiest district and A being the poorest. DFG data
given reflects data from the 1990 Census.

The New Jersey Statewide Systemic Initiative for the Implementation of Standard
Based Science and Mathematics (NJSSI) refers to a one-year grant, renewable up to 3
years, funded by the National Science Foundation. The grant is part of NSF’s systemic
reform initiative to build system reform by increasing capacity of standards-based instruction in science and mathematics.

**Standards** refer to a body of work that provide criteria for what is necessary to be scientifically literate. Standards may exist at the national, state, or local level. **Standards-based** refers to programs that conform to the national reform efforts put forth in the *National Science Education Standards* and in *Benchmarks for Science Literacy*.

**Integrated Science** is defined as a college preparatory science course offered in the high school that includes a variety of disciplines, e.g., Environmental Science, General Science, Biochemistry, Geophysical Science, etc. The term excludes Earth Science and Physical Science.
CHAPTER II
REVIEW OF THE LITERATURE

Introduction

To better understand the issues presented in this research, this review will provide an overview of science education reform at the national and state level, a look at the high school science curriculum and its scope and sequence, and the potential benefits of the current reform movement.

Overview of Science Education Reform

Historical Perspective on Science Reform

Before World War II, science curriculum was considered a local issue. School administrators and teachers relied on textbooks to meet their needs (Yee & Kirst, 1994). After World War II, the pace of scientific knowledge escalated rapidly, leaving many high school students unprepared for college. University scientists became concerned with students' lack of background and instituted a series of reform movements that were further heightened after the successful launch of Sputnik I in 1957 (Anderson, et al, 1994;
Yee & Kirst, 1994). These reform efforts were supported by the National Science Foundation (NSF) and continued from the late 1950s through the early 1970s.

Given the backdrop of the Cold War, curriculum developed by scientists and engineers was designed to prepare college-bound students for university science courses and possible science careers (DeBoer, 1991). Little attention was paid to science literacy or to those students that were not headed for college.

The programs developed were discipline-specific and inquiry-driven. Students were given opportunities to practice science skills. Among these programs were Biological Science Curriculum Study (BSCS), Physical Science Study Committee (PSSC), and Chemical Bond Approach (CBA). Each program was designed by a separate group of scientists was accompanied by a textbook. Little attention paid to integrating disciplines.

Teachers had little to do with the development of these programs. Scientists, not teachers, determined the initial content and instructional approach. Yee and Kirst (1994) point out, "Doing science was what scientists and students were expected to do, and educators were given the role of transmission." (p.161). Teachers were trained at NSF summer institutes but had little to do with the development of the curriculum or the training. It was not until the 1980s that educators and psychologists joined forces with scientists to develop new curriculum.

In the late 1970s and early 1980s support for science education had all but disappeared on the national level. NSF funding for summer institutes had dried up. As soon as funding disappeared, teachers were content to return to their reliance on standard texts that were much like ones that existed prior to 1957 (Yager, 1992). Teachers felt that
these NSF-developed curriculums were too challenging for the average student. Without training many found the modules difficult to use often because they did not understand the conceptual structure of the program or lacked mastery of inquiry-based instruction (Anderson, 1995).

As such, these reform efforts failed to bring about much instructional change in classroom practice as seen in the case studies described by Stake and Easley (1978). Their studies found that teachers relied heavily on traditional textbooks and used lecture, worksheets, and verification-type laboratories as their primary means of instruction. Interviews with teachers revealed that few used the NSF materials, and then only for their top students.

Lacking financial support and success, reform efforts slowed down to a stop. Much time was spent assessing needs, problems, and the status of science in the United States. At the same time that these studies were taking place, the United States economy took a severe downturn.

**Current National Science Reform Movement**

Reformists were intent upon not repeating the mistakes of the 1960s reform movement (Yager, 1992). One of the failures of the 1960s reform effort was the lack of materials developed by the curriculum developers. Once NSF funding dried up, textbook publishers incorporated the factual content of the projects adding an emphasis on laboratory work into their traditional texts.
During the 1960s there had been no centralized effort to train teachers or build capacity among teachers. As such, teachers were not given the skills needed to sustain the reform effort. The notion was that teachers would simply implement the written curriculum, providing little consideration to the training of teachers in inquiry-driven strategies as well as content. The connection between curriculum and staff development was disjointed and did not originate from the educational community. As these reform materials gained wider dissemination, teachers used them with little understanding of the pedagogical strategies necessary for inquiry-based instruction.

This lesson yielded the notion that for reform efforts to work, change would have to be systemic. That is, there would have to be a coordinated effort of all stakeholders with a central vision that anchored all reform activities. Efforts were made to target change at the state, district, and school level. In the early 1990s, NSF began providing funding for Statewide Systemic Initiatives in Math, Science, and Technology. The goal of standards-based systemic reform is high academic achievement for all students.

Many of the innovations in science reform were prompted by the country’s concern with economic competitiveness. By the mid-1980s the United States Department of Education and NSF were involved in massive reform. The publication in 1983, of *A Nation At Risk* (National Commission on Excellence in Education, 1983) was prompted by the realization in the 1980s that the United States was not competing well in the international economic arena (Yager, 1992). Once again the economic survival of the United States was being linked to excelling in science and math. Raizen (1998) suggests that one reason for the weakness of the United States economy is the shift from the industrial age to the information age. Thus, a solution to this downturn would be to
educate the future workforce in mathematics, science, and technology in such a way as to make them productive workers in this new economy.

**Science Literacy and its Impact on Science Reform**

A vision of science for all guides the efforts of the present-day reform effort (Raizen, 1997). This is markedly different from the elitist stance of the 1960s reform movement. The inclusive goal of science literacy responds to the needs for the United States to be economically competitive, with a scientifically literate citizenry able to make informed personal and political decisions, and providing opportunities to access scientific careers for the ever increasing diverse population of students in United States schools.

Many observers suggest that this focus is a result of several factors: the need for the United States to maintain its competitive edge in the world economy; the need for citizens to know and understand enough to deal in an informed way with individual, family, and community decisions that have become increasingly linked to science and technology; and American students’ low standing in a number of international assessments that compare the math and science achievement of these students with other students in industrialized nations (Bybee, 1995; Raizen, 1997; Raizen, 1998).

Bybee (1995) notes that early discussions of science literacy lacked precision. As a result, the term science literacy was used to describe an assortment of educational goals. In the 1980s, F. James Rutherford, chief education officer of AAAS established Project 2061 to take a long term, large-scale view of science reform grounded in the principle of science literacy. The project’s goal was to establish a conceptualized base
for science reform by identifying the knowledge, skills, and habits of mind necessary to achieve science literacy. The process took more than three years and culminated in the publication of the landmark document Science for All Americans (SFAA) and the clarification of science literacy (Rutherford & Ahlgren, 1989).

SFAA launched the present-day discussion of science education reform. SFAA was developed by a panel of scientists, engineers, mathematicians, historians, and educators out of a concern for the poor showing of United States students in science literacy accompanied by a world that is ever-increasing its dependence on technology and scientific knowledge. SFAA included discussions about the nature of science, mathematics, technology, as well as physical, chemical, earth, and life sciences. Separate chapters are devoted to the history of science, habits of mind, and common themes of science. This emphasis was a significant departure from the traditional classroom model of science education reform.

SFAA differed from traditional treatments of science education in several ways; boundaries between traditional subject matter were blurred, and connections were emphasized through the use of conceptual themes, such as systems, cycles, evolution, and energy. Another difference was the inclusion mathematics and technology into its discussion. Finally, the amount of detail that students were expected to learn was much less than traditionally taught; rather key concepts and thinking skills were emphasized.

The second landmark document published by Project 2061 was Benchmarks in Science Literacy (American Association for the Advancement of Science, 1993). This document was widely disseminated and regarded by many as the science standards analogous to the ones produced by the National Council of Teachers of Mathematics
(NCTM). * Benchmarks* identified the concepts students were to master in grade levels: grouped at K-2; 3-5; 6-8; 9-12. Many of the concepts were radically different from what was traditionally taught at each of those grade levels. Nevertheless, *Benchmarks* was well received. Recent examination of newly developed state frameworks found that a number of the states refer to *Benchmarks* as a cornerstone document in their own formulation of standards (Raizen, 1998).

**National Science Standards**

The science reform movement was energized with the introduction of the National Council of Teachers of Mathematics’ *Curriculum and Evaluation Standards* in 1989 (National Council of Teachers of Mathematics, 1989). Against these standards and the backdrop of *Science for All Americans* and *Benchmarks for Science Literacy* NSTA in 1991 asked NRC to coordinate efforts to develop national standards for science education.

NRC received funding from NSF and the United States Department of Education. Part of its organization was to establish three working groups, one in content, one in teaching and one in assessment. Each group included teachers, scientists, science education researchers and curriculum developers, and academic scientists and teacher educators. Drafts of the standards were widely distributed to focus groups for input in 1994. By 1996 the standards were complete. Table 1 illustrates the critical events that led to the development of the National Science Standards.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>1983</td>
<td>Publication of A Nation At Risk as well as many other reports of weaknesses of the United States education system</td>
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| 1989 | Establishment of National Education Goals by Governors and President George Bush.  
Publication of National Council of Teachers of Mathematics’ *Curriculum and Evaluation for School Mathematics*  
Publication of the American Association for the Advancement of Science’s *Science for All Americans* |
| 1991 | Publication of National Council of Teachers of Mathematics’ *Professional Standards for Teaching Mathematics* |
| 1993 | Publication of American Association for the Advancement of Science’s *Benchmarks for Science Literacy*  
Drafting and review of National Research Council’s *National Science Education Standards* |
| 1995 | Publication of National Council of Teachers of Mathematics’ *Assessment Standards for School Mathematics* |
| 1996 | Publication of National Research Council’s *National Science Education Standards* |

Although produced by two different organizations, *NSES* (1996) felt it was aligned to both *SFAA* and *Benchmarks*, and that schools using those documents would also reflect the new standards, in their introduction they state: “...... gratefully acknowledges the seminal work by the American Association for the Advancement of Science’s Project 2061 and believes that the use *Benchmarks for Science Literacy* by state framework committees, .......... complies fully with the spirit of the content standards” (p. 15).
Science Reform and the National Standards Movement

The publication of a Nation at Risk set the stage for the national standards movement. The Governor’s Education Summit and the publication of the National Council of Teachers of Mathematics’ Curriculum and Evaluation Standards further propelled the movement. The United States Department of Education provided funds for professional organizations to develop standards much like those done by the NCTM. In addition to mathematics, standards have been written for Science, Social Studies, English/Language Arts, History, Fine Arts, Health, Civics, Economics, Geography, and Physical Education. Like science, many of these have multiple organizations writing standard-type documents (Marzano & Kendall, 1997).

Accompanying standards has been a call for states to develop their own set of standards (often called frameworks) and assessments. Blank (1996) reports that a 1994 Council of Chief State School Officers survey of all states, the District of Columbia, and Puerto Rico found that a total of 40 states had developed curriculum frameworks. Controversy about whether these standards will improve education continues to spark debate among educators (Anderson, 1995; Bracey, 1999; Clune, 1998; Finn, 2000; Gratz, 2000; Marzano & Kendall, 1997; Massell, Kirst & Hoppe, 1997; Wolf, 1998).

These state frameworks have policy implications since half of them link content to state assessments. Some, like New Jersey link state standards to high-stakes assessments such as the New Jersey High School Proficiency Assessment (HSPA). The
call for standards, high student achievement, and teacher accountability have greatly impacted on the scope of education.

Science Reform and the Political Implications of National Assessments

*A Nation At Risk* sparked a wealth of studies. Studies consistently found United States students lacking in a deep understanding of the natural laws of science. Furthermore, studies such as those of Lapointe, Mead and Phillips (1989) and others revealed that American students were perceived as doing poorly on international assessments that compare their mathematics and science achievement to those of other students in industrialized nations.

In 1994-95 the largest study of student achievement in mathematics and science was undertaken. Forty-five countries participated in the study, known as the Third International Mathematics and Science Study (TIMSS). Data from the study provided a wealth of information on curriculum as well as student achievement. The achievement tests were administered in five grades, encompassing approximately the same grades as NAEP, i.e., 4th, 8th, and 12th. Students, as well as their teachers and principals, were asked to respond to questionnaires about their background, attitudes, experiences, and teaching practice. Results from TIMSS have been generally accepted by the education community, although Bracey and others have critiqued the technical aspects of the study (Wang, 2001, Bracey, ER Online, May 2000).

The results from the achievement tests were consistent with previous international studies, in which United States students demonstrate a weak understanding of physical
science. Fourth graders in the United States tied for second among TIMSS countries (United States Department of Education, 1997). The TIMSS 8th grade results show United States students to be slightly above average (United States Department of Education, 1996). By 12th grade, however, American students perform well below average (Takahair, Gonzales, Frase, & Salganik, 1998). Two exams were given to twelfth graders, one in general science and one in advanced physics. In the general science exam, the United States outperformed only two other nations. In the advanced physics exam, American students were at the bottom of the international rankings (Takahair et al., 1998). The downward trend of United States students and the poor showing of our students in advanced students sparked a great deal of interest among the scientific and science education communities.

In A Splintered Vision: A Study of US Science and Mathematics Education, Schmidt, McKnight, and Raizen (1997) compare the math and science curriculums of all the TIMSS nations. The results reveal that American students cover an extensive number of topics but at no depth. Schmidt and associates have coined the phrase “a mile wide and an inch deep” to describe the United States curricula. The authors propose that a national curriculum would provide a more coherent vision to science and mathematics education, thereby improving the quality of student learning; a view is not shared by all (see Bracey, 1999). Upon examining science curriculum Schmidt, McKnight, and Raizen (1997) found that the American practice of instruction is to introduce new topics at intervals from grades one to five with little change in intervening grades. Thus, students are exposed to many topics over time but with little attention to understanding. Because of our “layer cake” approach in secondary school, by grade 10 we drop many more topics
that most international countries. The study described the United States curricula as unfocused varying widely from state to state, and lacking any clear definition of basics.

An examination of texts used by TIMSS countries revealed that United States science textbooks include far more topics than was typical internationally at all three grade levels. Teachers' heavy reliance on textbooks result in an unfocused curriculum in which teachers have little time to develop deeper understandings among students. Rather, teachers are concerned about covering topics. Valverde and Schmidt (1997) go on to argue that since the curriculum is unfocused, it lacks little coherence. Others, such as Bracey argue that a national curriculum would have little impact on student learning. Whatever one's opinion, the TIMSS studies align to the views put forth by *NSES* and *Benchmarks*.

Recent results from the newest TIMSS study, TIMSS-Repeat (TIMSS-R) find that there has been little improvement of student scores over the past four years (TIMSS International Study Center, 2001). In 1999 TIMSS was again administered to 8th grade students in 40 countries. The study was designed to provide trends in science achievement at the international level. This study was conducted four years after the 1995 TIMSS, thus, 4th graders who had participated in the 1995 TIMSS had now advanced to the eighth grade. Seventeen of the 26 countries that participated in TIMSS 1995 were able to determine if there had been any relative improvement in student achievement. As before, students were asked to complete a questionnaire on their classroom experiences, attitudes towards math and science, and background. As in the original TIMSS, students' mathematics and science teachers were also asked to complete questionnaires about their academic background, instructional practices and views on
current issues in mathematics and science education. The United States results for TIMSS-R, 8th graders suggest no significant improvement in math or science achievement (Schmidt, 2000).

Other national assessments support the perception that United States students lack a deep understanding of the natural laws of science. In 1996, states were able to have fourth, eighth and tenth graders assessed in science using NAEP’s science assessment. The results show that only 3% of all students performed at an advanced level in each of those grades. In Grade 4, 3% of students performed Below Basic; 38% performed at the Basic Level, and 26% performed at Proficient. Eighth graders performed in a similar manner, 39%, 32%, and 26% in those respective categories. Twelfth graders performed somewhat worse, a trend that conforms to the TIMSS studies. Forty-three percent of 12th graders performed Below Basic; 36% performed at Basic; and only 18% performed at Proficient (O’Sullivan & Weiss, 1999).

Campbell, Hombo, and Mazzeo (2000) examined the academic trends of United States students in science, mathematics, and reading for the past three decades. They find that generally, trends in science are characterized by declines in the 1970s, followed by increases during the 1980s and early 1990s with more stable performance since that time. The trend lines in Figure 1 show that overall achievement results are relatively stable. Results for 17 year-olds show an initial 22-point decline over a 12-year period. Between 1982 and 1992 gains in average scores erased half of that decline. Since 1992, the average science scores for students remain unchanged. On the average, 17 year olds in 1999 had higher average science scores than their counterparts in 1990, however, these
Figure 1. Trends in the Average Science Scale Scores by Quartile of 17 Year Olds. (Campbell et al, 2000).

Note: stars represent data significantly different from 1999.
1990 average scores remain 10 points lower than when the study started in 1970. Their scores remain at a level similar to that in 1977.

Trends in 17-year olds' attainment of science performance levels 250 (Applies General Scientific Information), 300 (Analyzes Scientific Procedures, and Data, and 350 (Integrates Specialized Scientific Information) are shown in Figure 2. The percentage of students who could apply general scientific principles as described at level 250 decreased five percentage points between 1977 and 1982. The percentages of 17 years olds who could perform moderately complex procedures and reasoning (level 300) generally increased across the assessment years and by 1991, 61% of students were at or above this performance level. Although significant increases were not evident in the 1990s, the percentage in 1999 was higher than percentages from 1978 through 1990. Little change however is evident at the highest performance level, 350, in which students could apply a range of reasoning skills to solve multistep problems. A look at Figure 2 shows that across the years, only five to eight percent of students achieve this level of competency.

These and previous national and international assessments confirm the notion that science education must be reformed if United States students are to be competitive internationally. Such results provide leverage within the political landscape of standard reform.

Science Reform in New Jersey

In 1993 New Jersey was awarded a Statewide Systemic Initiative grant from NSF. The initiative is housed in Rutgers University and was initiated by the New Jersey
Figure 2. Trends in Percentages of 17 Year Old Students At or Above Science Performance levels: 250 (applies general scientific information), 300 (Analyzes Scientific Procedures and Data), and 350 (Integrates Specialized Scientific Information). (Campbell et al, 2000).
Department of Education (NJDOE). Utilizing an infrastructure of regional centers, NJSSI provides a variety of professional development programs, technical assistance and planning services to help districts implement standards-based curriculum programs in math, science, and technology.

Since its inception in 1993, NJSSI has impacted over 40,000 teachers and administrators in over 40% of the schools in New Jersey (New Jersey Statewide Systemic Initiative, http://dimacs.rutgers.edu/~njssiweb/, 2000). NJSSI program is an attempt to develop a common vision and to build capacity among staff. NJSSI regional centers, which are part of universities, work with school districts in identifying curriculum, brokering resources for professional development, and/or providing expertise in a particular area of science. For example, teachers in participating NJSSI districts can work with staff members at Stevens Institute of Technology to learn how to use real-world, on-line data rich science projects in their classrooms. Other regional centers may have expertise in mathematics strategies, technology education, and chemistry.

According to a 1997 study by the Consortium for Policy Research in Education, standards-based systemic reform has made impressive gains in recent years, despite the difficulties of implementing change at a statewide level (Massell, Kirst, & Hoppe, 1997). Some of the issues facing NJSSI is the need for teachers to be supported by their administrators to access rich opportunities for professional growth. This problem will persist as the reform movement continues to grow.
The New Jersey Science Standards

The standards movement in New Jersey emerged from the efforts of two groups, working over a period of 15 months between 1992 and 1995. Educators, business people, and local citizens comprised both groups. During 1992 and 1993 a panel of educators worked on the standards. In 1995 a similarly comprised panel built upon the preliminary standards and engaged the public in a review process that resulted in several revised drafts. Seven core content standards and five cross content workplace readiness standards were presented to the State Board of Education and approved in 1996 (New Jersey Department of Education, 1996).

The science standards developed contained twelve standards including systems, problem solving, technology, history of science, and mathematics. Life science was divided into two standards; one relating to the structure and characteristics of living things and one addressing diversity. Physical science was also divided into two standards, one in chemistry and the other in physics. Earth science was divided into two standards as well: astronomy and geophysical systems. A separate standard was developed for the environment. Each standard was broken into cumulative progress indicators that were grouped by grade level: 4th grade, 8th grade, and 12th grade. The standards site Benchmarks, NSES, and the NSTA’s SS&C project as models that were consulted during their development (New Jersey Department of Education, 1996). A Fordham study on state standards consistently awarded the New Jersey Science standards a grade of A (Finn & Petrilli, 2000).
The standards adopted by the state were to be linked to assessments that would take place at grades 4, 8, and 12. A timeline was developed that articulated which grades would be tested first and the sequence of content standards that would be assessed. Language arts, mathematics, and science were selected to be the first content areas to be assessed.

The first test to be developed was the Elementary School Proficiency Assessment (ESPA). In the summer of 1996, 15 educators and a state testing specialist met for five weeks to develop the test specification for the science portion of the ESPA. The test was piloted in May of 1998 and made operational in May 1999. Over 50% of the students across the state are performing at or above proficient.

In August of 1996 a committee of 32 New Jersey teachers, administrators, business people and the state testing specialist met to develop the test specifications for the Grade Eight Proficiency Assessment (GEPA) and the High School Proficiency Assessment (HSPA) in science. The science test specifications for all three tests identified a testing matrix; they defined the content to be assessed and identified the skill boundaries of the Core Curriculum Content Standards (New Jersey Department of Education, 1998a, 1998b).

During this same time, a separate committee of educators met to develop Science Frameworks. The frameworks attempt to give teachers strategies and activities that can be used to address each of the standards. Once completed, the frameworks were distributed to districts throughout the state.
The next test to be made operational was the Grade Eight Proficiency Assessment (GEPA). Science was field tested in 1999 and made operational in 2000. Language arts and mathematics were operational in 1999.

Controversy surrounded the time of year identified for assessing high school students. Originally, the state had identified the fall of students’ junior year as the time for the High School Proficiency Assessment (HSPA). Educators throughout the state worked to move the test to the end of students’ junior year, thereby ensuring that students had completed almost three full years of study. In October of 1999 the state agreed and identified the testing times for the HSPA to be spring of student’s junior year. The science portion of the HSPA will be operational in the spring of 2003.

District Factor Groupings

New Jersey classifies its school districts by socio-economic demographics. The categories, call District Factor Groupings rate districts from wealthiest to poorest. The range of District Factor Groups goes from A to J, with J being the wealthiest district and A being the poorest (New Jersey Department of Education website, 2000)
The High School Science Curriculum

Historical Perspective

The discussion of science reform is not new. Bybee and DeBoer (1994) remind us that, "History shows that there is remarkable stability in that we stability in what we are trying to accomplish and even in why are trying to accomplish it" (p. 359). Reform efforts prompted in the 1960s by Sputnik I and more recently the United States' loss of economic power illustrate that the dynamics of the changing goals of society have a profound influence on the structure of the science curriculum.

Notwithstanding these changing goals, an emphasis of rigor, a heavy reliance on textbooks, and the general dullness of high school science has been part of the discussion of science "reform" since the late 1890s (Bybee & DeBoer, 1994). Indeed, the approach to the teaching of science as a rigorous subject for purposes of mental development is deeply ingrained in the American teacher mindset. Educators as early as 1898 lamented over the general dullness of science and of teachers' heavy reliance on textbooks. This same reliance on texts and a lecture format for instruction is noted in studies done by Cuban (1984), Stake & Easley, Jr, 1978, and Tobin and associates (1990).

The contemporary high school science curriculum stems from a 200-year old tradition of designing school science curriculums in a vocational context (Hurd, 1995). Students are expected to learn to think like scientists in order to do science. Essentially it
means having students learn the technical terms, symbols, and mathematical
computations characteristic of each discipline studied. The enormous increase in
scientific knowledge has made the number of terms students learn each year run into the
thousands. Professional organizations such as AAAS have long been dissatisfied with
this perspective and have been proponents of changing that focus. As early as 1928, the
AAAS has said that the task of training scientists should be left to the colleges and
universities. Nevertheless, as Hurd points out, high school teachers were not concerned
with the educational goals of teaching; rather they view themselves as science specialists
trained to portray science disciplines. Other studies continue to provide evidence of that

Yager (1992) points out that over 95 % of teachers in the United States view their
major goal as one of preparing their students for the next academic level. A study by
Weiss (1997) reveals that the most heavily emphasized objectives in high school science
class were learning basic concepts.

The teaching of high school science from the vocational perspective of grooming
future scientists does not resonate with all students. Kyle Jr. (1989) states,

It should be apparent, however, as evidenced by the steady decline in student
achievement and attitude toward science, that science presented in the way it is
known to scientists is not inherently interesting to all students. For over twenty-
five years now, science educators have adhered to a goal that is appropriate for
only 3% of the high school graduates (p.19).

Chemistry in the Community (ChemCom) in many ways epitomizes the debate of
the purpose of science teaching (Atkin, Kilpatrick, Bianchini, Helms, & Holthuis, 1997).
ChemCom is a high school chemistry course developed by the American Chemical
Society. The question posed by many educators is, “Should chemistry be taught at the
high school level to produce chemists? Or should it be taught to forward science literacy among the future voting citizenry?" The American Chemical Society most emphatically believe that ChemCom should be taught to all college-bound students. Yet its lack of mathematical orientation and exclusion of certain core chemical concepts is resisted by many high school chemistry teachers who strongly believe that ChemCom does not adequately prepare students for further study in chemistry. This tension between groups who believe that science should be taught as it really happens versus those who aim to make science relevant continues on many fronts.

The Scope and Sequence of High School Science

The organization of the secondary science curriculum in the United States has been called that of a layer cake, in that students move through science disciplines as they progress through high school. This approach was implemented in the early 1900s and remains tenaciously attached to most present day high school science programs. The typical approach involves the study of biology, chemistry, and physics.

A recent look at the science curriculum from other countries indicates that this "layer cake" approach is indigenous to the United States. Schmidt and others argue that this approach is one reason why American students do so poorly in the physical science portion of the TIMSS.

This traditional curriculum and its fundamental purpose of grooming scientists has become increasingly viewed as inadequate for helping our youth cope with the life demands of this emerging age. The organization of Science for All Americans,
Benchmarks, and the National Science Standards envisioned a blurring along disciplinary lines. Increasingly, science disciplines are being hybridized to form new fields of research, such as astrophysics, biophysics, bioengineering, and genetic engineering. Contemporary science is more holistic in concept and operates in broader contexts (Hurd, 1995).

Thus, school science curriculums are seen as making no sense in this new era characterized by a knowledge-intensive and contemporary science. Some of the issues related to reinventing the science curriculum include making learning to learn a goal of science education; promoting a culture of student as a lifelong learner; teaching higher-order thinking skills in science courses; have the context of science curriculums be one that focuses on the future; match the nature of contemporary science with its emphasis on strategic research (Hurd, 1995). Hurd also points out that research from cognitive scientists reveal that in order for students to achieve any of the above goals, they must be involved in their learning, a phrase he coins is that of a “living curriculum”.

Ultimately, the tenets and ethos of contemporary science curriculums will “require a ‘core’ curriculum representing the unity of various sciences in contrast to isolated disciplines” (p. 10).

Student Access to Science Courses

One impact of an integrated curriculum would be that more students would have an opportunity to learn the physical sciences, typically taught in the United States in the junior and senior year of high school. In addition to being more aligned to the current
nature of science, an integrated curriculum that mirrors the nature of science would be one that is interactive and employs higher order thinking skills.

Case studies findings done by Ashwill, Foraker, Hofer, Maldanodo de Johnson, LeTendre, Lubeck, Nerison-Low, and Sanders (1999) show that many high school offer courses at different levels or tracks and that a student’s enrollment or assignment to a particular level course was often determined by their prior course selection. Furthermore, lower track courses tended to deal with more simplified topics and rote skills.

As Aldridge (1992) points out, offering an integrated curriculum that is developmentally appropriate would provide students with opportunities to learn all of the science disciplines. Furthermore, integrating curriculum in ways that are thematic and developmentally appropriate would align to current cognitive research (Dempster, 1992).

Similar studies done of the high school senior’s instructional experiences in math and science show differences in student background are associated with instructional variation. The most powerful predictor of instructional differences is the achievement level of the class (Hoffer, Quinn, & Suter, 1996).

The study done by Hoffer and associates also that another obstacle to learning is the socioeconomic (SES) status of the school and/or student. Students from higher SES families tend to place greater emphasis on higher-order thinking skills. Moreover, schools from higher SES were content with their curriculum and were not concerned with state standards (Ashwill et al., 1999).

Campbell and associates (2000) found that by age 17, students typically took at least two or three years of science. In most high schools, the sequence of classes is biology, chemistry, and then physics. Figure 3 reveals a general increase in the
percentages of students taking science courses at every level, particularly in chemistry. Data reveals that students who had taken chemistry tended to score high on the NAEP than those that had no chemistry.

Porter, Kirst, Osthoff, Smithson, & Schneider (1994) compared urban and suburban/rural schools that added a science course graduation requirement to similar courses to schools where there was no such requirement. No evidence was found that requiring more students to take more advanced courses in science resulted in compromising the curricula of the courses. The required Chemistry/Physics course appeared as challenging as the college prep Physical Science course it was compared to, with the actual quality of instruction appearing better in the required course.

Scope, Sequence and Coordination of Secondary School Science

The notion of blurring disciplines, or integrating disciplines is the lynchpin of the NSTA’s secondary science curriculum movement: Scope, Sequence, and Coordination of Secondary School Science (SS&C). The NSTA, also concerned about the state of science education and the low performance of American students on international tests. Educators began looking at how science education was organized in the United States. In 1989, NSTA executive director, William Aldridge launched its Scope, Sequence, and Coordination of Secondary School Science (SS&C) project. Aldridge (1992a) argued that, “the present sequencing of courses and tracking of students reinforce the accumulation of advantage for some students and effectively preclude others from later selecting science as a career.” (p.1). The SS&C curriculum reform project sought to
Figure 3. A Comparison of the Percentage of 17 Year-Olds by Science Courses Taken for years 1986 and 1999 (Campbell et al, 2000).

★ Significantly different from 1999.
revamp science education from its traditional "layer cake" model to one that was more integrated. NSTA argued that since most students terminate science study after grade 10 or grade 11. Thus, using the traditional layer cake approach did not provide a sufficient science background for students, particularly in the area of physical science, an area in which United States students consistently perform poorly. NSTA proposed classifying topics not by discipline, but by the level of intellectual development needed to comprehend and master the material (National Science Teachers Association, 1992). This notion conforms to the ideas presented in both Benchmarks and NSES (Texley & Wild, 1996).

Rather than produce a prescribed curriculum, NSTA worked with NSF to plan a strategy for establishing reform centers throughout the United States that would use the SS&C model. The first awards were given to Baylor College of Medicine in Houston and to the California Department of Education. Later awards went to the University of Iowa, a North Carolina project, and the University of Puerto Rico (A perspective on reform in mathematics and science education, monograph #3, 1996). Each group developed curriculum using the strategies put forth in SS&C. Most of the curriculum work was done at grades 6-9. Although data was collected for each project, most was qualitative in nature and provided no conclusive evidence that the SS&C model improved student understanding of science concepts. More recent data however, shows that students enrolled in integrated courses show an increase in interest and enrollment into a third year of science, while maintaining the same degree of achievement as students in traditional courses (Scott, 2000). The new California Frameworks (California Department of Education, 2001) continues to mirror the need to integrate the sciences.
Nevertheless, the scope and sequence of secondary schools seems to have changed little since the inception of SS&C.

Examples of Integrated High School Science Curricula

Although integrated science programs are not the norm, case studies of innovative science programs done by the National Center for Improving Science Education show a pronounced move toward integration (Raizen, McLeod, & Budd Rowe, 1997; Raizen & Britton, 1997). Integration, however, can mean many things. It can be an attempt to preserve existing subject distinctions, but at the same time incorporate relationships among the disciplines; or it can mean an entirely new subject sequence and course title, which are intended to displace such traditional courses as biology, chemistry, and physics.

One such example, on the local level is the first two-year sequence of courses at Kinnelon, New Jersey where all students take Geophysics in their first year and Biochemistry in their second year. These two courses replaced the traditional sequence of Biology, Chemistry, and Physics. Students in their junior and senior years may take advanced level courses of these more traditional subjects (personal communication, Dudley, 2001).

An example of a statewide effort to embrace integrating is the California school system. California stands out as an effort that has placed the interrelatedness of science subjects at the core of its curriculum (Atkin et al, 1997). Here, science is treated as a core subject, but the disciplines of earth science, biology, chemistry, and physics, while
considered separately in the state frameworks are not the main focus. Rather, the interconnectedness of the disciplines is the main focus. This change has been promoted at every level in the K-12 system through the California Scope, Sequence & Coordination project. What is so interesting about the high school curriculum portion of the project is the individuality of the curriculum at each school. In some schools courses are completed integrated, other schools take a more thematic approach and look at a topic, such as water through the lens of earth science, biology, and chemistry. Still other schools teach each discipline for one semester. This flexibility is supported at the state and local level. Data on student achievement indicates that this approach supports student learning. Lawrenz and Huffman (1997) show that students enrolled for two years in these integrated courses scored significantly higher in physical science than comparison students. Although there was not significant difference in overall achievement, preliminary data shows that an increased exposure to this type of program might produce more significant changes in achievement. Data from Scott (2000) supports that hypothesis. In this study students, in integrated courses achieved significantly higher science scores on the California Achievement Tests than their traditional counterparts. Additionally, data on several studies show that female students consistently perform better than male students on measures of integrated understanding (Linn, 1992).

Other examples of integrating high school science can be found in individual schools across the county. Eggebrecht, Dagenais, Dosch, Merczak, Park, Styer, & Workman (1996) discuss the experiences of Illinois high school teachers that have developed integrated high school science curriculums that reflect a thematic approach to
science. Yager and Penick (1992) discuss the Iowa Science, Technology and Society (STS) effort to provide students with a real-world interdisciplinary context of learning science. This approach incorporates technology into the integration of the sciences. Here, students work on real-world problems as they learn science concepts. Ownership among the students is one outcome of the curriculum.

**Barriers to Changing the Scope and Sequence of the Curriculum**

The tenacity of the science curriculum mirrors the conservative nature of schools (Evans, 1996). Indeed, the present science reform movement reflects almost 50 years of discussion, with little change seen in the classroom. Weiss's study points out that although teachers profess to instructional objectives aligned to reform goals, classroom activities reflect a heavy reliance on the text, lecture, and an emphasis on basic science concepts (Weiss, 1997). This pattern of behavior harkens back to a complaint by Charles Elliot in 1898, in which he lamented about the excessive emphasis on memory and boring routine totally lacking in human interest (Bybee & DeBoer, 1994).

One reason for the heavy reliance on texts is the poor preparation given to teachers. TIMSS and TIMSS-R report that fewer eighth grade teachers in the United States are prepared to teach science than their international counterparts (US TIMSS, 2000). Teachers with a weak background in any given subject are more likely to emphasize low cognitive thinking skills and rely heavily on the text (Tobin & Espinet, 1989). Poorly prepared teachers as well as an increasing teacher shortage make changing the science curriculum a formidable task.
The use of science as a means of developing mental discipline and the domination of colleges on the high school curriculum are two additional barriers to an integrated curriculum. Colleges have long dominated the course structure of high school (DeBoer, 1991). This sentiment is further reflected by professors and the public at large that feel that real science cannot be taught to a significant portion of the population (Roberts, 1995). Other barriers to integration include the present structure of certification of high school teachers. The present certification for secondary teacher usually reflects a concentration of one science discipline; hence teachers become “experts” in one field. Indeed, presently in New Jersey there are separate certifications for teachers of Earth Science, Biology, and the physical sciences; and there is a movement at the state level to separate the physical science certification and make separate certifications for Chemistry and Physics teachers. Such specialization makes it difficult for teachers to provide their students with a robust, deep-thinking integrated science course.

A further resistance to change is the complacency of high performing schools. As Ashwill and associates (1999) report that generally, teachers in high performing schools felt that their state standards were not relevant to their students, since the majority of their students demonstrated that they were well above the state mean on the state assessment test. TIMMS and TIMSS-R results, as well as the results from NAEP belie a need for all teachers to embrace the notion of an integrated standards-based curriculum.

Kirst and Bird (1999) say that political tension makes it difficult to develop a supportive coalition to support science reform. This includes the tension between leadership and the political consensus; the tension between flexible and specific standards; the tension between dynamic standards and reasonable expectations for change
in the system; and the tension between professional leadership and public understanding of what the new standards will entail.

Potential Benefits to Current Science Reform Movement

Clearly one intended benefit of the current reform movement is science literacy among our citizens. Interviews with students in *A Private Universe* attest the notion that an Ivy League education does not guarantee science literacy (Shapiro et al., 1987). An integrated science curriculum that reflects the current nature of science and engages students in learning mirrors the type of teaching advocated by Gardner and others (Gardner, 1991). Similarly, as *NAEP* and the TIMSS report illustrate, decreasing the amount of content being covered will provide opportunities for students to delve more deeply into science content with the possible outcome of deeper understandings in science, ultimately leading to a more scientifically literate society.

A study done by Porter and associates report that as a result of state, district, and school standard-setting, more high school students are receiving more worthwhile math and science instruction than ever before (Porter, et al., 1994). While the content of these courses appeared not be compromised, the instruction remained the traditional lecture, independent student seatwork mode of delivery.

Recent research is beginning to show an increased performance by students in integrated science studies. *Kyle Jr.* (1989) reports that several studies show that the average student in classes using new science curricula outperformed students in
traditional science classes. More recent data from Scott (2000) corroborate these findings. Studies find that exemplary programs do not rely heavily on textbooks.

Louks-Horsley and Bybee (1999) see the greatest potential benefit of standards as their use as a tool for continuous improvement. Standards have the potential of supporting more ambitious teaching and greater levels of student success. They have the potential of leveraging the kind of staff development needed to support the new vision of science education. Darling-Hammond and Ball (1999) have shown the cumulative effects of teacher effectiveness. Teachers with a strong science background and who spend more time studying teaching are more effective overall, and do so by developing the higher-order thinking skills of their students.

Science educators must view reform holistically and systemically as the reconstruction of science education. The new standards movement is more inclusive, involving stakeholders at the national, state, and local level to form coalitions connected by a common vision of a science curriculum that consists of experiences that exemplify the spirit, character, and nature of science and technology. This new vision holds great promise of improving the goals of scientific literacy for all of its citizens.
CHAPTER III

METHODOLOGY

Introduction

One of the fundamental pillars of the standards movement is to improve student learning (Lee, 2000). As Darling-Hammond and Ball (1999) and others point out, implementing standards will not ensure improved student learning (Schmoker & Marzano, 1999; Raizen, 1998; Bybee, Ferrini-Mundy, & Loucks-Horsley, 1997). Indeed, as pointed out by Yee and Kirst (1994) and Yager (1992), past reform efforts have had little effect on secondary science education. This resistance to change is well documented in case studies of high school teachers that show a persistent heavy reliance on textbooks with lecture as the primary means of instruction (Ashwill, et al., 1999; Tobin & Fraser, 1990; Cuban, 1984; Stake & Easley, Jr., 1978) Moreover, as Aldridge points out (Aldridge, 1992a, 1992b); the layer cake science curriculum, unique to the United States is well entrenched in high schools, although there is significant evidence to support integrating the disciplines. Many think that this reform movement will also have little lasting change on the lives of American students (Elmore, 1996).

Black and Atkins (1996) mention that successful state reform movements, such as the one in California include both a top-down and bottom-up approach. Knapp’s (1997) analyses of large-scale systemic reform also note that building capacity takes multiple strategies, including changing requirements. In New Jersey the implementation of a
three-year science graduation requirement will immediately impact students. Whether the science that they learn promotes science literacy or whether it will continue to be the same lecture-based layer cake model of instruction remains to be seen. This study examines whether the high school curriculum offered to students has changed in scope (e.g., whether it remains segregated into distinct “layers” of disciplines or whether it models the current nature of science by integrating disciplines) and whether students will have opportunities to increase learn as more physical science as is commonly experienced by adolescents in other industrialized nations (Schmidt, McKnight, & Raizen, 1997).

The Data

The primary data was collected from a survey mailed to the 285 high schools in the state. Return samples were collated and organized to reflect the percentage of schools in each DFG, as shown in Table 2.

Data from returned surveys were collapsed into three groups to reflect a more distribution of districts by DFG. A further discussion of how the data was treated can be found in Chapter IV. Table 6 illustrates the collapsed distribution.

Data was obtained describing the scope of required science courses for the College Preparatory students and the sequence for taking those courses. Data was also disaggregated to describe the scope and sequence of those schools that have participated in the New Jersey Statewide Systemic Initiative (NJSSI).
TABLE 2: Percentages of Secondary School Districts in Each DFG

<table>
<thead>
<tr>
<th>DFG</th>
<th>Number of Districts</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>26</td>
<td>9%</td>
</tr>
<tr>
<td>B</td>
<td>34</td>
<td>12%</td>
</tr>
<tr>
<td>CD</td>
<td>40</td>
<td>14%</td>
</tr>
<tr>
<td>DE</td>
<td>48</td>
<td>17%</td>
</tr>
<tr>
<td>FG</td>
<td>40</td>
<td>14%</td>
</tr>
<tr>
<td>GH</td>
<td>40</td>
<td>14%</td>
</tr>
<tr>
<td>I</td>
<td>54</td>
<td>19%</td>
</tr>
<tr>
<td>J</td>
<td>3</td>
<td>1%</td>
</tr>
</tbody>
</table>

Method

The study quantified data retrieved from the survey. A survey was developed to determine the scope and sequence of curricular reform that has taken place in each high school.

Questions and survey design were developed in accordance with the parameters outlined by Rea and Parker (1997) and Fowler (1995). As such, questions were designed for clarity; responses to questions included simple as well as scaled responses. An occasional open-ended response was offered, when appropriate. School responses are kept confidential and anonymity was guaranteed. All surveys were coded to reflect DFG and NJSSI status.
Codes were assigned to each response and participants had an opportunity at the end of the survey to include additional written responses. Open-ended responses were categorized and collated. Collation and categorizing described the sequence of required courses and possibly to describe the kind of interdisciplinary courses offered, e.g., General Science, Geophysics, Physical Science, etc.

Frequency was used to determine the courses offered in Grades 9, 10, and 11. This data was then disaggregated into DFG to see the relationship between DFG and science courses offered. A Chi Square test was used to determine the statistical significance of the three-year course sequence.

Science reform efforts at Grades 9, 10, and 11 were determined by assigning a point value of one to each response in question 4. Mean and frequency were then calculated for each grade level. Data was then disaggregated by DFG to determine whether DFG influenced a district's reform effort.

Mean and frequency was also used to describe changes to the scope of college preparatory courses at each grade level. Data was then disaggregated by DFG to compare changes. A value of 1 was assigned to each portion of questions 10, 14, and 18 to measure changes to the scope of courses at every grade level. Mean composite reform scores and frequency were then calculated. A one-way ANOVA was done to compare mean scores at between groups at each grade level. Data was then disaggregated by DFG to determine whether DFG influenced changes to the scope of the science curriculum.

Finally, composite reform scores at each grade level were disaggregated by participation in NJSSI as a method of examining the influence of NJSSI on changes to the science curriculum. A one-way ANOVA was done to compare the composite mean
scores at each grade level of those districts that participated in NJSSI to those that did not participate in NJSSI.

Procedures

The survey was developed using survey strategies discussed by Fowler (1995) and Rea and Parker (1997). Questions included simple response questions, three used a Likert scale, and 10 questions involved simple multiple responses to questions. Room for additional responses were provided for Questions # 3, 4, 6, 7, 10, 14, 16, and 26. Questions were created and mapped to this study’s research questions to ensure that the survey would gather the necessary data.

After an initial review by the mentor, Dr. Lindemer, the survey went through two peer-reviews during the spring of 2000, the first by 5 New Jersey science administrators and the second by 10 New Jersey science administrators. The survey was modified according to comments made by these administrators and submitted to the doctoral committee consisting of mentor Dr. Lindemer, Dr. Gutmore, Dr. Cook, and Dr. Madden. After receiving their approval, the survey was submitted to the Seton Hall University’s Internal Review Board in March 2001. A final copy of the survey can be found in Appendix A.

District factor groups were determined through the New Jersey 2000 Report Card database available online from the New Jersey Department of Education. Addresses for the school districts were provided through another online state database. The second database did not identify the school district, rather the town address. A total of 285
districts were identified. Surveys were mailed to all 285 school districts, percentages are calculated from the state’s School Report Card 2000 database.

A recruitment letter was sent to the science administrators in each secondary school district asking requesting their participation in the survey. See Appendix B for a sample letter of the recruitment letter.

Science reform efforts at Grades 9, 10, and 11 were determined by assigning a point value of one to each response in question 4. Mean and frequency were then calculated for each grade level. Data was then disaggregated by DFG to determine whether DFG influenced a district’s reform effort.

Mean and frequency was also used to describe changes to the scope of college preparatory courses at each grade level. Data was then disaggregated by DFG to compare changes. A value of 1 was assigned to each portion of questions 10, 14, and 18 to measure changes to the scope of courses at every grade level. Mean composite reform scores and frequency were then calculated. A one-way ANOVA was done to compare mean scores at between groups at each grade level. Data was then disaggregated by DFG to determine whether DFG influenced changes to the scope of the science curriculum.

Analysis of Data for Subsidiary Problem 1

The first subsidiary problem is stated as: Is there a relationship between a district’s District Factor Grouping (DFG) and revising its curriculum?

All tests done in the study were disaggregated by DFG to determine the relationship between a districts’ DFG and its reform efforts.
Analysis of Data for Subsidiary Problem 2

The second subsidiary problem is stated as: What impact did participating in the New Jersey Statewide Systemic Initiative have on the scope and sequence of secondary science?

Composite reform scores at each grade level were disaggregated by participation in NJSSI as a method of examining the influence of NJSSI on changes to the science curriculum. A one-way ANOVA was done to compare the composite mean scores at each grade level of those districts that participated in NJSSI to those that did not participate in NJSSI.

The Instrument

The survey was first mailed to 285 secondary school districts on April 23, 2001 (see Appendix A). Eighty-one surveys were received within the first two weeks. A second reminder mailing was done on May 14, 2001. A third letter was sent on June 14, 2001. Fifty-six additional surveys were received as of June 30, 2001, for a total return of 137 surveys. Five respondents were unusable; two contained no data other than DFG status, one was from a special education high school, and two additional ones were from vocational schools. Thus, a total of 132 surveys that were returned were used in the study. The total response rate was 48%. Rea and Parker (1997) suggest that 50% of low population studies is considered appropriate for data analysis.
All data collected was voluntary and anonymous. Districts only had to state their district factor group. School data was identified by number and raw data was put into an SPSS program for analysis.
CHAPTER IV
ANALYSIS OF THE DATA

A 26 question-survey was constructed using strategies discussed by Rea and Parker (1997) and Fowler (1995). Questions included simple response questions, three used a Likert scale, and 10 questions involved simple multiple responses to questions. Room for additional responses were provided for Questions # 3, 4, 6, 7, 10, 14, 16, and 26. Questions were created and mapped to this study’s research questions to ensure that the survey would gather the necessary data. Table 3 shows how each survey questions maps to the research question. The survey went through two peer-reviews during the spring of 2000, the first by 5 New Jersey science administrators and the second by 10 New Jersey Science Administrators. The survey was modified according to comments made by these administrators and submitted to Seton Hall University’s Institutional Review Board in March 2001.

Response Data

The analysis of the data collected included several tests that were examined collectively and then disaggregated to answer subsidiary research questions. As such, the analysis examined several of the research questions simultaneously rather than sequentially. All research questions, however, are addressed.
The first survey was mailed out to 285 secondary school districts on April 23, 2001 (Appendix B). Eighty-one surveys were received within the first 2 weeks.

<table>
<thead>
<tr>
<th>Question</th>
<th>DFG</th>
<th>Reform</th>
<th>NJSSI</th>
<th>Scope</th>
<th>Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>3</td>
<td>X</td>
<td></td>
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<td>X</td>
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<td>4</td>
<td></td>
<td></td>
<td></td>
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<td>X</td>
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<td></td>
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<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
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<td>21</td>
<td></td>
<td></td>
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<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
A second reminder mailing was done on May 14, 2001. A third letter was sent on June 14, 2001. Fifty-six additional surveys were received as of June 30, 2001, for a total return of 137 surveys. Five respondents were unusable; 2 contained no data other than DFG status, one was from a special education high school, and two additional ones were from vocational schools. A total 132 surveys that were returned were used in the study. The total response rate was 48%. Rea & Parker (1997) suggest that 50% of low population studies is considered appropriate for data analysis.

SPSS was used for data analysis. Raw data was organized and put into the program. Since this is a qualitative study, responses were coded for analysis. Questions 1, 3, 5, 6, 7, 8, 11, 12, 15, 16, 19, 20, 21, 22, 23, 24, and 25 were coded. Responses to questions 4, 10, 14, and 18 were given a value of 1 to be used in for determining reform efforts. Table 4 shows the question and the coding. Any coding that was modified after an analysis of raw data is also given.

Study of the Data

The survey was a rich source of data. A number of tests were used to answer the research questions. Frequency was used to determine the courses offered in Grades 9, 10, and 11. This data was then disaggregated into DFG to see the relationship between DFG and science courses offered. A Chi Square test was used to determine the statistical significance of the three-year course sequence.

Science reform efforts at Grades 9, 10, and 11 were determined by assigning a point value of 1 to each response in question 4. Mean and frequency were then
calculated for each grade level. Data was then disaggregated by DFG to determine whether DFG influenced a district’s reform effort.

**TABLE 4: Coding of Survey Questions**

<table>
<thead>
<tr>
<th>Question</th>
<th>Code</th>
<th>Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1=A; 2=B; 3=CD; 4=DE; 5=FG; 6=GH; 7=I; 8=J; 9=blank; 10=Don’t Know</td>
<td>1=A,B,CD; 2=DE,FG,GH; 3=I,J</td>
</tr>
<tr>
<td>3</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Environmental Science; 7=Geophysical Science; 8=IPS; 9=Physical Earth Science; 10=Intro Physical Science/Earth Science; 11=Integrated Science; 12=quarter science; 13=CP Science; 14=other; 15=Biochemistry</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Integrated Science</td>
</tr>
<tr>
<td>5</td>
<td>1=yes; 2=no</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1=Elementary School; 2=Middle School; 3=High School; 4=All; 5=8-12; 6=K-8; 7=7-8; 8=other</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1=Elementary School; 2=Middle School; 3=High School; 4=All; 5=8-12; 6=K-8; 7=7-8; 8=other</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Environmental Science; 7=Geophysical Science; 8=IPS; 9=Physical Earth Science; 10=Intro Physical Science/Earth Science; 11=Integrated Science; 12=quarter science; 13=CP Science; 14=other; 15=Biochemistry</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Integrated Science</td>
</tr>
<tr>
<td>11</td>
<td>1= Before next academic year; 2= During next academic year; 3= within 2 years; 4= not currently planned</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Code</td>
<td>Modifications</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>12</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Environmental Science; 7=Geophysical Science; 8=IPS; 9=Physical Earth Science; 10=Intro Physical Science/Earth Science; 11=Integrated Science; 12=quarter science; 13=CP Science; 14=other; 15=Biochemistry</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Integrated Science</td>
</tr>
<tr>
<td>15</td>
<td>1= Before next academic year; 2= During next academic year; 3= within 2 years; 4= not currently planned</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Integrated Science</td>
</tr>
<tr>
<td>16</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Environmental Science; 7=Geophysical Science; 8=IPS; 9=Physical Earth Science; 10=Intro Physical Science/Earth Science; 11=Integrated Science; 12=quarter science; 13=CP Science; 14=other; 15=Biochemistry</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Integrated Science</td>
</tr>
<tr>
<td>19</td>
<td>1= Before next academic year; 2= During next academic year; 3= within 2 years; 4= not currently planned</td>
<td>1=Earth Science; 2=Biology; 3=Chemistry; 4=Physics; 5=Physical Science; 6=Integrated Science</td>
</tr>
<tr>
<td>20</td>
<td>1=a; 2=b; 3=c; 4=d; 5=3; 6=f</td>
<td>1=a; 2=b; 3=c; 4=d; 5=3; 6=f</td>
</tr>
<tr>
<td>21</td>
<td>1=Yes; 2=No</td>
<td>1=Yes; 2=No</td>
</tr>
<tr>
<td>22</td>
<td>1=a; 2=b; 3=c; 4=d; 5=3; 6=f</td>
<td>1=a; 2=b; 3=c; 4=d; 5=3; 6=f</td>
</tr>
<tr>
<td>23</td>
<td>1=Yes; 2=No</td>
<td>1=Yes; 2=No</td>
</tr>
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<td>24</td>
<td>1=a; 2=b; 3=c; 4=d; 5=3; 6=f</td>
<td>1=a; 2=b; 3=c; 4=d; 5=3; 6=f</td>
</tr>
<tr>
<td>25</td>
<td>1=Yes; 2=No</td>
<td>1=Yes; 2=No</td>
</tr>
</tbody>
</table>

Mean and frequency was also used to describe changes to the scope of college preparatory courses at each grade level. Data was then disaggregated by DFG to
compare changes. A value of 1 was assigned to each portion of questions 10, 14, and 18 to measure changes to the scope of courses at every grade level. Mean composite reform scores and frequency were then calculated. A one-way ANOVA was done to compare mean scores at between groups at each grade level. Data was then disaggregated by DFG to determine whether DFG influenced changes to the scope of the science curriculum.

Finally, composite reform scores at each grade level were disaggregated by participation in NJSSI as a method of examining the influence of NJSSI on changes to the science curriculum. A one-way ANOVA was done to compare the composite mean scores at each grade level of those districts that participated in NJSSI to those that did not participate in NJSSI.

**District Factor Grouping Data**

Data was first analyzed by DFG. Responses from each DFG were collected and then coded. Of the 132 respondents, 107 included information about their DFG. The frequency of that distribution is exhibited in Table 5. Percentages gathered from the

<table>
<thead>
<tr>
<th>DFG</th>
<th>Frequency</th>
<th>Survey Percentage</th>
<th>Actual Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>7.6%</td>
<td>9%</td>
</tr>
<tr>
<td>B</td>
<td>13</td>
<td>9.9%</td>
<td>12%</td>
</tr>
<tr>
<td>CD</td>
<td>10</td>
<td>7.6%</td>
<td>14%</td>
</tr>
<tr>
<td>DE</td>
<td>18</td>
<td>13.7%</td>
<td>17%</td>
</tr>
<tr>
<td>FG</td>
<td>15</td>
<td>11.5%</td>
<td>14%</td>
</tr>
<tr>
<td>GH</td>
<td>14</td>
<td>10.7%</td>
<td>14%</td>
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<tr>
<td>I</td>
<td>22</td>
<td>16.8%</td>
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<td>J</td>
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<td>3.8%</td>
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<tr>
<td>Left blank</td>
<td>24</td>
<td>18.3%</td>
<td></td>
</tr>
</tbody>
</table>
survey are comparable to the actual distribution as shown in Table 2. To facilitate data analysis, DFGs were collapsed into three groups. One category included low-income districts consisting of district factors groups A, B, and CD. A second category included the mid-income group, consisting of districts from DE, FG, and GH. The third category consisted of high-income districts having a DFG of I and J. It was thought that this organization would allow for comparisons of high to low income groups, if so desired.

The frequency and percentages of these collapsed categories can be seen in Table 6.

<table>
<thead>
<tr>
<th>DFG</th>
<th>Frequency</th>
<th>Percent</th>
<th>Actual Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, CD</td>
<td>33</td>
<td>30.8%</td>
<td>35%</td>
</tr>
<tr>
<td>DE, FG, GH</td>
<td>47</td>
<td>43.9%</td>
<td>45%</td>
</tr>
<tr>
<td>IJ</td>
<td>27</td>
<td>25.2%</td>
<td>20%</td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

**Course Offerings and Their Sequence**

Data was then analyzed to determine the course offerings of Grades 9, 10 and 11. The analyzed data reflected the traditional American high school science curriculum; i.e., courses offered at each grade level primarily consisted of one discrete discipline with little integration of content (Mervis, 1998; Bybee & Melnerne, 1995; Chemocology, 1991). Single-discipline courses were more prevalent in Grades 10 and 11. The
exception is in Grade 9 where 41 or 32% of all districts report offering an integrated to their college preparatory students.

Table 7 shows the course offerings for Grade 9. Integrated courses described by respondents included Biochemistry, Environmental Science, General Science, and other courses tailored to the needs of students in those districts. The course next most frequently offered in Grade 9 was Biology. Thirty-four districts or 26.6% of all districts report offering Biology as their 9th grade college preparatory course. Twenty-seven, or 21.1% of all districts report offering Earth Science as the Grade 9 college preparatory course. Twenty-three districts or 18% of the respondents state that offer Physical Science is the 9th grade college preparatory course. As one might expect, Physics is least commonly offered at this level; only 3 districts or 2.3% report Physics as the Grade 9 college preparatory course (Lederman, 1999).

<table>
<thead>
<tr>
<th>Course</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td>27</td>
<td>21.1%</td>
</tr>
<tr>
<td>Biology</td>
<td>34</td>
<td>26.6%</td>
</tr>
<tr>
<td>Physics</td>
<td>3</td>
<td>2.3%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>23</td>
<td>18.0%</td>
</tr>
<tr>
<td>Integrated Science</td>
<td>41</td>
<td>32.0%</td>
</tr>
<tr>
<td>Total</td>
<td>128</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The data in Table 8 displays the Grade 9 course offerings disaggregated by DFG. It shows that of the districts that reported their DFG, 13 of those with lower-incomes, or 39.39% offer an integrated science course. A similar percentage 16 or 34.04% is
identified in those districts that state a DFG of DE, FG, or GH; offer an integrated course to Grade 9 students. A smaller percentage of high-income districts, 6 or 23.07% report offering integrated science in Grade 9 to their 9th grade college preparatory students.

Biology appears to be offered most frequently at Grade 9 in upper-income districts. Ten districts, or 38.46% report offer Biology to its college preparatory students in Grade 9. Five, or 23.07% of the upper-income districts report offering Physical Science; 4, or 15.38% report offering Earth Science; and only 1 or 3.84% report offering Physics.

None of the districts reporting a mid-income DFG offer physics in the 9th grade.

Earth Science and Biology are each offered in 11 districts or 23.40%. Nine mid-income districts, or 19.14% report offering Physical Science in the Grade 9.

<table>
<thead>
<tr>
<th>Course</th>
<th>A, B, CD</th>
<th>Percent</th>
<th>DE, FG, GH</th>
<th>Percent</th>
<th>IJ</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td>6</td>
<td>18.18%</td>
<td>11</td>
<td>23.40%</td>
<td>4</td>
<td>15.38%</td>
</tr>
<tr>
<td>Biology</td>
<td>9</td>
<td>27.27%</td>
<td>11</td>
<td>23.40%</td>
<td>10</td>
<td>38.46%</td>
</tr>
<tr>
<td>Physics</td>
<td>1</td>
<td>3.03%</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3.84%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>4</td>
<td>12.12%</td>
<td>9</td>
<td>19.14%</td>
<td>5</td>
<td>19.23%</td>
</tr>
<tr>
<td>Integrated Science</td>
<td>13</td>
<td>39.39%</td>
<td>16</td>
<td>34.04%</td>
<td>6</td>
<td>23.07%</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>47</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An analysis of Grade 9 college level course offerings by DFG suggest that there is a greater interest in teaching an integrated science course in low-income districts than in high-income districts. The data might suggest a more traditional science program in the
high-income districts, which may be the result from concern about college admission rather than a concern about students passing the state’s high stakes High School Proficiency Assessment (DeBoer, 1991). Indeed, many comments from high-income districts stated they changes would be made after results from the first HSPA were made available. Case studies by Ashwill, et.al (1999) reveal a much greater concern about state standards at low achieving districts than at high-achieving ones. The study states:

Generally, teachers at high-achieving schools felt that state standards were not relevant to their students, since the majority of their students demonstrated that they were well above the state mean on the state assessment test. However, teachers at schools where the majority of the student population scored below the mean on the state assessment said that they felt pressure to choose textbooks based upon the state’s curriculum guidelines (p.28).

Table 9 illustrates the course offerings for Grade 10. Note that unlike Grade 9, which appears to have no preferred course offered, Biology is the preferred course offering statewide for Grade 10. The data shows that 79 or 61.7% of all districts report that Biology is the science course offering to 10th grade college preparatory science students. Thirty-six districts or 28.1% report Chemistry as the Grade 10 science course. Two districts, or 1.6% districts report Physics as their Grade 10 college preparatory science course. Three districts or 1.1% of the districts report Physical Science as the 10th grade science course. Eight districts or 6.3% responding offer an integrated science course in the 10th grade college preparatory science sequence. No district reported offering Earth Science as the Grade 10 college preparatory science course.
TABLE 9: Grade 10 College Preparatory Science Course Offerings

<table>
<thead>
<tr>
<th>Course Offerings</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>79</td>
<td>61.7%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>36</td>
<td>28.1%</td>
</tr>
<tr>
<td>Physics</td>
<td>2</td>
<td>1.6%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>3</td>
<td>2.3%</td>
</tr>
<tr>
<td>Integrated Science</td>
<td>8</td>
<td>6.3%</td>
</tr>
<tr>
<td>Total</td>
<td>128</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Table 10 illustrates the data disaggregated by DFG. When data is disaggregated by DFG, it appears that Biology is most frequently offered in mid-income districts.

Thirty-two districts, or 69.56% of those reporting their DFG to be DE, FG, or GH report Biology as the Grade 10 college preparatory science course. Twelve mid-income districts, or 26.01% report Chemistry as its Grade 10 course. Only 1 district, or 2.17% reported offering Physical Science and 1 other mid-income district reported offering an integrated science course.

TABLE 10: Grade 10 College Preparatory Science Course Offerings by DFG

<table>
<thead>
<tr>
<th>Course</th>
<th>DFG</th>
<th>Percent</th>
<th>DFG</th>
<th>Percent</th>
<th>DJ</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A, B, CD</td>
<td>Percent</td>
<td>DE, FG, GH</td>
<td>Percent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>19</td>
<td>65.51%</td>
<td>32</td>
<td>69.56%</td>
<td>11</td>
<td>44%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>8</td>
<td>27.58%</td>
<td>12</td>
<td>26.01%</td>
<td>10</td>
<td>40%</td>
</tr>
<tr>
<td>Integrated Science</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>2.17%</td>
<td>3</td>
<td>12%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>2</td>
<td>6.89%</td>
<td>1</td>
<td>2.17%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Physics</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>46</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A total of 80% of those districts reporting their DFG as I or J teach Biology or Chemistry in Grade 10. The data reflects that Biology and Chemistry are offered with almost the same frequency. Forty-four percent, or 11 districts report offering Biology as the 10th grade college preparatory science course while 40% or 10 other such districts report offering Chemistry. Ten districts offering Chemistry in Grade 10 would seem to substantiate the view of the traditional United Science high school science curriculum offering distinct discipline-based courses, typically beginning with Biology and followed by Chemistry, since 10 high-income districts report offering Biology as their Grade 9 college preparatory course (Lederman, 1999; Bybee & Mcinerne, 1995, Hurd, 1995).

Three high-income districts, or 12% of those reporting offer an integrated science course and 1 district, or 4% reporting offer Physics as their Grade 10 course. No high-income district included Physical Science as their Grade 10 college preparatory course.

There are fewer course offerings in those districts that report their DFG to be A, B, or CD. Well over half of the low-income districts, or 65.51% offer Biology as the 10th grade college preparatory science course; 8 or 27.58% offer Chemistry; and 2, or 6.89% offer Physical Science. No low-income district report to offer physics or an integrated science course as the 10th grade course.

As shown in Table 11, 61.1%, or 77 of the districts reporting offering Chemistry as their 11th grade college preparatory science course. Twenty-five percent, or 32 districts offer Physics as their 11th grade college preparatory course. Approximately 5%, or 7 districts state that they offer an 11th grade integrated science. Three percent, or 4 districts offer Earth Science.
TABLE 11: Grade 11 College Preparatory Science Course Offerings

<table>
<thead>
<tr>
<th>Course</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td>4</td>
<td>3.2%</td>
</tr>
<tr>
<td>Biology</td>
<td>6</td>
<td>4.8%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>77</td>
<td>61.1%</td>
</tr>
<tr>
<td>Physics</td>
<td>32</td>
<td>25.4%</td>
</tr>
<tr>
<td>Integrated Science</td>
<td>7</td>
<td>5.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>126</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Table 12 disaggregates Grade 11 college preparatory courses by DFG. The data shows that 65.62% or 21 of those districts reporting their DFG to be A, B, or CD offer Chemistry as an 11th grade course. Another 25% or 8 districts report offering Physics. One district or 3.12% offers Earth Science as their Grade 11 college preparatory course. Biology and integrated science courses are also offered by 1 district each. No poor district offers Physical Science as a third-year college preparatory science course.

Middle-income districts report a similar landscape of course offerings. Sixty-two percent, or 28 districts report offering Chemistry to Grade 11 students. Slightly over 24% or 11 districts report offering Physics to their college preparatory students. Two districts, or 4.44% reporting offer Earth Science, Physical Science, or an integrated science course for Grade 11. No mid-income district reported offering Biology as the Grade 11 science course.
### TABLE 12: Grade 11 College Preparatory Science Course Offerings by DFG

<table>
<thead>
<tr>
<th>Course</th>
<th>A, B, CD</th>
<th>DE, FG, GH</th>
<th>DE, FG, GH</th>
<th>IJ</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Biology</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>8.69%</td>
<td></td>
</tr>
<tr>
<td>Chemistry</td>
<td>21</td>
<td>28</td>
<td>12</td>
<td>52.17%</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>30.43%</td>
<td></td>
</tr>
<tr>
<td>Physical Science</td>
<td>0</td>
<td>2</td>
<td>0%</td>
<td>4.44%</td>
<td></td>
</tr>
<tr>
<td>Integrated Science</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>8.69%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>45</td>
<td>23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An overall view of the data indicates that the most variety of course offerings occurs in Grade 9. Grade 10 offers the least variety. Several districts reported that they did not require a specific course in Grade 11, rather they required a third year of a science, which could be physics, environmental science, earth science, or some other type of elective developed specifically by that district. This might explain why there is a greater variety of courses offered at the 11th grade level than at the 10th grade level.

The data suggests that the typical three-year high school curriculum includes Biology in Grade 9 or 10 followed by Chemistry. Indeed, 81.4% of all the districts surveyed report a Biology/Chemistry sequence. This sequence reflects the typical layer-cake model noted by NSTA and other science educators (Lederman, 1999; Aldridge, 1992; DeBoer, 1991). Physics appears to be offered in high-income districts at a slightly higher percentage than in mid and low income districts. Integrated science courses appear most frequently in Grade 9 and most infrequently in Grade 11. Data from this study indicates that the general sequence of courses is discipline based in Grades 10 and
11; one in which Biology is followed by Chemistry. This sequence of Biology, Chemistry, followed by Physics is similar to Campbell’s study, which found that in most high schools the sequence of course offerings is Biology, Chemistry and then Physics (Campbell, Hombo, & Mazzeo, 2000).

An examination of course offerings by DFG shows that mid-income districts have the widest variety of course offerings. Chi square tests were done to determine whether course offerings at each grade level were statistically significant. Table 13 shows that, there was no statistical significance between the observed and the expected course offerings at any grade level within any DFG. The Pearson Chi-Square for Grade 9 has a value of 8.98 residual with a $p$ value of $.534$, indicting that the variation of course offerings between districts is not statistically significant. On the other hand, the data in Table 14 illustrates a trend that appears to occur in Grade 10. In this grade, the Pearson Chi-Square residual is 13.779 with a $p$ value of $.088$. A residual of 13.779 indicates more variation than in Grade 9. When one looks at the course offerings, one sees that the expected number of districts taking Biology in middle-income districts is 28.5; 32 districts actually offer Biology. In high-income districts, the expected number of districts offering Biology is 15.5; the actual number of districts offering Biology is 11. Similarly, 10 high-income districts offer Chemistry in Grade 10 compared to the expected number 7.5. The number of districts offering Chemistry in Grade 10 coincides with the same number of high-income districts that offer Biology in Grade 9. These figures align to the Biology/Chemistry sequence seen frequently throughout the state.
### TABLE 13: Grade 9 DFG Crosstabulation and Chi Square Tests

<table>
<thead>
<tr>
<th>Course</th>
<th>Count</th>
<th>A, B, CD</th>
<th>DE, FG, GH</th>
<th>LJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td></td>
<td>5</td>
<td>9</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Expected Count</td>
<td>5.4</td>
<td>8.0</td>
<td>4.6</td>
<td></td>
<td>18.0</td>
</tr>
<tr>
<td>Biology</td>
<td></td>
<td>9</td>
<td>12</td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td>Expected Count</td>
<td>9.7</td>
<td>14.2</td>
<td>8.2</td>
<td></td>
<td>32.0</td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Expected Count</td>
<td>.3</td>
<td>.4</td>
<td>.3</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Expected Count</td>
<td>.3</td>
<td>.4</td>
<td>.3</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Physical Science</td>
<td></td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Expected Count</td>
<td>5.4</td>
<td>8.0</td>
<td>4.6</td>
<td></td>
<td>18.0</td>
</tr>
<tr>
<td>Integrated Science</td>
<td></td>
<td>13</td>
<td>17</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Expected Count</td>
<td>10.9</td>
<td>16.0</td>
<td>9.2</td>
<td></td>
<td>36.0</td>
</tr>
<tr>
<td>Count</td>
<td>32</td>
<td>47</td>
<td>27</td>
<td></td>
<td>106</td>
</tr>
<tr>
<td>Expected Count</td>
<td>32.0</td>
<td>47.0</td>
<td>27.0</td>
<td></td>
<td>106.0</td>
</tr>
</tbody>
</table>

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>8.984*</td>
<td>10</td>
<td>.534</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>8.956</td>
<td>10</td>
<td>.536</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.829</td>
<td>1</td>
<td>.363</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>106</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 8 cells (44.4%) have expected count less than 5. The minimum expected count is .25.
### TABLE 14: Grade 10 DFG Crosstabulation and Chi Square tests

<table>
<thead>
<tr>
<th>Course</th>
<th>DFG</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A, B, CD</td>
<td>DE, FG, GH</td>
</tr>
<tr>
<td>Biology</td>
<td>Count</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>18.0</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Count</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>8.7</td>
</tr>
<tr>
<td>Physics</td>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>.3</td>
</tr>
<tr>
<td>Physical Science</td>
<td>Count</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>.9</td>
</tr>
<tr>
<td>Integrated Science</td>
<td>Count</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>Expected Count</td>
<td>29.0</td>
</tr>
</tbody>
</table>

**Chi-Square Tests**

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>13.779⁸</td>
<td>8</td>
<td>.088</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>13.808</td>
<td>8</td>
<td>.087</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>2.997</td>
<td>1</td>
<td>.083</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⁸9 cells (60.0%) have expected count less than 5. The minimum expected count is .25.
The data in Table 15 for Grade 11 does not show a trend toward one subject. It appears from the data however, that Physics is taught more commonly in this grade than in any other. The Pearson Chi-Square is calculated at 8.685 shows a little variation from the expected. The p value for Grade 11 is .370, which is neither statistically significant nor indicative of a trend. However, if one looks at the course offerings in Grade 11 one sees that there are more courses offered at this grade than at Grade 10, bearing out the data provided by respondents that schools may offer their students a variety electives for their third year science requirement. In addition, Chemistry and Physics are more prevalent at Grade 11 than in either Grade 9 or 10; a phenomenon noted by Aldridge and others who suggest that American students have less opportunity to learn the physical sciences than students in other countries (Aldridge, 1996; Hoffer, Quinn, & Suter, 1996; Hurd, 1995). The data in Table 15 shows that the number of middle-income schools offering Chemistry in Grade 11 is 30 as compared to the expected number of 16.4, which agrees with the number of mid-income districts that offer Biology in the 10th grade. Thirty-two mid-income districts offer Biology in Grade 10; 30 offer Chemistry in Grade 11. These numbers reflect the Biology/Chemistry sequence of course offerings that exists throughout the state. The data in low-income districts also reflect the Biology/Chemistry sequence. Nineteen low-income districts offer Biology in Grade 10; 17 offer Chemistry in Grade 11. The same sequence is reflected in upper income districts where 11 districts offer Biology in Grade 10 and 12 districts offer Chemistry in Grade 11.

Physics occurs with a similar regularity. Nine low-income districts offer Physics in Grade 11; 8 offer Chemistry in Grade 10. Thirteen mid-income districts offer Physics in Grade 11; 12 mid-income districts offer Chemistry in Grade 10. Eight wealthy
districts offer Physics in Grade 11, 10 districts offer Chemistry in Grade 10. As Aldridge, Lederman and others have noted, the typical American college preparatory student takes three years of science, Biology, followed by Chemistry, followed by Physics. The increased number of districts offering Physics in Grade 11 and the comparable number of districts offering Chemistry in Grade 10 would seem to support the discipline-based Biology/Chemistry/Physics trend noted in studies done of the practices of secondary schools in the United States (Ashwill et al., 1999; O'Sullivan & Weiss, 1999; Hoffer, Quinn, & Suter, 1996).

The variation of course offerings and the small discrepancy between districts offering Chemistry in Grade 10 to those offering Physics in Grade 11 may be due to districts not requiring a particular course for Grade 11, but rather offering students a variety of electives, one of which is Physics.

The types of courses offered throughout the state reflect the traditional American high school science curriculum, one that offers discrete, discipline-based courses. Few districts appear to have adopted Lederman's view of teaching physics first. None of the respondents offer thematic integrated courses such as those endorsed by NSTA's SSS&C curriculum (Lederman, 1999; Aldridge, 1996, 1992). It is only in Grade 9 that an integrated course is as just as likely to be offered as a discipline-based one such as Biology or Earth Science. The findings in this study point toward the view that the secondary science curriculum in the United States is discipline-based with little integration (Bybee & DeBoer, 1994).
TABLE 15: Grade 11 * DFG Crosstabulation and Chi Square Tests

<table>
<thead>
<tr>
<th>Courses</th>
<th>DFG</th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>A, B, CD</td>
<td>DE, FG, GH</td>
<td>IJ</td>
</tr>
<tr>
<td>Earth Science</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Expected Count</td>
<td>1.2</td>
<td>1.8</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Count</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Biology</td>
<td>1.5</td>
<td>2.2</td>
<td>1.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Count</td>
<td>17</td>
<td>30</td>
<td>12</td>
<td>59</td>
</tr>
<tr>
<td>Chemistry</td>
<td>18.0</td>
<td>26.4</td>
<td>14.6</td>
<td>59.0</td>
</tr>
<tr>
<td>Expected Count</td>
<td>9.1</td>
<td>13.4</td>
<td>7.4</td>
<td>30.0</td>
</tr>
<tr>
<td>Count</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Physics</td>
<td>2.1</td>
<td>3.1</td>
<td>1.7</td>
<td>7.0</td>
</tr>
<tr>
<td>Expected Count</td>
<td>32</td>
<td>47</td>
<td>26</td>
<td>105</td>
</tr>
<tr>
<td>Count</td>
<td>32.0</td>
<td>47.0</td>
<td>26.0</td>
<td>105.0</td>
</tr>
</tbody>
</table>

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>8.685a</td>
<td>8</td>
<td>.370</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>9.410</td>
<td>8</td>
<td>.309</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.181</td>
<td>1</td>
<td>.671</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>105</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 9 cells (60.0%) have expected count less than 5. The minimum expected count is .99.
Reforming the Science Curriculum

Fifty-five districts responded that they had made no change to their science curriculum. Fifteen districts stated that they moved Biology to Grade 9. Twenty-one districts stated that they changed a Grade 8 course to accommodate a new sequence for high school. Thirty-five districts stated that they created a new 9th grade course, but the sequence for courses in Grades 10 and 11 remained the same. Eleven districts stated that they created a new course in Grades 9 and 10, with sequence for Grade 11 remaining the same.

As shown in Table 16, disaggregated data indicates little variation among those districts showing no change, with 15 low-income districts, 16 mid-income districts and 13 high-income districts that reported their DFG stating that no change had been made to their curriculum. Similarly, an even number of districts, 5 of low-income, 6 of mid-income, and 4 of high-income, report moving Biology to Grade 9. On the other hand, 18 mid-income districts state that they created a new course in Grade 9. Only 5 low-income districts and 4 high-income districts report creating a new Grade 9 course. Five low-income districts report creating new courses in Grades 9 and 10. Two mid-income districts and 3 high-income districts report similar changes. Four low-income districts report changing Grade 8 courses to accommodate a new high school sequence; 10 mid-income districts and 3 high-income districts report similar changes.

When data is disaggregated by DFG it appears that mid-income districts have made changes to their curriculum than high and low income districts. Figure 4 illustrates
the comparative reform efforts by DFG. The data indicates that there appears to be no prevalent reform effort in low-income districts reporting their DFG, or in upper-income districts reporting their DFG. Only in mid-income districts demonstrate some evidence of reform, particularly in Grade 9.

<table>
<thead>
<tr>
<th>DFG</th>
<th>No change</th>
<th>Moved Biology to Gr. 9</th>
<th>Created a new Gr. 9 course; sequence Gr. 10 &amp; 11 remain the same</th>
<th>Create new courses in Gr. 9 &amp; 10; sequence Gr. 11 remain the same</th>
<th>Changed Gr. 8 course to accommodate new sequence for HS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, CD</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>DE, FG, GH</td>
<td>16</td>
<td>6</td>
<td>18</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>IJ</td>
<td>13</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>15</td>
<td>27</td>
<td>10</td>
<td>17</td>
</tr>
</tbody>
</table>

The data also indicates that the most frequent reform effort was a creating a new course in Grade 9. This would account for the data that shows that Grade 9 has more variety of course offerings than any other grade and middle-income districts were most likely to use this strategy. Fewer districts took the strategy of revising courses in Grades 9 and 10, except in low-income districts where the data shows that change is evenly distributed.
Figure 4. Comparing Reform Efforts by DFG

- No Change
- Bio to Gr. 9
- New Grade 9
- New Gr. 9&10
- Changed Grade 8

Number

A, B, CD  DE, FG, GH  IU  Total

DFG
Scope of Courses

Determining changes to the scope of courses was done in two ways. The kinds of changes as described in Questions 10, 14, and 18 were examined first. Figure 5 compares the comparative changes to the scope of courses in Grades 9, 10 and 11. It appears from the data that districts were more likely to change the scope of Grade 9 than courses in Grade 10 or 11. The types of changes to scope varied considerably among grades, although the most frequent action taken was a change in text.

Changing texts was the most frequent response in all grade levels; appearing with the greatest frequency in Grade 11 and with the least frequency in Grade 9. Data shows that in Grade 9, 65 or 32% of those reporting changes report a change in text. Changing text aligns to the responses of districts reporting appreciable revisions to their Grade 9 college preparatory science courses.

When comparing the other categories of change in scope, it appears that adding Chemistry occurred at all grade levels with similar frequency; 16% in Grade 9, 15% in Grade 10 and 15% in Grade 11. Data from other categories indicate that Grade 9 courses were more likely to have been changed in scope than Grades 10 and 11.

The data reported from Grade 9 indicate that districts have added more physical science to their Grade 9 college preparatory science course. Thirty-six districts, or 18% report adding physics; 32 districts, or 16% report adding Chemistry; 31 districts, or 15% s report adding Earth Science, and 8% report adding Biology. The data appears to indicate that districts have addressed the issue of increasing students’ exposure to the physical
Figure 5. Comparing Changes to the Scope of College Preparatory Science Courses in Grades 9, 10 and 11
sciences as pointed out by Schmidt, et.al. in their analysis of the TIMSS studies (Schmidt, W., McKnight, C., Cogan, L., Jakwerth, P., & Houang, R., 1999).

Districts appear to have added additional Biology most frequently in Grades 9 and 10; 17 districts, or 8% added Biology to their Grade 9 science course and 14 districts, or 16% added Biology to their Grade 10 science course. Since Biology is primarily taught in Grades 9 and 10, the data indicates that the topics taught within the high school college preparatory Biology course have changed as a result of the NJCCCS.

Chemistry was added with the similar frequency across all three grade levels; 32 districts, or 16% added Chemistry to their Grade 9 college preparatory science course; 12 districts, or 15% added Chemistry to their Grade 10 course; and 11 or 15% added Chemistry to their Grade 11 science course. The addition of Chemistry to the curriculum reflects the findings of Campbell et.al., which showed that the percentage of students taking Chemistry increased from 40% in 1986 to 57% in 1999 (Campbell et al., 2000).

Earth Science was also added with some uniformity; again most frequently in Grade 9 where 31 districts or 15% report adding Earth Science to their Grade 9 course; 13% in Grade 10; and 10% in Grade 11. These changes indicated that Earth Science may have been infused into existing course offerings.

Physics was also added most frequently to Grade 9 courses; 36 districts, or 18% reported adding Physics to their Grade 9 course; 5 districts, or 6% reported adding it to their Grade 10 course; and 8 districts, or 11% reported adding some Physics to their Grade 11 college preparatory course.

It appears from the data provided, that districts were more likely to change the scope of their existing courses than to create a new course. In addition, districts appear to
have added more physics and chemistry to Grades 9 and 10. These changes to courses in Grade 9 and 10 may be in response to the implementation of the NJCCCS in science.

Changes to the scope of courses taught at each grade were also measured by assigning a value of 1 to each part of Question 10, 14, and 18 and calculating a composite score. The highest possible score is 6; no district earned that score. The mode in Grades 10 and 11 was a score of 1; in Grade 9 it was a score of 2.

Table 17 shows the composite scores for all three grades. The data found agrees with data found throughout this study; i.e., districts appear to be more likely to modify courses in Grade 9 than to modify those courses in Grades 10 and 11. The data indicates that 84 districts or 63.63% of all respondents revised the scope of their ninth grade course. The data indicates that no district in Grade 10 earned a score of 5.

Of the courses offered, the one most likely to be modified was an integrated science course. Thirty-seven of those districts that offered an integrated course in Grade 9 report some change to the scope of the course. Five districts, or 9.80% report changes to the scope of an integrated science course in Grade 10. One district, or 2.73% report revising an Integrated Science course in Grade 11.

The next most commonly revised course in Grade 9 was Physical Science where 18 or 21.49% report revisions. One district in Grade 10 and 0 districts in Grade 11 report revisions for Physical Science. Seventeen districts, or 20.23% report revising Biology in Grade 9. This compares to the 34 or 66.67% of districts that revised Biology in Grade 10. Only 1 district reports revisions for Biology in Grade 11. Ten districts report modifying Earth Science in Grade 9. No district reports offering Earth Science in Grade 10, so no revisions were possible.
TABLE 17: Comparison of Scores Reflecting Changes to the Scope of Courses, Grades 9, 10, and 11.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Course</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Earth Science</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Biology</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Physical Science</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Integrated Science</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>37</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>24</td>
<td>25</td>
<td>16</td>
<td>12</td>
<td>7</td>
<td>84</td>
</tr>
<tr>
<td>10</td>
<td>Biology</td>
<td>20</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Physical Science</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Integrated Science</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>26</td>
<td>17</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>51</td>
</tr>
<tr>
<td>11</td>
<td>Earth Science</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Biology</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>18</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Integrated Science</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>24</td>
<td>14</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>44</td>
</tr>
</tbody>
</table>

Few districts reported revisions in Grade 9 for Chemistry and Physics. This is to be expected given the low number of districts that offer these courses as their ninth grade college preparatory science course. Ten, or 19.60% of districts report revisions to Chemistry in Grade 10. Twenty-seven, or 61.36% of districts report revision in Grade 11. Most of the revisions in 11th Grade Chemistry reflect a value of 1, which reflects relatively little change.
Revisions in Physics are relatively infrequent. One district in Grade 9 and 1 district in Grade 10 report revisions to Physics. Eleven districts in Grade 11 report revisions.

A one way ANOVA was done to determine whether there was a significant difference in composite scores reflecting revisions to the scope of courses between grade levels. Table 18 indicates there is no significant difference between groups at any grade level, although a trend appears to occur in Grade 9. Indeed, a post hoc ANOVA shows that there is a significant difference in mean composite scores between low and middle-income districts.

<table>
<thead>
<tr>
<th>TABLE 18:</th>
<th>One-way ANOVA comparing composite scores reflecting revisions to scope of courses in Grades 9, 10 and 11.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
<td>9.704</td>
</tr>
</tbody>
</table>
| Grade 9 Composite Score
| Within Groups | 111.781 | 67 | 1.668 |        |       |
| Total | 121.486 | 69 |        |        |       |
| Between Groups | 2.414 | 2 | 1.207 | 1.690 | .198  |
| Grade 10 Score
| Within Groups | 27.146 | 38 | .714 |        |       |
| Total | 29.561 | 40 |        |        |       |
| Between Groups | 3.180 | 2 | 1.590 | 1.871 | .170  |
| Grade 11 Composite Score
| Within Groups | 28.042 | 33 | .850 |        |       |
| Total | 31.222 | 35 |        |        |       |
As Table 18 illustrates, the data shows an $F$ value for Grade 9 is 2.908, indicating a degree of variation between groups, which is significant at the .061 level, indicating a trend. The data in Grade 10 produces an $F$ value of 1.690, showing less variation than in Grade 9, but some variation between groups, however not at the .05 level of significance. In Grade 11 that data produces an $F$ value of 1.871, indicating that there is more variation in Grade 11 than in Grade 10, although the variation is not significant at the .05 level. Variation in Grade 11 may be attributed to the variation of course offerings at this grade level. As mentioned previously, many districts responded that although they require 3 years of a science, they do not have a specific course requirement for Grade 11, students may select from a variety of electives including physics, Earth Science, Environmental Science, as well as other course. The data suggests that changes to the scope of courses in Grades 9, 10, 11 have not changed significantly since the implementation of the NJCCCS in Science.

A post hoc test on the ANOVA shows that there is a statistically significant difference between the composite scores of low-income groups to mid income groups. Table 19 shows that when comparing the differences between means of the mid income group, whose mean composite score for Grade 9 is 2.78 to the low-income groups whose mean composite score for Grade 9 is 1.89, the mean difference of .89 is statistically significant at the .05 level of significance. The data indicates that middle-income districts have done significantly more reform efforts than lower income districts. On the other hand, the mean difference between middle and high income groups, whose mean is .32 which is not statistically significant at the .05 level statistically significant, suggesting
that although middle-income districts have a higher composite score for science reform
efforts, the differences between these two districts are not statistically significant.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 9 Composite Score</td>
<td>DE, FG, GH</td>
<td>-0.89*</td>
<td>.37</td>
<td>.048</td>
<td>-1.78</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.58</td>
<td>.45</td>
<td>.412</td>
<td>-1.66</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>.32</td>
<td>.40</td>
<td>.703</td>
<td>-.63</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>.58</td>
<td>.45</td>
<td>.412</td>
<td>-.50</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.32</td>
<td>.40</td>
<td>.703</td>
<td>-1.26</td>
</tr>
<tr>
<td>Grade 10 Composite Score</td>
<td>DE, FG, GH</td>
<td>-8.03E-02</td>
<td>.29</td>
<td>.960</td>
<td>-.80</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.78</td>
<td>.44</td>
<td>.195</td>
<td>-1.87</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>.78</td>
<td>.44</td>
<td>.195</td>
<td>-.30</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.70</td>
<td>.42</td>
<td>.223</td>
<td>-1.72</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.26</td>
<td>.34</td>
<td>.720</td>
<td>-1.08</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.94</td>
<td>.49</td>
<td>.145</td>
<td>-2.13</td>
</tr>
<tr>
<td>Grade 11 Composite Score</td>
<td>DE, FG, GH</td>
<td>.26</td>
<td>.34</td>
<td>.720</td>
<td>-.56</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>-.68</td>
<td>.47</td>
<td>.326</td>
<td>-1.82</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>.94</td>
<td>.49</td>
<td>.145</td>
<td>-2.25</td>
</tr>
<tr>
<td></td>
<td>DE, FG, GH</td>
<td>.68</td>
<td>.47</td>
<td>.326</td>
<td>-.47</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.
As expected, when the data is disaggregated by groups for Grades 10 and 11, there is no statistically significant difference in mean composite scores, indicating that the reform efforts in districts throughout the state at all DFGs in Grades 10 and 11 are not statistically significant.

Table 20 further illustrates the range of composite scores disaggregated by DFG.

<table>
<thead>
<tr>
<th>TABLE 20: Comparing Composite Scores Of Grades 9, 10, &amp; 11 by DFG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade 9 Composite Score</strong></td>
</tr>
<tr>
<td>DFG</td>
</tr>
<tr>
<td>A, B, CD</td>
</tr>
<tr>
<td>Grade 9</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Grade 10 Composite Score</strong></td>
</tr>
<tr>
<td>DFG</td>
</tr>
<tr>
<td>A, B, CD</td>
</tr>
<tr>
<td>Grade 10</td>
</tr>
<tr>
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<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Grade 11 Composite Score</strong></td>
</tr>
<tr>
<td>DFG</td>
</tr>
<tr>
<td>A, B, CD</td>
</tr>
<tr>
<td>Grade 11</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
When the data is disaggregated the pattern that emerges differs somewhat from the disaggregated data of the ANOVA reform model. In the ANOVA we found that middle-income districts demonstrated the most revisions to their curriculum, particularly in Grade 9. An examination of the range of scores for all three grades shows that upper income districts have earned a more consistently mean score for each grade; i.e. 2.78; 1.70, and 1.72 for Grades 9, 10, and 11.

A closer look at the composite scores shows that the low sample size in upper-income districts and a single score of 5 in Grade 11 skew the data. More middle-income districts report reform at each grade level, suggesting that more reform is taking place in schools in this socio-economic group. Middle-income districts have the highest mean score in Grade 9 of 2.78. Their Grade 10 composite score is 1.70 and the Grade 11 composite score is 1.72. The data shows that high-income districts have responded to the NJCCCS in science by modifying the scope of existing courses at each grade level rather than by changing courses entirely, or by concentrating their efforts in any one grade.

This conservative approach to change reflects the findings of Aldridge (1996), Ashwill et al, (1999) Tobin and Fraser (1990) and Black and Atkin (Black & Atkin, 1996)

Overall, every income district’s highest composite score is in Grade 9, which aligns to the reform efforts identified previously. It appears that statewide, Grade 9 courses have been revised more than college preparatory science courses at Grades 10 and 11. Figure 6 graphically compares the mean composite scores for Grades 9, 10, and 11 in each DFG.
Figure 6. Mean Composite Scores of District by DFG and Grade
to the sequence of courses reflect more changes in Grade 9 than in Grades 10 and 11 and more districts report changing their Grade 9 course than the other two grades.

Thus the implementation of the NJCCCS in science has had more of an impact on Grade 9 than on Grade 10 or 11, which reflects the view of many science educators that the college preparatory curriculum is one designed to prepare students to be future scientists (Atkin, Kilpatrick, Bianchini, Helms, & Holthuis, 1997). Little changes to the "high: sciences of Chemistry and Physics reflect the view that these courses are designed to prepare students for the rigors of a science college career, and that changes to the traditional curriculum will negatively impact students (Lederman, 1999). This too may explain why high-income districts make fewer changes to the scope and/or sequence of science courses than their middle income and low-income counterparts.

The poor preparation of teachers may also account for lack of change to the scope of courses. Newman points out that teachers have been socialized to construe knowledge from the outlines of textbooks (Newman, 1988). In a case study by Tobin and Espinet (1989), poorly prepared teachers relied heavily on the text and on low-cognitive skills such as recall and memorization.

Participation in the New Jersey Statewide Systemic Initiative

One hundred twenty nine respondents replied to the questions regarding participation in NJSSI. Seventy-four, or 54% of those that replied, reported that they had participated in NJSSI. Thirty-three of those replying reported their district to have a rating of A, B, or CD; 47 reported a rating of DE, FG, or GH; and 27 reported a rating of
I or J. Of those that reported participating in the NJSSI, 22.8% report some participation at the secondary level. Forty-four districts describe their participating in NJSSI as attending workshops sponsored by NJSSI. Twenty of those districts reporting participation in NJSSI report being awarded a Standards Implementation Grant; 3 of those districts used a Standards Implementation Grant in high school. Thus it would appear that only a few districts engaged their high schools in long-term reform efforts, as Elmore points out, “The closer an innovation gets to the core of schooling, the less likely it is that it will influence teaching and learning on a large scale” (Elmore, 1996 p.4).

One way to determine whether districts that participated in NJSSI were more likely to generate changes to their science curriculum was to compare the mean composite scores to changes in scope of districts that participated in NJSSI to those that did not. Those districts that participated in had a slightly higher mean composite score in Grade 9 with a mean composite score of participating districts to be 2.55 as compared to 2.21; scores in Grade 10 are 1.69 each and in Grade 11 the mean for participating districts was 1.66 as compared to 1.67. Table 21 exhibits those results.

<table>
<thead>
<tr>
<th>Participation in NJSSI</th>
<th>Grade 9 Score</th>
<th>Grade 10 Score</th>
<th>Grade 11 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Mean</td>
<td>2.55</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>56.00</td>
<td>35.00</td>
</tr>
<tr>
<td>No</td>
<td>Mean</td>
<td>2.21</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>28.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Total</td>
<td>N</td>
<td>84.00</td>
<td>51.00</td>
</tr>
</tbody>
</table>
A one-way ANOVA was calculated to compare means between groups to see if there was any significant variation between those districts that participated in NJSSI to those that did not. Table 22 shows the findings of the ANOVA.

<table>
<thead>
<tr>
<th>TABLE 22: One-way ANOVA comparing revisions to scope of courses in Grades 9, 10 and 11 of NJSSI districts vs. those that did not participate in NJSSI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Grade 9 Composite Score Within Groups</td>
</tr>
<tr>
<td>Grade 10 Composite Score Within Groups</td>
</tr>
<tr>
<td>Grade 11 Composite Score Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Grade 11 Composite Score Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

The trend throughout this study of Grade 9 demonstrating the most change also occurred for districts participating in NJSSI. The test found F values that indicated some variations between groups. In Grade 9, the F value of 1.33 indicates more variation than in Grades 10 and 11, variation however is not significant at the .05 level. Variation between groups in Grade 10 is insignificant, as indicated by an F value of .00. A similar F value of .002 for Grade 11 also indicates very little variation between groups.
Similarly, 27 districts that participated in NJSSI reported changing the scope of their curriculum; 28 of those districts participating in NJSSI reported not making any changes to the curriculum.

These findings may reflect the resistant nature of reform as noted by, Stake and Easley (1978) and others (Weiss, 1997; Tobin & Espinet, 1989; Cuban, 1984). Huberman (1997) also points out the complexity of systemic change:

In effect, the conventional time frame from such audacious or ambitious ventures is millennial. The original work of Paul Mort and his associates at Columbia showed a 50-year gap between the initial use of an educational innovation and an informed awareness by 30 to 40 percent of the appropriate teaching staff in the proximate region (Havelock 1969). Moreover, reformers are not interested in just a handful of districts or experimental projects, but in getting critical mass (p. 158).

Answers to Research Question and Subsidiary Questions

The primary research question asks: How have the New Jersey Core Curriculum Content Science Standard in influenced the scope and sequence of the high science curriculum? The data from this study shows that the implementation of the NJCCCS in science has not had a significant impact on the scope and sequence of the high school science curriculum. Changes made to the scope of courses have been made within the traditional layer cake curriculum that already exists. Course sequence remains traditional, except on 2 occasions where Physics is taught first. Integration exists primarily in the ninth grade with the more traditional college preparatory courses, Biology and Chemistry occurring in Grades 10 and 11. More change occurs in Grade 9 than in any other grade.
The first subsidiary question asks: Is there a relationship between a district’s District Factor Grouping (DFG) and revising its curriculum? This question is addressed in every statistical analysis by disaggregating the data. The scope of courses in schools does vary among DFGs. Mid-income districts report more revisions to Grade 9 than low and high-income districts. All districts reported the most frequent revision to be changing the text. The sequence of courses remains relatively unchanged at all levels.

The second subsidiary question posed is: What impact did participating in the New Jersey Statewide Systemic Initiative have on the scope and sequence of secondary science? The hypothesis is that high schools participating in NJSSI will have significantly more change in the scope and sequence of their curriculum than those high schools that did not participate in NJSSI. Little variation existed between those districts participating in NJSSI to those that did not. As has been consistent throughout the study, those districts participating in NJSSI showed more reform efforts in Grade 9 than in Grades 10 and 11.
CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

Summary Conclusions of Research

This research study examined the influence of the New Jersey Core Content Standards in science on the scope and sequence of the high school science curriculum. The hypothesis of this study was that there would be little significant change in the scope and sequence of the high school science curriculum as a result of the adoption of the NJCCCS in science. Conclusions that can be drawn from the self-reported data suggest that science reform efforts in New Jersey mirror the conservative nature of science education found throughout the United States as documented in the case studies of Stake and Easley Jr. (1978), Cuban (1984), Tobin and Espinet (1989), and Ashwill et al (1999).

Data from this study shows that while changes were made to the curriculum, they were made within the context of the existing curriculum; perpetuating the layer-cake science curriculum that has been in place in American high schools for the past 100 years, “A major accomplishment of this period was the establishment of a definite sequence of courses that included general science in the first year of high school, followed by the specialized courses of biology, physics and chemistry in the last three years” (Bybee & DeBoer, 1994, p. 369). In this survey, 81.4 % of the respondents report
a Biology/Chemistry sequence. Thus, most of the reform reported was done within the context of the traditional secondary science curriculum.

The general resistance of education to change is no surprise. Studies done in the 1970s by Stake & Easley Jr. (1978) report the persistence of teaching styles and a resistance to change. More recent studies as those done by Tobin and Fraser (1990) and Ashwill, et al (1999) corroborate these findings. Cuban (1984) points out that classroom practice has endured for many reasons; schools are a form of social control and sorting; the organizational structure of the school and classroom drives teachers into adopting instructional practice that have changed little over time; the culture of teaching itself tilts toward stability and a reluctance to change.

Evans’ also suggests that the conservative nature of teachers and schools contributes to the resistance educational institutions to embrace change, “If anything, such change is even harder in schools than in corporations, since schools are by their very nature less entrepreneurial and more bureaucratic and since most are mature rather than new institutions”, (Evans, 1996 p. 50). Indeed, bureaucratic obstacles to changing science curriculum in New Jersey include the limitations of teacher licensing; e.g., the separate licenses for teachers of Earth Science, Biology, and the Physical Sciences make it difficult to develop interdisciplinary courses.

This study finds that much of the reform efforts that took place took place in mid-income districts; primarily by creating a new ninth grade college preparatory course for students; very few districts took an aggressive approach to reform, i.e., creating new courses in Grades 9 and 10. The overwhelming majority of districts that reported creating a new Grade 9 were those in the mid-income range. Low and high-income
districts report an even distribution of reform efforts. High-income districts reported the fewest reform efforts. Case studies done by Ashwill et al. note such resistance to change in high income districts, "Generally, teachers in high achieving schools felt that the state standards were not relevant to their students, since the majority of their students demonstrated that they were well above the state mean on the state assessment test", (Ashwill et al., 1999, p. 28). Indeed, several comments made by supervisors in the survey suggested that they would do no reform until they saw the results from an operational HSPA, which will not take place until 2002. The recent findings of the TIMSS-R study show little change in student achievement even with the onslaught of the reform efforts of AAAS, NSTA, and NSRC (Schmidt, 2000).

Analysis of data shows that the traditional sequence of courses continues to prevail; 81.4% of all districts reported a layer-cake type curriculum; in which the courses being offered to students are discipline specific. This phenomenon was perceived throughout the state regardless of the district's economic status. Biology was taught with equal frequency in Grade 9 as in Grade 10 with Chemistry being offered in the corresponding following year. A district's DFG did not significantly impact the placement of Biology; it appears with almost equal frequency in Grade 9; and is more commonly offered in Grade 10, followed by Chemistry.

Thus, the implementation of the NJCCCS in science has not had a significant impact on the typical science course sequence of the college preparatory student, regardless of the district's DFG or its participation in NJSSI. When data is disaggregated, mid-income districts do report making more changes to their curriculum than high and low income districts. One explanation for the resistance to change in high-
income districts might be due to the influence of college on the high school curriculum. Changing the curriculum in high-income districts might be viewed from the perspective of college admissions (Newman, 1988). On the other hand, pressure for schools to be accountable and to prove their effectiveness through test scores may be an impetus for mid-income districts to alter the scope of their science curriculum (Newman, 1988).

There was no statistical evidence that districts participating in NJSSI engaged in greater reform than those that did not participate. Reform efforts found throughout this study are incremental in nature and within the context of existing course offerings. It should be noted, however, that participation in NJSSI could range from enrollment in a one-day workshop to three-five year grants (Thrust II). Moreover, the survey did not examine the number of staff members participating in any NJSSI sponsored activity; nor the district’s capacity for change.

Massell, Kirst, & Hoppe’s (1997) study of standards-based reform in nine states point out that standards-based reform has made impressive gains in the recent years, despite its complexity, “Overall, local respondents often expressed concerns about the overwhelming needs for building capacity to meet the stringent demands of standards-based reform. It was another motivation for some, to deliberately choose a more incremental approach to change. Capacity remains a persistent challenge of reform”, (p.9). Massell et al., conclude that while systemic reform has made impressive gains in recent years, teachers need access to richer opportunities on an ongoing basis, and they need direction and support from central office staff, “Yet, these administrator are often pivotal conduits for reform, interpreting its substance and providing – or not providing, as the case may be – both organizational structures and resources that affect whether and
how reform policies are translated into school and classroom practices." (p. 9). A
district’s participation in NJSSI may be equally dependent upon the knowledge base of
the administration of that school district regarding science reform and systemic change.

NJCCCS Influence on the Scope of College Preparatory Courses

The data measured changes to the scope of science courses in two ways – kinds of
changes to courses and within specific courses. Again the conservative nature of school
is demonstrated by the data on changes in scope of courses. Fifty-five districts responded
that they had done no change to their college preparatory curriculum; that response was
evenly distributed by DFG and NJSSI. Eighty-two districts responded that they had
implemented some change to their curriculum.

The study found that changes in scope were made within the context of existing
courses. Districts were more likely to change the scope of courses in Grade 9 than in
Grade 10 and 11, which reflects the wider variety of courses offered in Grade 9 than in
Grades 10 and 11, and the conservative nature of educators as noted throughout this
study.

While change to the scope of courses was noted, the most often noted change was
a change of text. Teachers’ heavy reliance on textbooks has long been noted (Schmidt &
Wang, 1999; Cuban, 1984; (Stake & Easley Jr., 1978). Knapp points out that curricular
changes are often dependent upon the text being used, “The textbook is indisputably
central to Mr. Burch’s (Mathematics,) teaching. Therefore, Mr. Burch’s practice may at
times reflect elements of the reforms to the extent that the new text series itself embodies
them" (Knapp, 1997, p. 15). Reliance on the text, however often varies with the competency of the teacher (Tobin & Fraser, 1990). Such change is superficial in nature and provides little evidence of broad systemic reform. Moreover, today’s textbooks do not reflect the current nature of science. Hurd tell us, “The majority of science textbooks commonly used in grades K-12 are history books; their goals and standards are unlike today’s sciences” (Hurd, 2001, p.59). Thus changes in textbooks do not reflect substantive reform efforts.

For reform to be meaningful it must extend beyond texts otherwise it is likely to become a low level of reform in both quality and quantity “Approaching the improvement of science education by changing textbooks, buying new computers, or adding new courses simply will not work” (Bybee, 1995, p. 17).

Other changes to the scope of courses were noted, however. These changes reflected an increase in physical science in Grades 9 and 10, which would address the issues raised by Schmidt, et al.; that the discipline-centered science curriculum in the United States offers students less opportunity to delve in depth in the physical sciences (Schmidt et al., 1997). This increase in physics and chemistry occurred throughout the state, regardless of a district’s DFG. The increase of physics and chemistry in Grades 9 and 10 indicate more robust science courses.

Data from this study also found that the scope of Biology courses has also changed as a result of the NJCCCS in science. These results reflect the findings of Porter, Kirst, Osthoff, Smithson & Schneider (1994), which found that higher standards resulted in more high school students receiving more worthwhile mathematics and science instruction.
Unlike Biology, it appears that the scope of Chemistry has changed little since the implementation of the NJCCCS in science. Atkins, et al. (1997) point out that a current debate among high school science teachers is the purpose of teaching science. Many traditional Chemistry teachers teach high school Chemistry to produce future scientists. As such, changes to the scope of the curriculum or the implementation of new programs such as ChemCom are often viewed as not adequately preparing students for further study in chemistry. An earlier study by Razali and Yager (1994) show that high school Chemistry teachers were persistent in their support of the study of specific topics in chemistry as a means of preparing their students for college. Interestingly, however the study found that college professors were more interested in the personal traits of their students than in their general knowledge of chemistry. The authors point out,

The difference in the perceptions concerning the importance of chemistry knowledge as preparation for the study of chemistry in college as perceived by high school chemistry teachers and college chemistry instructors is the most striking result arising from this study. Teachers who are confident that the content they teach is important as preparation for college are, in fact, teaching something that college professors do not expect the incoming students to possess (p744).

Physics too has shown little change in scope since the implementation of the NJCCCS in science. As with Chemistry, changes to Physics, such as those proposed by Lederman (1999), were not incorporated by many districts throughout the state.

The resistance of these two subject areas to change may also be reflected in the self-concept and informal hierarchy that exists in high schools today. Anderson, Anderson, Varanka-Martin, Romagnano, Bielenberg, Flory, Mieras, & Whitworth, (1994), report that self-concept is a factor that may need to be addressed to accommodate
real curricular change. They suggest that this self-concept harkens back to the issue of occupational identity,

Some areas of science, for example, appear to be held in greater or lesser regard, often based on the rigor of the discipline and the mathematical requirements to succeed in that discipline. A perceived, but persistent hierarchy of science disciplines, and therefore, science teachers exists. Physics teachers are viewed at the pinnacle, with chemists a close second, and teachers of biology at the lower rung. (p.30)

The present teacher shortage and the difficulty of finding qualified physics and chemistry teachers only adds to this perceived hierarchy. Anderson et al., point out that this perceived hierarchy has significant implications for curricular reforms that endeavor to integrate disciplines, or where more attention is given to the application of science to societal issues, as supported by the reform movements of the NSTA and Project 2061.

Thus it would seem that the NJCCCS in science has had some influence on the scope of science courses; much of its influence may be superficial as evidenced by the majority of districts reporting only changes to texts; other influences include changing the scope of courses in Grades 9 and 10 by the addition of chemistry and physics to those courses as well as a change in the scope of Biology courses as evidenced by the addition of biology topics in Grades 9 and 10. These latter changes would appear to be more substantive; thereby increasing the opportunity for students to learn physics and chemistry, two areas in which United States students have consistently demonstrated poor academic achievement in both international and national assessments.
Influence of NJCCCS in Science to High School Science Curriculum

Data from this study shows that the NJCCCS in science has not had a significant influence on curricular reform in New Jersey. Although a high-stakes graduation test can leverage change, districts, by and large exhibit a conservative approach to change. This conservative approach may be a prudent one, when one looks at the state's present structure for licensing science teachers – one that supports discipline-based instruction. Moreover, the current standards in science have been reviewed and revised; early reports indicate significant changes to the standards, which will result in changes to the science portion of HSPA. Once again, the cyclical nature of educational reform seems to be rearing its head. This type of rhetoric and political change encourages nay-sayers and those that resist curricular reform to wait out any current reform effort. As Evans (1996) puts it, “Public sector institutions rarely experience such focus and clarity, in part because they are caught between the demands of multiple constituencies” (p. 75). Indeed, schools are faced with a plethora of reform efforts with little funding to support them. The question, then, becomes one triage; which reform effort first?

Darling-Hammond and Ball (1999) note that reform strategies that do not make substantial efforts to improve teaching have been much less. Thus, while the implementation of higher standards has made some difference to the college preparatory science curriculum, the differences appear to reflect the conservative nature of school; a resistance to change, and perhaps a lack of understanding by key administrators for the need for curricular reform. A district’s economic status seems to have little to do with its
overall responsiveness to reform. NJSSI appears to be quite successful in providing school districts with professional development models, primarily in the form of workshops. Few secondary schools have taken advantage of long-term partnerships with NJSSI regional centers, which is not surprising given the conservative nature of high school (DeBoer, 1991).

Suggested Studies for Further Research

A study that examines whether the implementation of the NJCCCS in science has had a greater or lesser influence on courses offered to students in different tracks would be worthwhile. The study of Ashwill, et al (1999) notes that in general, instruction in low track classes tend to deal with simplified topics and focus on rote skills. It would be helpful to compare the scope of science courses offered to general studies students to those offered to college preparatory students, and honor students. The study could compare whether physics and chemistry have been added to Grades 9 and 10 and whether Biology has been modified as school districts in this study reported. It would also be beneficial to see whether the Biology/Chemistry sequence is found in the general studies course sequence and whether evidence for reform occurred within the context of existing courses, with more course changes being made in Grade 9 than in Grades 10 and 11 or with the development of new courses.

Opportunity to learn is a key factor in any reform movement (Firestone & Camilli, Yurecko, Monfils, Mayrowetz, 2000; Flaxman, 1998). Several schools reported that they did not require a specific science course in Grade 11, rather students were
required to take a third year of science. If one considers opportunity to learn important to reform movement as do Firestone and others such as Schmidt and Raizen, it would be useful then to examine the types of 11th grade science courses offered and the distribution of students taking those courses within a school population to see the frequency with which students take courses that include physics as compared to courses that have a preponderance of biology. Disaggregating the data by DFG would also be worthwhile.

Furthermore, it would be beneficial to see whether the course sequence for urban students impacts their SAT scores, as compared to the 1999 ACT study done by Lewis, Williams, Naik, Schmeiser, Duval, Ziomek & Hayden, (1999) and the study done by O’Sullivan, Weiss and Askew (1998). Such a study would compare the SAT or NAEP scores to youngsters taking a Biology, Chemistry, Physics sequence as compared to those students taking a sequence that includes general science. Such a test might reinforce the findings of Ashwill et al., that science courses in lower tracks tend to deal with simplified subjects.

Comparing state and national science achievement scores from those districts that offer physics to first year students might test Lederman assertion that a sound understanding of physics is possible when offered in Grade 9. It would be valuable to compare those students test scores the scores of comparable students that take a more traditional sequence of courses, that is, taking physics in their third year of high school.

One question pertinent to a district’s willingness to change may be its perception of a having a successful science program. Gardner and others assert that successful students often show little understanding of science (Gardner, 1991). The video, “A Private Universe” provides compelling evidence to that point (Shapiro, et al., 1987).
would therefore, be interesting to compare the district’s perceived success to the scientific understanding of its students. Such a study might include surveying districts and competitive colleges on their perception of the characteristics of a successful science program. Student performance could then be used to compare the perceived success against a more objective measure. This perception of success may also be attributed to a lack of understanding of science reform. Massell et al. (1997) indicate that central office is a key factor in promoting systemic change. It is conceivable that many science administrators do not agree with Bybee and DeBoer (1994) that the present science curriculum does not adequately prepare youngsters to be scientifically and technologically literate. As such, it would be worthwhile to examine the knowledge base of science administrators and their role in leveraging science reform. Given the turnover of administrators, that study might be a longitudinal one that follows the administrator, rather than the district.

The past decade has seen a call for higher standards both by politicians and scientists. Science literacy is clearly important for our economic success as a nation, even more so after the events of September 11, 2001. Systemic reform comprises a complex set of changes that must occur simultaneously if they are to be successful and sustainable. Higher standards must be coupled with meaningful, long-term professional development; teachers must be knowledgeable in their content area; and the taught curriculum should engage students, be relevant, and model the nature of science. Any one of these changes is difficult; all of them together create a daunting task to policy makers as well as to classroom teachers.
The NJCCCS in science are aligned to national science standards and reflect the need for science literacy for all students. Reform efforts address issues of equity as well as content. The conservative nature of education, particularly secondary education is reflected in the reform efforts found in this study. While change has indeed taken place; it has done so within the context of the existing curriculum. Students throughout the state are taking more science courses and those courses have more physics and chemistry in Grades 9 and 10 than ever before. Changes to the sequence of course offerings faces a much greater challenge – changes in state licensing of science teachers, a change among teachers of the hierarchal order of science courses, and a willingness to consider that discipline-based science courses may no longer reflect the present nature of science.

Many of the decisions that needed to make these curricular changes require science administrators who understand the complexity of change and leadership. Administrators need to understand the dynamics of change and the actions required to effect systemic change. A study comparing the leadership styles of those school districts that have implemented successful, inquiry-based science programs aligned to national and state standards to those who have done little change to their curriculum would help science administrators understand what skills and attributes are needed to effect change and how to best approach the complex problem of systemic reform.

Finally, no change takes place unless it impacts the teacher. As Weiss’s study shows (1997) teachers often think they are implementing instruction that aligns to standards, when they are not. A study examining the impact of changing teaching methodologies and instructional strategies of the new NJCCCS science standards would
provide information about whether the standards are making significant changes to
instruction.

Recommendations for the Schools

After reviewing the data from the study, it appears that districts have begun to
infuse more physical science into their present course offerings. The present course
sequence remains relatively unchanged. In order for students to receive meaningful
instruction in the physical sciences, more physics should be integrated throughout the
curriculum. This could take place by creating integrated courses in Grades 10 and 11, but
it would seem unlikely from the data collected. Another strategy might be to look for
ways to further integrate Grade 9 courses, using the NSTA SS&C approach of
developmentally appropriate themes. In addition, low and high-income districts might
want to analyze the reform efforts of middle-income districts that appear to have created
more integrated courses in Grade 9 than the other two districts.

Districts and industry might wish to create partnerships with NJSSI to develop
opportunities for staff development at the secondary level for teachers and supervisors
that focused on current research that continues to blend science disciplines.

Finally, the New Jersey Department of Education might wish to consider
changing its certification requirements for secondary science teachers. The present
system is a barrier to integration since teachers must be certified by discipline. A
comprehensive certification could leverage integration in two ways: it would provide
opportunities to certify alternate route candidates who may have a diverse scientific
background, rather than in one concentrated field and secondly, it would allow districts to develop interdisciplinary courses. The present certification makes it difficult for teachers certificated in one discipline, i.e., Biology to teach courses such as Biochemistry or Biophysics.
References


Dudley, A. (personal communication, February 18, 2001)


__________. (1998b). Directory of test specifications and sample items for the grade eight proficiency assessment (GEPA) and the high school proficiency assessment (HSPA) in science.: New Jersey Department of Education.


Appendix A

Survey Instrument
1. Please circle your district’s District Factor Group.
   A  B  CD  DE  FG  GH  I  J

2. What year did you institute your 3 years of science graduation requirement?

3. What courses are required at each grade for your College Preparatory Students?.
   Grade 9:                                        Grade 10:                                        Grade 11:

Additional Comments:

4. Please check all of the following phrases that describe ways that the implementation of the New Jersey Core Content Standards influenced the sequence of science courses required for your College Preparatory students?
   □ No change; sequence has remained the same
   □ Moved Biology to Grade 9
   □ Created a new Grade 9 course; sequence for Grades 10 and 11 remain the same
   □ Created new courses in Grades 9 and 10 course; sequence for 11 remains the same
   □ Changed Grade 8 course to accommodate new sequence for HS
   □ Additional changes:

5. Has your district ever participated in the New Jersey Statewide Systemic Initiative (NJSSI) activities?
   □ Yes □ No

   If your answer to Question #5 is YES, please answer Questions #6. If your answer to Question #5 is NO, please go directly to Question #8.

6. Circle the grade levels in your district that have been involved with NJSSI?
   K  1  2  3  4  5  6  7  8  9  10  11  12
   Additional Comments:

7. Describe the type of NJSSI activities in which you have been involved.
   □ Thrust I  What years? _______  What grades? _______
   □ Thrust II  What years?_________
   □ Workshops
   □ Standards Implementation Grant  What years? _______What grades?____
   □ Other:
Please answer the questions below about your Grades 9, 10, and 11 courses.

<table>
<thead>
<tr>
<th>GRADE 9 COURSE</th>
<th>GRADE 10 COURSE</th>
<th>GRADE 11 COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Title:</td>
<td>12. Title:</td>
<td>16. Title:</td>
</tr>
<tr>
<td>9. Date of Board Approval</td>
<td>13. Date of Board Approval</td>
<td>17. Date of Board Approval</td>
</tr>
<tr>
<td>If more than 4 years ago please answer question # 11</td>
<td>If more than 4 years ago, please answer question # 15</td>
<td>If more than 4 years ago, please answer question # 19</td>
</tr>
<tr>
<td>10. Please check all the statements that best describe your course revisions in each grade:</td>
<td>14. Please check all the statements that best describe your course revisions in each grade:</td>
<td>18. Please check all the statements that best describe your course revisions in each grade:</td>
</tr>
<tr>
<td>- Requires new text</td>
<td>- Requires new text</td>
<td>- Requires new text</td>
</tr>
<tr>
<td>- Added additional physics</td>
<td>- Added additional physics</td>
<td>- Added additional physics</td>
</tr>
<tr>
<td>- Added additional biology</td>
<td>- Added additional biology</td>
<td>- Added additional biology</td>
</tr>
<tr>
<td>- Added additional chemistry</td>
<td>- Added additional chemistry</td>
<td>- Added additional chemistry</td>
</tr>
<tr>
<td>- Added additional earth science</td>
<td>- Added additional earth science</td>
<td>- Added additional earth science</td>
</tr>
<tr>
<td>- Completely revised the course; new content being offered</td>
<td>- Completely revised the course; new content being offered</td>
<td>- Completely revised the course; new content being offered</td>
</tr>
<tr>
<td>Other revisions</td>
<td>Other revisions:</td>
<td>Other revisions:</td>
</tr>
<tr>
<td>11. If more than 4 years ago, when do you anticipate doing a revision:</td>
<td>15. If more than 4 years ago, when do you anticipate doing a revision:</td>
<td>19. If more than 4 years ago, when do you anticipate doing a revision:</td>
</tr>
<tr>
<td>- Before next academic year</td>
<td>- Before next academic year</td>
<td>- Before next academic year</td>
</tr>
<tr>
<td>- During next academic year</td>
<td>- During next academic year</td>
<td>- During next academic year</td>
</tr>
<tr>
<td>- Within next 2 years</td>
<td>- Within next 2 years</td>
<td>- Within next 2 years</td>
</tr>
<tr>
<td>- Not currently planned</td>
<td>- Not currently planned</td>
<td>- Not currently planned</td>
</tr>
</tbody>
</table>
Use the scale below to describe the percentage of each science discipline included in your current Grade 9, 10, and 11 College Preparatory classes.

<table>
<thead>
<tr>
<th>a.</th>
<th>b.</th>
<th>c.</th>
<th>d.</th>
<th>e.</th>
<th>f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10%</td>
<td>11-25%</td>
<td>26-50%</td>
<td>51-75%</td>
<td>76-90%</td>
<td>91-100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>20. GRADE 9</th>
<th>22. GRADE 10</th>
<th>24. GRADE 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>Biology</td>
<td>Biology</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Chemistry</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Earth Science</td>
<td>Earth Science</td>
<td>Earth Science</td>
</tr>
<tr>
<td>Physics</td>
<td>Physics</td>
<td>Physics</td>
</tr>
</tbody>
</table>

21. Did percentages change as a result of your latest course revision?
☐ Yes ☐ No

23. Did percentages change as a result of your latest course revision?
☐ Yes ☐ No

25. Did percentages change as a result of your latest course revision?
☐ Yes ☐ No

26. **Additional comments.** Please use this space, or the back of this paper to describe any other reform efforts you have done in College Preparatory science courses as a response to the implementation of the NJ Core Curriculum Content Standards in Science.

Thank You
Appendix B

Recruitment Letter to Science Administrators to participate in the survey of the New Jersey Core Science Standards Influence on the Scope and Sequence of the High School Science Curriculum
Tena Wright  
367 South Union Avenue  
Cranford, New Jersey, 07016  
908-276-1273  
wright367@home.com

March 2001

Dear Science Administrator:

I am a doctoral student in the College of Education and Human Services at Seton Hall University. My doctoral dissertation research explores the influence of the New Jersey Core Science Standards on the scope and sequence of the high school science curriculum.

I am asking all New Jersey Science Administrators to complete the enclosed 26-question survey. Your participation will help science educators to better understand the influence of the content standards throughout the state, thus your input is most important. Your participation is completely voluntary and your anonymity will be protected. You may withdraw from the study at any time. Data provided by you will be handled with the strictest of confidentiality. The responses of all school districts will be combined in the presentation of the data. No individual science department or school district will be identified in the study.

The enclosed survey should take you no more than 20 minutes to complete and I have enclosed a stamped return envelope for your convenience. Please do not put your name or any other identifying information on the survey.

I would appreciate your completing the survey and returning it to me within the next three weeks. Please inform your superintendent of your participation in this study. Your completion and return of the survey indicates your understanding of the project and your willingness to participate.

Upon your request, I will gladly provide you with the aggregated results of the completed study. I am available to address any questions you may have about the research or your district’s rights as a research subject.

The project has been reviewed and approved by the Seton Hall University Institutional Review Board for Human Subject Research (IRB). The IRB believes that the research procedures adequately safeguard the subject’s privacy, welfare, civil liberties, and rights. The Chairperson of the IRB may be reached through the Office of Grants and Research Services at 973-275-2974.

Thank you for your time and consideration in this matter.

Very truly yours,

Tena R. Wright