National Science Education Reform and its Effect on Science Education Reform in North Carolina

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NATIONAL SCIENCE EDUCATION REFORM AND ITS EFFECT ON SCIENCE EDUCATION REFORM IN NORTH CAROLINA

THESIS

Submitted to the Graduate Committee of the Department of Education and Human Development
State University of New York
College at Brockport
in Partial Fulfillment of the Requirements for the Degree of Master of Science in Education

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ABSTRACT

Purpose

The purpose of this paper is to give a historical background of the progress of elementary science education reform from a national perspective and to then show the impact of that reform on North Carolina’s efforts towards elementary science education reform. A comparison is made between the National Research Council’s 1996 publication of the National Science Education Standards and North Carolina’s 1994 publication of the new Standard Course of Study: Science K-12. The comparison shows that North Carolina has made an effort to incorporate the national vision of science education reform into its own vision of science education reform.
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CHAPTER ONE

Introduction

In the last twenty years, educators, scientists and government officials have worked together for the purpose of reforming science education standards. They have undertaken this effort with a realistic approach and with the understanding that true reform will take many years and will require a complete overhaul of the many components of an educational system. Within the last ten years, science education reform has become the focus of much attention with the publication of Science for All Americans in 1989 (the first report of the American Association for the Advancement of Science's Project 2061), Benchmarks for Science Literacy in 1993 (the second report of Project 2061), the passing of Goals 2000: Educate America Act on March 31, 1994, and the most recent publication of the National Standards for Science Education in 1996. With national standards in place, state governments now have the opportunity to use the national reform as a springboard into state reform. This paper will provide a historical overview of reform on the national level within the last twenty years and compare the national progress with the science education reform of North Carolina.
The awareness of the current need for reform of science education in the United States came into focus in the early 1980's. Science education was not keeping up with the rapid emergence of new technologies. Society was shifting to a science and technology base. Rodger W. Bybee discusses this shift by stating that:

Science and technology are recognized as lying at the center of the current shifts in our society. Education in the sciences and technology essential for living and adapting in the next century will require new goals, curricula, and instructional procedures. There is a consensus that the traditional programs of science education, which have endured for the past 200 years, should be reconceptualized.

(1993, p. ix)

Educators, scientists, and government officials began to realize that American students were leaving school unequipped to compete in a technological society. The competitive future of the nation was in question. This emerging reality added a sense of urgency to the cause of science education reform. The realization that the longer the country waits to reform science education, the greater the task will be:
Achievements in science and technology have led to a global economy that is rapidly giving rise to a world community. The competitive position of any society today rests primarily upon its ability to produce and make use of the knowledge generated in the sciences and technology. The primary assets of a nation are no longer natural resources and brawn, but rather the production and utilization of knowledge. (Bybee, 1993, p. xi)

The United States has made great progress in initiating science education reform. Now the difficult task of implementation will begin. Effective state programs of science education reform will be necessary in order for the vision of the national reform to be realized. North Carolina has begun to answer the challenges set forth in the national science education reform. North Carolina has begun to initiate several programs inspired by national reform and has completely revised its standard course of study in order to align with the national vision of science education reform established by Goals 2000 and Project 2061. North Carolina's educational system has much catching up to do. According to the 1992 Report to the Citizens of North Carolina North Carolina 2000: A Plan for Action, North Carolina ranks among the lowest in student achievement on
the National Assessment of Educational Progress and The Scholastic Aptitude Test; among the highest in drop out rates; among the lowest in math and science scores; and among the lowest in healthy children (p. 1).

In this paper, a historical context for discussing the progress of science education on the national level and an evaluation of the effect the national reform has had on North Carolina science education reform will be provided. By using North Carolina as an example of a state that has reached its crisis point in education, the paper will evaluate and assess how successful North Carolina has been in establishing a plan for science education reform and how that plan measures up to the national standards recently established.
Literature Review

The National Council on Science and Technology Education in conjunction with the American Association for the Advancement of Science (AAAS) appointed a group of scientists and educators to begin the work that would eventually be known as Project 2061. The AAAS initiated the plan Project 2061 in 1985 with the idea that science education reform would be a long task requiring long-term commitment. In 1989, AAAS published the first report of Project 2061: Science for All Americans. The report states that America has an urgent need for reform of science, math, and technology education. The report states that concisive reform is need because the nation is indecisive in how to prepare young people for a competitive, technology based society. The goal of science education, according to the report, should be scientific literacy for all American children. The report contains proscriptions for basic learning goals for America's children.

In 1993, AAAS published Benchmarks for Science Literacy. The Project 2061 benchmarks are exact statements of what students should know by the end of Grades 2, 5, 8, and 12. If a students meets the goals established in benchmarks, the student will attain the goal of scientific
literacy that is described in Science for All Americans (SFAA). The goal of benchmarks is to establish curriculum guidelines that will align with SFAA. In establishing the curriculum guidelines, these benchmarks give state agencies a model for curriculum design that will align with national standards of science literacy.

SFAA and benchmarks are the substance of Project 2061 at the present time. Much has been written in the last few years discussing and debating the success of Project 2061’s efforts. In 1992, The National Association of Elementary School Principal published an article by G. Robert Moore and Peggy Moore discussing the implications of Project 2061. The article voices the almost unanimous support of Project 2061, but recognizes the enormous task of implementation at the local level. The article also details the realistic concerns that administrators and educators must investigate in order for reform to be successful.

Andrew Ahlgren, Associate Director of Project 2061, published a concise summary of Benchmarks in 1993 in Educational Leadership. In this article, Ahlgren states the purpose of benchmarks and their relevance to certain grade level assessment. Ahlgren emphasizes the importance of benchmarks being developmentally appropriate and relevant for a child.
Benchmarks should progress smoothly from grade to grade giving students a gradually more sophisticated understanding of scientific concepts.

Recently, Millicent Lawton published an article in Education Week titled "Project 2061 Puts Big Mark on Curriculum" (1996). In this article, Lawton gives a current assessment of the impact of Project 2061 on state education reform. Citing statistics provided by SRI International, the article gives a clear vision of the impact that Project 2061 has made on curriculum development at the state level. While the article gives a positive review of Project 2061 and its two publications, the article raises some criticisms about the expectations of benchmarks established in Project 2061's most recent publication and the realistic concerns surrounding the difficulty of classroom implementation for many educators.

On March 31, 1994, President Bill Clinton signed Public Law 103-227 (Goals 2000: Educate America Act). Goals 2000 established eight National Education Goals to be in place at the national, state, and local level by the year 2000. In the same year, the Educational Resources Information Center published a summary of Goals 2000. The summary details the purpose and objectives for each of the eight goals. In 1995, the Educational Resources Information Center published a progress report for Goals 2000.
The report focused on the partnership between the federal government and state governments in achieving the goals.

The most recent publication cited as relevant to Goals 2000 is the April 30, 1996, Report to Congress published by the U.S. Department of Education. The overall tone of the report is positive. The report states that, as intended, state governments have designed their own goals and strategies for achieving those goals. The report provides statistics from selected states where students are showing achievement gains. The report also finds that educators have learned from the business world that success stems from clear, concise statement of goals. The report states that state governments have appropriately used the national Goals 2000 as a model for establishing their own goals for student achievement and for a curriculum design which will help promote student achievement.

Another recent advancement in national science education reform is the publication of the National Research Council's "National Science Education Standards" (1996). The National Research Council (NRC), an agency of the National Academy of Sciences and the National Academy of Engineering, published a final version of the National Science Education Standards (NSES) after five year of research and collaborations between
thousands of teachers, scientists, and government officials. The 262-page document is a comprehensive set of standards for science education K-12. Most reviews at this point are favorable; however, it is not without criticisms.

Robert Donmoyer of the National Center for Science Teaching and Learning published a critique of the proposed standards in 1995. Donmoyer's article discusses the pitfalls of systemic reform in something as enormous as national educational standards. Donmoyer explores the difficulties with moving from political rhetoric to a practical reality.

Another national program which has been adopted and used as a model for science curriculum design is the Scope, Sequence and Coordination (SS&C) reform set forth in 1989 by the National Science Teachers Association (NSTA) as a plan submitted to the National Science Foundation (NSF). The plan outlined a science education plan for grades 6-12. In 1990, North Carolina was awarded a 3 year grant to become a project site. The National Clearinghouse for Mathematics and Science Education published a report on the status of SS&C in 1996. The report features North Carolina's adoption of the reform program. The report offers
statistics showing that North Carolina educators found implementation of
the SS&C plan effective and successful.

North Carolina's recent reform in science education was discussed in
report was published by the Governor's Office of North Carolina. The
details the monumental task that educators and administrators will face in
implementing and achieving the educational goals. The report emphasizes
the importance of science education reform and technology education as a
necessary component of science education.

In 1994, North Carolina published a new Standard Course of Study
specifying new standards for science education in the state. The new
standards were published by the North Carolina Department of Public
Instruction. The Standard Course of Study for science will be compared
with the National Science Education Standards recently released by the
National Research Council.

The New ABCs of Public Education (1995) is the result of legislation
by the North Carolina state government that is aimed at making individual
schools accountable for student performance. The plan directed the State
Board of Education to reorganize public schools in North Carolina so that Higher educational standards could be attained. The present paper will use the New ABCs of Public Education to show the direction that North Carolina is taking in improving education standards in the state.

The recent publications of science education reform both at the state and federal level show, at least, a written commitment to the advancement of higher educational standards in science education. This paper will evaluate the recent publications in order to present a clear vision of the national standards for science education. This paper will also use these recent publications to compare and contrast the federal standards with the new science education standards of North Carolina.
CHAPTER TWO

Historical Perspective: National Science Education Reform: 1983-Present

April, 1983: A National at Risk: The Imperative for Educational Reform
Published by: The National Commission for Excellence in Education.

June, 1985: Project 2061, Published by the National Council on Science and Technology Education.

Feb., 1989: Science for All Americans, The first report of Project 2061

Sep., 1989: Educational Summit in Charlottesville, VA
President George Bush meets with nation's governors
Strategy for goals 2000


April, 1996: U.S. Department of Education releases a report to Congress on the Success of Goals 2000

1996: National Research Council releases final draft of National Science Education Standards.
The need for science education reform began to receive national attention in the early 1980's. The 1983 publication of *A National at Risk* was a catalyst for reform that has continued to present. In publishing *A Nation at Risk* the National Commission on Excellence in Education issued a warning of educational crisis. The report concluded that American students were not performing well on an international level. This suggested that America was losing its competitive edge, and its status as world leader in economics and technology, was being threatened internally by its own deteriorating educational system.

The findings of this and many other reports created a climate of urgency regarding national education reform in science, mathematics, and technology. The American Association for the Advancement of Science (AAAS) published a report on science education reform in 1995. In the report, the climate of reform of the 1980's is discussed:

Many reports on education also alluded to the nation's decline as an economic and technological world leader, implicitly (and at times explicitly) linking this decline to the failures of the educational system. Taken up by the media, the reports impressed upon educators
and the general public the importance of improving education—especially science and technology education—to prepare students and the nation to compete in a high-tech world. This climate inspired numerous reform projects in the 1980s and early 90s. (p. 7)

Project 2061

AAAS saw the need for a large-scale project that would work to create long-term solutions for the problems of the educational system. In June 1985, AAAS launched a project with the goal of creating science, mathematics, and technology education reform that would last into the next century. The significance of the timing revolved around the appearance of Haley’s comet in 1985 which will not be seen again until the year 2061. Therefore, AAAS named the project: Project 2061.

AAAS appointed a distinguished group of scientists and educators to begin the work of drafting a proposal for educational reform. The group was known as the National Council on Science and Technology Education (NCSTE). In 1989, NCSTE released the first report of Project 2061: Science for All Americans. The goal of the report was not to outline the problems of the current ideas surrounding science education; but rather, the
report revolved around the idea of scientific literacy. The purpose of the report is stated in the following quote:

Science for All Americans, the first report of Project 2061, has little to say about what ails the educational system, points no finger of blame, prescribes no specific remedies. Rather, its basic purpose is to characterize scientific literacy. Thus, its recommendations are presented in the form of basic learning goals for all American children. A fundamental premise of Project 2061 is that the schools do not need to be asked to teach more and more, but to teach less so that is can be taught better. Accordingly, the recommendations given in Science for All Americans form a common core of learning are limited to the ideas and skills that have the greatest scientific and educational significance. (p. 3-4)

The report outlined a three phase plan for action. Phase I will emphasize the need for a unified definition of what scientific literacy means. Phase II will involve the development of various curriculum models for states to use in developing their own curriculums. And Phase III will be an on-going, long-term effort to combine Phase I and Phase II so that the whole
naton can move towards an educational system that will promote scientific literacy for all.

AAAS outlines four major steps that will be necessary in order to realize the goal of scientific literacy:

1. Develop a new curriculum model.
2. Improve teaching of science, mathematics, and technology.
3. Develop understanding of what it will take to achieve a lasting reform.
4. Form a collaboration of effort on many levels.

The underlying intent of the report is to clarify goals for scientific literacy in the U.S., giving states a clear model for curriculum design. The report states the importance of changing school curricula from kindergarten through twelfth grade so that science education emphasizes scientific skills that have the greatest significance in achieving scientific literacy, and one which pays more attention to the connection that exists between science, mathematics, and technology.

In 1992, the National Association of Elementary School Principals published an article by G. Robert Moore and Peggy Moore discussing the impact of Science for All Americans. While few can debate the message of
Project 2061, the article suggests the difficulty in realizing the goals of Project 2061:

   Elementary school principals who agree with the premise of Project 2061 must find answers to the question, "How do you ensure that science becomes an integral part of the elementary school curriculum?" A recent survey showed that less than 30 percent of elementary school teachers felt confident teaching science, compared to approximately 80 percent who felt confident teaching reading.

   (p. 1)

The article goes on to discuss the importance of staff development and support. Implementation of the goals of Project 2061 will never be reached until educators are trained adequately and supported with curriculum that is based on the ideas of scientific literacy.

   In order to address the many concerns surrounding implementation of Project 2061 and its effect on curriculum reform, the AAAS published an article in 1992 discussing the reality of reform. The article offers realistic suggestions to schools and educators. AAAS suggests that educators need to begin to move towards emphasizing inquiry skills in class work, move away from textbooks and worksheets, and reduce the divisions between
science, technology, and mathematics in the learning process. AAAS also suggests that schools should work together in holding seminars to examine the recommendations of Project 2061. The article recognizes the challenge that reform brings:

The task ahead of us is monumental. The needed reform of science, mathematics, and technology education will take the best and long-term efforts of all of us. To have our collective contributions add up to progress toward reform, however, we must pull in more or less the same direction. For now, Science for All Americans provides a guiding light. Before long, SFAA will be joined by related benchmarks, models, blueprints, database, and other reform tools to expedite your work. (p. 30)

AAAS held true to this promise by publishing Benchmarks for Science Literacy in 1993. Using the ideas of Science for All Americans, Benchmarks was published as a tool that states and school districts could use for curriculum reform and design. Andrew Ahlgren, Associate Director of Project 2061, published an article in Educational Leadership stating the goals and rational behind the creation of Benchmarks:
We intend the benchmarks to be used by school districts or curriculum developers in constructing alternative K-12 curriculum models adapted to their own populations and circumstances. In crafting the lower-grade expectations, we drew partly on an analysis of what ideas would be needed to achieve the 12th-grade understandings in Science for All Americans. We also considered estimates of what students are capable of at different ages, drawing information from the experienced teachers on our district teams and from researchers who study how children understand and learn science. (1993, p. 46)

In 1995, AAAS published an update on the status of Project 2061 and its two reports. The article stated that Benchmarks was receiving very positive reviews from educators, scientists, and the general public. By setting benchmark goals for the end of grades 2, 5, 8, and 12, Benchmarks successfully mapped the progress required for a student to complete grade 12 with a scientific foundation necessary for scientific literacy.

The success of Project 2061 is discussed by Millicent Lawton in a 1996 editorial in Education Week. Lawton cites research conducted by SRI International which was released in November, 1996. SRI polled 39
respondents representing 27 states, including state science supervisors, leaders of NSTA-affiliated state professional associations, and curriculum framework writers. The report showed that 90 percent of the respondents were using Benchmarks for Science Literacy and that 64 percent of the respondents were using Science for All Americans. The report showed that the most overwhelming use of Benchmarks at the state level was in curriculum development and planning of professional development for educators. Lawton cites SRI as stating that:

    Project 2061's broad influence demonstrates its positive contribution to the national climate for science education reform...Project 2061 wove these concepts together into one coherent, comprehensive, compelling vision of science literacy and disseminated the unified vision to a greater number of communities and audiences than ever before. (p. 22)

However, the SRI report did reveal some questions that are plaguing educators regarding Project 2061 and its Benchmarks for scientific literacy. The foremost concern revolved around the project's ability to impact the daily classroom activities, and the feasibility of having students achieve the goals established by the Benchmarks. Educators question the validity of
Benchmarks at all in a curriculum that revolves around inquiry-based education. Also educators complained of the textbook lag that seems to exist. Textbooks do not appear to be complying with the "less is more" philosophy of Project 2061. Lawson culminates the article be quoting F. James Rutherford, the director of Project 2061. Rutherford states that the goal of Project 2061 at this point is not to mandate classroom practices or materials, but rather to give direction to the entire community of educators and curriculum designers and publishers. (p. 22)

Goals 2000

National education reform has also progressed on another front. In 1989, President George Bush called for an educational summit. The summit was held in Charlottesville, VA and involved a meeting between President Bush and the nation's governors. The summit was led by, then governor of Arkansas, Bill Clinton. It was a call to action for federal mandating of the need for national education reform that would be carried out at the state and local level. The result of the summit meeting was the formation of the National Education Goals, which would later be known as Goals 2000. The eight educational goals spelled out the national standards for education that every state could use as a guide for curriculum design and assessment.
standards. The fourth goal challenged U.S. students to become world leaders in science and mathematics achievement.

The passing of "Goals 2000: Educate America Act" took place on March 26, 1994, shortly after midnight. There was an April 1, 1994, deadline established by Congress for the signing of the bill in order to receive the $125 million appropriated for funding. The debate over the bill occurred along party lines with Republicans opposing and Democrats favoring. However, with a Senate vote of 63-22, the $400 million bill passed and President Bill Clinton signed it on March 31, 1994. While the bill does establish eight national educational standards, the bill also paved the way for educational reform at the state level. Goals 2000 established a 19-member council known as the National Education Standards and Improvement Council (NESIC) which will oversee the development of a curriculum content model. Any state agreeing to participate in Goals 2000 will be able to use NESIC's curriculum model as a guideline for establishing state standards. "States can either adopt the national standards or use them as a guide to set their own standards, which would have to be at least as rigorous as the NESIC standards" (Wells, 1994, p. 804).
Goals 2000 allocates $400 million in state aid to be distributed to participating states over five years. Any state requesting funds will apply to the Secretary of Education for a grant by submitting the state's own plan outlining educational reform at the local level. In the 1995 progress report on Goals 2000, the U. S. Department of Education details the appropriation of funds for state grants:

In the year since President Clinton signed the Goals 2000: Educate America Act, 46 states, American Samoa, the District of Columbia, Guam, the Virgin Islands, the Mariana Islands, the Marshall Islands, Micronesia, Palau, and Puerto Rico have received Goals 2000 grants. (p. 1)

In order to receive Goals 2000 funding, states have to agree to the following conditions:

1. Establish challenging academic standards in core subjects
2. Advance school improvement plans already underway.
4. Design programs that meet the specific needs of student in their communities.
5. Provide more effective professional development for teachers.

6. Make computers and technology available in classrooms to better prepare students for college and the workplace.

7. Form partnerships at the local level with parents, educators, and business and community groups to meet the challenges of educating children for the next century. (U. S. Dept. of Education, 1995, p. 1)

By emphasizing the responsibility the state government must play in implementing educational reform, the national government has defined its own role as one more of supporting and strengthening the state programs rather than mandating or controlling them.

Goals 2000 also calls for the creation of an 18-member National Education Goals Panel to direct and report on the national progress towards the eight educational goals established in the bill. Also, in order to establish a national data base for studying model programs, the bill calls for the establishment of five research institutes, which will be modeled after the National Science Foundation. Finally, the bill appropriates up to $3 million in two years to local school agencies that are in areas labeled high risk for crime and violence. The money will be used to address the issue of making America's schools a safe place to learn.
In April, 1996, The U. S. Department of Education published a report to Congress on the progress of Goals 2000. The report details many state incentives that were inspired by Goals 2000 and aided by the grants made available by the bill:

At the state level, Goals 2000 planning activities have created and strengthened partnerships and support for learning. Over the past two years, governors and chief state school officers have together assembled broad-based planning panels representing viewpoints from across their states--including state and local policymakers, educators, business, parents, and community members. These panels assess the current state of education, and design a plan for raising student achievement. Many states that already had commissions or task forces in place used them for the Goals 2000 planning process. In addition, states that already had comprehensive reform plans could utilize them to meet the Goals 2000 planning requirements. (p. 8)

The report culminates on a positive note stating that Goals 2000 has had a significant impact on state educational reform. Goals 2000 has advised states on creating and implementing new standards for assessment, accountability, and teacher training. Goals 2000 has also encouraged school
districts to take an active role in creating standards at the local level, and to make sure that their resources are being used to their full potential. The report states a renewed commitment to supporting state reform efforts in light of the 1996 National Education Summit that involved governors, business leaders, and President Clinton. The report emphasizes the importance of the national government reassuring states that national support of educational reform will continue into the next century.

While there has been much support for the premise of Goals 2000, there have also been some vocal criticisms. Much of the criticism revolves around the vagueness of the goals:

Even its most sanguine supporters admit that Goals 2000 is too vague and too optimistic, but they hope it marks a step in the right direction. Some teachers and states have been inspired by it to try and write their own standards. Discussion of a core curriculum, with concepts all children of all backgrounds should know, has been gaining ground. By comparison with Europe and Japan, however, American education remains a feast of individualism and experiment: often quirkily successful, but shying away instinctively from the idea that
there are some standards everyone should reach. ("Learning alike", 1994, p. 25)

National Science Education Standards

While Goals 2000 did affirm a national commitment to education, it did not offer a detailed plan for achieving the goals laid out. The need for a more definitive set of standards for science and mathematics education was needed. The National Research Council (NRC), and 39-member National Committee on Science Education, operated under the National Academies of Sciences and Engineering set out to develop a comprehensive and detailed list of standards for national science education. The NRC worked for five years drafting the standards and collaborated with teachers and scientists throughout the country to revise and critique the drafts as they were being developed. In May, 1996, NRC published the 262-page report which proposed national science education standards for grades K-12. The report has been heralded as a landmark in science education.

NRC's National Science Education Standards were built upon the foundation laid out in Project 2061. The overlap that exists between Project 2061 and the National Science Education Standards was not an accident.
During the drafting of Project 2061's *Benchmarks for Science Literacy*, Project 2061 shared drafts of Benchmarks with the staff of the Standards. The influence of Project 2061 is clearly stated in the introduction of the Standards where it states that the NRC gives much credit to the educational framework laid out in Project 2061. Mary Ann Brearton, Field Coordinator for Project 2061, published "Update on Project 2061: A Comparison of Project 2061 & National Science Education Standards". In the article, she draws a comparison between Project 2061 and the Standards and finds the following similarities:

A commitment to reducing the sheer number of topics students must know to allow time for them to concentrate on and learn the most important ideas; a common core of ideas and understanding about science and technology that all students should know; and similar approaches to the placement of ideas and topics within grade ranges and closely allied levels of difficulty and detail. (1996, p. 276)

Upon the publication of the *National Science Education Standards*, School Science and Mathematics published a detailed outline stating the main points of the Standards. The goals of the Standards are that upon completing grade 12, students will be able to use scientific principles and
processes that will give them the necessary knowledge for making personal
decisions. Students will gain educational experiences that will enrich their
understanding of the natural world, and also give them insight into
understanding the implications that science and technology has on the
nation and its economic productivity. And finally, students will engage
intelligently in public discussion and debate regarding issues that involve
science and technology. The article goes on to cite seven principles that
underlay the Standards:

1. All students, regardless of gender, cultural or ethnic background,
   physical or learning disabilities, aspirations, or interest and
   motivation in science, should have the opportunity to attain higher
   levels of scientific literacy than they do currently. This is the
   principle of equity.

2. All students will learn all science in the content standards.

3. All students will develop science knowledge as defined in the
   content standards and an understanding of science that enables them
to use their knowledge as it relates to scientific, personal, social, and
   historical perspectives.
4. Learning science is an active process.

5. For all students to understand more science, less emphasis must be
given to some science content and more resources, such as time,
personnel, and materials must be devoted to science education.

6. School science must reflect the intellectual tradition that
characterizes the practice of contemporary science.

7. Improving science education is part of systemic education reform.

(1996, p. 274)

When drafting the Standards, the NRC understood that in order to
make an effective reform of the science educational standards of the nation,
the Standards would have to be a document that would lay out guidelines
for a systemic change of the educational system. In order to accomplish this
task, the Standards specifies six areas of reform that will need special
attention: science content, science teaching, professional development,
assessment, science education programs, and the science education systems
as a whole.

The guidelines for science content are detailed in order to specify
what students should be expected to learn from kindergarten through high
school. Detailing science content will assist schools with the job of
assessing what children should be focusing on at each grade level. The Standards state that overall, educators should not be concerned with rigidly following a curriculum, focusing on students retaining and reciting information, or supporting competition and independent work. Instead educators should emphasize that students understand and apply scientific ideas, students be involved in discussion and debate regarding scientific ideas, and that students learn to work in cooperative groups in order to enhance the science program. In the Standards, the NRC also suggests that curriculums be adaptive and flexible so that educators can guide and facilitate active involvement in the scientific process.

The NRC developed the Standards realizing that in order for science education reform to be successful, educators must be guided and trained in how to successfully facilitate scientific learning. In response to this need, the Standards offers suggestions on how to teach science and what types of professional development will be needed in order to help educators feel more confident in teaching science. In the Standards, the NRC advocates that teacher training extend beyond the initial education process. The document states that educators should be taught how to put more emphasis on inquiry, investigation, and collaboration. The Standards supports
professional development for educators that will encourage teachers to be facilitators of knowledge, investigation, and change. The document discourages professional development such as courses, workshops, and fragmented one-shot sessions.

The reform detailed for science content and teaching will, of course, require reform in assessment. Educators will need new ways of judging how well students are learning and understanding. The new ideas for assessment revolve around assessing active knowledge, comprehension, and reasoning abilities. Students should also be encouraged to engage in self-assessment. Assessment should emphasize consequential and face validity rather than statistical validity. What is important is assessing what the students do understand rather than what they do not know.

In the Standards, the importance of making the effort cohesive so that high-quality science education programs are created that are successful school-wide and across all grade levels, is discussed. The Standards also suggests that coordination should be made between science and mathematics education so that the skills learned will be compatible and will help students make successful transitions from one grade and one content
area to the next. In discussing standards for designing and implementing science education programs, the document states:

The program standards are rooted in the assumptions that thoughtful design and implementation of science programs at the school and district levels are necessary to provide comprehensive and coordinated experiences for all students across grade levels, and that coordinated experiences result in more effective learning. But a balance must be maintained. To the extent that district and school policies and consequent decisions provide guidance, support, and coordination among teachers, they can enhance the science program. However, if policies become restrictive and prescriptive, they make it difficult for teachers to use their professional ability in the service of their students. (p. 210)

The last standard covered involves successful creation of a science education system where individual schools work as a subsystem of a local school district, and school districts work as subsystems of a state educational system. All of these systems must be supported by a national education system that will work to create laws supporting science education and will designate the necessary resources for a successful science
education system. According to the Standards, "coordination of action among the systems can serve as a powerful force for change. But if actions are at cross purposes, their effects can be negated and create waste and conflict" (p. 228). The support for science education must begin at the level of the individual and extend across broad systems in order for the vision of science education reform to be successful.

In the Epilogue of the National Science Education Standards, the NRC address the implications and the enormous job of implementation:

The real journey of educational reform and the consequent improvement of scientific literacy begins with the implementation of these standards. The National Research Council now passes the challenge to all those who must assume the ultimate responsibility for reform. Scientists, science teacher educators, state departments of education, local school boards, business and industry, governmental and nongovernmental agencies, school administrators, teachers, parents, and students all have a role to play. (p. 243-244)

However, there is much discussion and debate among educators, scientists, and educational administrators regarding how to proceed with the mandate set forth in the Standards.
One critique of the NRC’s discussion of systemic reform in the National Science Education Standards comes from Robert Donmoyer of the National Center for Science Teaching and Learning. In a response to the November, 1994, National Research Council's draft of the Standards, Donmoyer published "The Rhetoric and Reality of Systemic Reform: A Critique of the Proposed National Science Education Standards". In this article, Donmoyer discusses the reality of creating systemic reform at a state and national level. Donmoyer critiques the vagueness of the document. He suggests that the vagueness is a rhetorical tactic to gain support and funding for the effort, and that the document offers no real plan-of-action for curriculum developers, educators, and administrators. In the conclusion of the article, Donmoyer summarizes his critique in saying:

The difficulty is not so much with the way the National Research Council has implemented the systemic reform concept; the fundamental problem is with the concept itself...the realm of rhetoric-including rhetoric about systemic reform--gets quite messy when we move from rhetoric to reality. We must realize, therefore, that in reality we may not be able to have it all and that trade-offs will have to be confronted and hard choices will still have to be made even after
a "unifying vision" has been created. At the very least, we should openly acknowledge the task we have delegated to curriculum developers, test makers, and especially teachers, and we should not be surprised nor should we blame them when they fail to do the impossible. (1995, p. 8)

The vagueness of the document and the difficulty of implementing the reform suggested, are areas of concern for proponents and critics of the Standards. Angelo Collins of Vanderbilt University, former director of the National Research Council's National Science Education Standards project, offers some reflections on the positive and negative aspects of the Standards. Collins applauds the National Research Council's goal of emphasizing the importance of science for all. Collins also recognizes that the NRC set forth excellent standards for science content (with the emphasis on inquiry-based education), science teaching and assessment, professional development, and for emphasizing the need for a national approach to science education standards. However, Collins recognizes problems that may exist. Collin's concern for the reality of implementation parallels Donmoyer's concerns. The problem, according to Collins, stems from the ambiguity of the document. "My concern is whether we have the constancy
to live with ambiguity while tackling the many complex tasks that implementing the Standards demands" (1996, p. 8). Other problems that Collins finds with the document are redesigning curriculum materials which are time-consuming and expensive, the unrealistic hope of the National Research Council's 10-year implementation estimate, and the human tendency to pass the responsibility for reform onto others. Overall, Collins feels optimistic about what the standards have done for science education and believes that the vision it offers for the future is a reality that all involved in education must strive to realize.

Implementation of the science education reform that the Standards support has far-reaching implications for many aspects of education. G. A. Crosby of Washington State University, Department of Chemistry discusses the implications the Standards may have on higher education and teacher training. The Standards emphasizes the role of the teacher as key in implementing the vision of the National Research Council. In the article "Implications of the National Science Education Standards for Higher Education", Crosby focuses attention on reforming the training the teachers receive at the university level. While the Standards do discuss teacher training and professional development, the document does not realistically
suggest the reform that will be needed at the university level in order to have teachers with the training that will be need to implement the new standards for science education. Crosby states:

The Standards want teachers who can "integrate knowledge about science with knowledge about learning, pedagogy, and students". Does a current student in higher education aspiring to be a teacher see integration of that type at all? Hardly. The scientists pack them into lecture sections, lecture to them, and administer exams...Where is the integration of knowledge and pedagogy occurring during those formative years when a teacher is being educated? How many laboratory courses in higher education really emphasize inquiry, problem solving, and the synthesis of practical and theoretical knowledge? For that matter, where does a student write about science, and experience the kind of mentoring that the Standards expect of that same individual after joining the ranks of teachers. (1996, p.A201)

For all of its short comings, the Standards have set a precedent for state and local educational agencies. The National Research Council has offered a framework that state educational agencies can use to build upon.
The work of implementation is immense, but the Standards have exposed the areas where reform should be concentrated and offered a vision and direction for the reform to move towards. State educational agencies are now beginning to determine how to integrate the reform that the Standards, as well as Goals 2000 and Project 2061, have outlined. The next portion of this thesis will take a closer look at the state of North Carolina as an example of a state that is working to create science education reform and one that is integrating the mandate set forth by the national government.
CHAPTER THREE

Timeline for Science Education Reform in North Carolina

1990: North Carolina receives a 3-year award from NSTA (National Science Teacher Association) to become a project site for the Scope, Sequence, and Coordination project.


Jan., 1992: A thirty-six member bipartisan State Steering Committee meets to study the six national goals for 2000 and to how to use those goals to develop educational goals for North Carolina.


1995: North Carolina's State Department of Public Instruction publishes The New ABC's of Public Education.
The purpose of the present chapter is to detail the science education reform that has taken place in North Carolina in the present decade. On the national level, science education reform has been a main concern of educators and policymakers. Much of the national science education reform was drafted and published with state science education reform in mind. The present chapter will give a historical perspective to science education reform in North Carolina, and then build upon that historical perspective in order to understand the effect that national reform is having on state educational policy and reform.

**Scope, Sequence, & Coordination**

In 1989, the executive director of the National Science Teachers Association (NSTA), Bill Aldridge, published an article advocating drastic reform of present curriculum models for science education. Aldridge’s article lead to discussions between NSTA and the National Science Foundation (NSF). The result was the formation of the Scope, Sequence and Coordination (SS&C) project spearheaded by the NSTA and funded by the NSF and the U. S. Department of Education. The initial strategy was to create project sites in the United States that would model the curriculum
reform advocated by SS&C. Implementation began in September of 1989 when awards were made to California and Texas.

At the California site, 100 schools worked independently to design and implement curriculum reform. A central project staff worked to assist each school in the process. In Texas, the project site involved only three schools. The site differed from the California site in that a project staff worked with curriculum specialists in order to design the new curriculum model. The project staff then worked in conjunction with lead teachers from each of the three schools to work on implementation. Both project sites were quite successful with the implementation of the new science curriculum. Many other states were anxious to become project sites for SS&C. Therefore, NSTA turned to the NSF for additional financing for new project sites. In August of 1990, NSF awarded the University of Iowa, the University of North Carolina (at Greenville and Wilmington campuses), and the University of Puerto Rico 3-year grants for the formation of new sites for the SS&C project.

In 1996, the Eisenhower National Clearinghouse for Mathematics and Science Education in association with the American Association for the Advancement of Science published a report on SS&C. The report shows
that in North Carolina, the project, which involved science curriculum reform for sixth and seventh grade, has had a significant impact on student’s and teacher’s attitudes regarding science education. The theme for the North Carolina project was *Where in the World Are We*. In implementing the program, emphasis was placed on teacher/teacher and teacher/staff interactions with educational technology. To encourage this technology friendly environment, teachers were linked electronically with the project staff in order to discuss the progress of the new curriculum model.

The report stated that in order to evaluate the effects of the SS&C reform, each project site was required to do data collection to evaluate the effect on “student gains in subject-matter knowledge and changes in attitudes, as well as changes in teacher behaviors and attitudes” (p. 9-10). Several studies were conducted in North Carolina to determine the effect of SS&C. The data (see Appendix A) show that the project did have a positive effect in changing student’s attitudes regarding science. Students stated that they found science interesting and that experiments were incorporated into class activities every week which encouraged students to think and understand the concepts being discussed.
The data (see Appendix B) also show that SS&C had a positive effect on teacher behavior and attitude. With the new integrated curriculum, teachers were now finding it more important to develop hypothesis, collect data, work in cooperative groups, and explore through hands-on activities. Teachers who participated in the SS&C project felt more comfortable with hands-on lessons, cooperative groups, and using various assessment techniques.

North Carolina: 2000

The next large reform project for North Carolina was outlined in the 1992 Report to the Citizens of North Carolina: North Carolina 2000: A Plan for Action. The report details the impact of the national goals for 2000 that were being developed by the national government. The report proposed nine state goals that were based on the six national goals that were established at that time. The North Carolina 2000 Plan was the joint effort of the NC State Steering Committee and the Goals Team. The goals outlined are as follows:

1. By the year 2000, all children will start school ready to learn.

2. By the year 2000, the high school graduation rate will increase to at least 90 percent.
3. By the year 2000, all students will leave grades four, eight, and
twelve having demonstrated competency in challenging subject
matter including English, mathematics, science, history, and
geography; and every school in North Carolina will ensure that all
students learn to use their minds well, so they may be prepared for
responsible citizenship, further learning, and productive employment
in our modern economy.

4. By the year 2000, North Carolina students will be first in the world
in science and mathematics achievement.

5. By the year 2000, every adult North Carolinian will be literate and
will possess the knowledge and skills necessary to compete in a
global economy and exercise the rights and responsibilities of
citizenship.

6. By the year 2000, every school in North Carolina will be free of
drugs and violence and will offer a disciplined environment
conducive to learning

7. By the year 2000, all North Carolina educators will meet standards
that will assure that they are effective in their fields.
8. By the year 2000, North Carolina will be first in the nation to effectively apply technology to teaching, learning, and administration.

9. By the year 2000, every community in North Carolina will have a responsive, integrated, comprehensive, parent development process that actively supports the national goals of education for our children.

The report begins by giving some historical background information on educational reform in the state and by giving some demographic information regarding the state’s failure regarding education. The report acknowledges in the opening statement that North Carolina students have lagged behind other South Eastern states in performance, which puts North Carolina near the bottom in the country. Therefore, students in North Carolina are at a greater risk than students in almost any other state. The data reported is taken from the 1990 federal census which showed that:

1. North Carolina has almost 1.3 million residents over 25 years of age without a high school diploma.

2. Our state trails the nation in the percentage of high school graduates by more than 5 percent, and the number with a bachelor’s degree or higher by 3 percent.
3. Median household income and median per capita income lag the national median by over 11 percent.

The report also recognizes that North Carolina’s initiatives towards education reform in the eighties were virtually unsuccessful due to the stop and start nature of the reform. This created an atmosphere of distrust among participants in the educational system. The division among government officials regarding long-term educational reform also exacerbated the situation. The report echoes the sentiment that in order for reform to be effective, North Carolina must:

Decide what young people should be learning, establish high expectations for all of them, and expand accountability for student performance. Communities must be places where education is valued and the attitude exists that all students can learn high level concepts. This calls for improved methods of assessing student mastery of concepts rather than their ability to answer standardized test questions. It also requires that a systems approach to education reform be taken rather than trying to fix one area at the time; such reform is long term, surviving from one administration to the next. (p. viii)
In Goal 4 of the report, objectives are outlined for reforming science education so that North Carolina students can be first in the world in science and mathematics education. The guiding principles of the goals are that all students can learn and achieve, students will place more emphasis on motivation and effort, and the state educational system will make better use of other agencies and organizations in order to realize the vision of the goal. The overall objective is to strengthen math and science education in all grades but especially in the early grades, and that the number of graduate and undergraduate degrees in math and science related fields will increase, especially for women and minorities.

The initial step in the process outlined in the report is the adoption of a new standard course of study for science and mathematics based on guidelines established at the national level. Critical changes will involve the integration of technology into the science curriculum, more hands-on activities in the classroom, more authentic assessment by educators, and an integration of the science and mathematics curriculum so that they complement each other throughout the grade levels. Assessment of student achievement will be made at grades 4, 8, and 12 using tests based on national standards outlined by the National Council of Teachers and the
National Science Teachers Association. The report also states that students entering high school in 1996 will be required to take four units each of mathematics and science so that all graduates by the year 2000 will graduate under the new requirements.

The report also describes programs that have been initiated with the new vision of science education reform in mind:

• North Carolina Science and Mathematics Alliance. An organization designed to affect public policy and education coordinating statewide efforts to improve science and mathematics education. Funding for this organization is provided for by the National Science Foundation.

• Project Team, a math and science initiative operating in 12 sites within the state.

• The North Carolina Math/Science Education Network is an organization comprised of 10 sites located on campuses of the University of North Carolina System. The goal is to improve teacher training and education so that teachers will be competent in teaching the new integrated curriculum of science and mathematics.

• Scope, Sequence and Coordination
The conclusion of the report emphasizes that educational reform in North Carolina will require a long-term commitment and will involve changes in curriculum, instruction, assessment, and with the structure and effectiveness of the educational system as a whole. It will be necessary for the state educational department in conjunction with the state government to define the vision of reform for the future and exert leadership and perseverance in attaining the reform needed.

**SERVE: SouthEastern Regional Vision for Education**

North Carolina is also part of a resource project operated by the U. S. Department of Education. The project is known as the SouthEastern Regional Vision for Education (SERVE). It operates to assist southern states (North Carolina, Alabama, Florida, Georgia, Mississippi, and South Carolina) with information that will promote systemic educational improvement. The project works as laboratory and research center that explores issues that are crucial for successful reform. SERVE emphasizes five main concepts: training, resources, methods, content, and enrollment. The overall goal is to prepare educators for the changes in science and mathematics education so that educators can facilitate cooperative and integrated science and mathematics education.
The New ABCs of Public Education

In 1995, the North Carolina General Assembly decided to take a closer look at the progress the state was making in educational reform. The decision was made that the state was making the improvements needed but at a slower pace than hoped for. The state government passed a law directing the State Board of Education to examine that situation and to find ways of improving the existing system. The State Board of Education responded with The New ABC’s of Public Education. In the opening statement of the New ABC’s, the reason and implication of the reform is described:

Teachers and principals have worked hard to make changes and to accommodate new education programs. Nevertheless, many state and local education and business leaders feel that schools have not made the significant changes needed to meet the demands of the 21st century workplace and society. To give public schools a real chance to succeed, however, the General Assembly recognized in its 1995 session that local teachers and principals needed authority to make more significant and sweeping changes. Also, they needed to be held accountable for student achievement at the school level. The New
ABC's is the result of 1995 legislation directing the State Board of Education to draft a plan to reorganize public schools in North Carolina. (p. 1)

The New ABC's is a plan to emphasize accountability for the teachers and school districts, emphasize the basics in mathematics, English, and science, and to return control to the local school districts for mandating how reform should progress. The accountability portion of the New ABC's operates in conjunction with the concept of local control. School districts will be responsible for assisting local schools with establishing standards and integrating the new curriculum models. Along with that, each school will be responsible for the performance of its students in the areas of reading, writing, mathematics, and science. The accountability aspect will ensure that schools have standards for student growth and performance and that students are assessed at constant intervals (throughout grades 3-8) to ensure that students are progressing according to state and national standards. Accountability will also allow school districts and state agencies to reward high performance. It will also identify schools that are not performing well and that may need assistance or intervention.
The New ABC's does not mandate any specific curriculum, but only specifies that educators use the *North Carolina Standard Course of Study* as a starting point for covering the basics of reading, writing, and mathematics with integration of science, art, history, and other curriculum areas. The goal is that this will give local school districts the flexibility to design curriculums that will best fit the local schools. In doing so, the local school district will be able to include suggestions from teachers and parents who are encouraged to take an active role in shaping the local educational system.

During the 1996-1997 and 1997-1998 school years, The State Board of Education will be collecting data regarding the test scores of schools participating in the ABC's project. The data will be used to determine if assistance teams will be needed for intervention in schools that do not perform well. The data will also be used to assess how much growth can be expected in the upcoming years.
CHAPTER FOUR

A Comparative Study: North Carolina’s Standard Course of Study and the National Science Education Standards

The culmination of a decade of national attention directed toward science education reform is the National Research Council’s comprehensive National Science Education Standards. After four years of drafting, the document was published in its final form in 1996. The ultimate purpose of the document is that it be utilized by state and local governments as a guide for implementing science education reform in every school district and every school. Using national science education reform as a guide, North Carolina revised its Standard Course of Study for Science (K-12) and published the new version in 1994. The reform in North Carolina science education parallels the national reform underway at the NRC. NRC published its first draft of the Standards in May 1994 and submitted the draft to several focus groups for critique and review. Changes were made, and in December of 1994, a new draft was published for national review. 40,000 copies of the document were circulated to 18,000 individuals and
250 different groups. The suggestions made by those reviewing the draft of
the NSES were incorporated into the final version published in 1996.

Although the North Carolina Standards Course of Study does not give
specific credit to the NRC and the Standards within the document, the North
Carolina document does list two initial reports from the NRC as sources
cited when complying the new Standard Course of Study: National Science
Education Standards: An Enhanced Sampler (1992) and National Science
Education Standards: July ‘93 Progress Report (1993). In comparing the
two documents, it is evident that the Standards had a significant influence in
the science education reform adopted in North Carolina.

Philosophy and Goals

To compare the elementary science education program endorsed by
the National Research Council in the National Science Education Standards
with the Standard Course of Study of North Carolina for elementary science
education reform, one must begin by comparing the guiding principles and
goals of each document.

The Standards lists four underlying principles:

1. Science is for all students.
2. Learning science is an active process.

3. School science reflects the intellectual and cultural traditions that characterize the practice of contemporary science.

4. Improving science education is part of systemic education reform.

(p. 19)

The North Carolina Standards lists five underlying principles:

1. All students can learn and succeed in science

2. Understanding science is essential for the survival of a free, democratic society.

3. Scientific literacy is essential for participation in an increasingly complex scientific society.

4. Success in science requires concept development through active participation in scientific processes and problem solving.

5. Experiential science instruction must be available to every student on a regular basis at all grade levels. (p. 4)

The similarities of these underlying principles are evident. Both documents emphasize the importance of science education for all students, the importance of learning scientific concepts and skills through active participation, and the importance of scientific literacy as a component of a
complex contemporary society. Both documents share the vision that students will need to understand scientific concepts and possess the critical thinking and problem solving skills required for scientific literacy in order to compete in a global economy that is continually becoming more complex and technologically based.

Both documents also emphasize the importance of scientific literacy, and both offer definitions regarding the meaning and implication of scientific literacy for students. In the Standards, the term is used to describe a person who has specific abilities regarding understanding and applying scientific concepts:

Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed.
A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. (p. 22)

The Standards also states that the scientifically literate person may demonstrate these abilities in a variety of ways. Some individuals may be more proficient in different domains of science, such as life science, earth science, and physical science. The Standards also emphasizes the importance of scientific literacy as a lifetime goal that "expands and deepens over a lifetime" (p. 22).

The North Carolina Standards does not give such a detailed definition regarding its use of the term scientific literacy:

Scientific literacy implies an understanding of basic science concepts and the scientific processes of reasoning. The scientifically literate person has a substantial knowledge of concepts, conceptual networks, and process skills which enable the individual to continue to learn and think logically. This individual both appreciates the value of science and technology in society and understands their limitations. North Carolina students can achieve scientific literacy through an
instructional program based on the goals in the Science Component of the Standard Course of Study. (p. 4)

Certainly while this definition does include some of the concepts mentioned in the Standards, on the whole it is a more narrow definition of one’s abilities and range of influence within society. The definition does not emphasize the importance of scientific literacy as a component of an educational system that seeks to equip students with the knowledge and abilities to take an active role in the direction of future scientific investigations. The North Carolina Standards also mentions the limitations of science and technology which is never mentioned in the National Standards. What exactly is meant or implied in the word limitation is never fully explained.

Content and Curriculum Standards

While both the North Carolina Standards and the National Standards do share a similar vision regarding scientific literacy and education, they differ in their approach and emphasis. The National Standards emphasizes science content standards which “outline what students should know, understand, and be able to do in the natural sciences over the course of K-12 education” (p. 6). The National Standards elaborates further on the content
standards by listing eight categories of the content standards and their relevance to each grade level. The North Carolina Standards focuses more on five program goals which serve as the basis for the framework of the entire science curriculum.

The eight categories of the National Standards content standards are:

1. Unifying concepts and processes in science.
2. Science as inquiry
3. Physical science.
4. Life science
5. Earth and space science.
6. Science and technology
7. Science in personal and social perspectives.
8. History and nature of science.

The first standard covers the abilities and mental processes need in order for students to understand and participate in the scientific process. The standard will be developed throughout the entire educational process. The next seven content categories are clustered for the following grades: K-4, 5-8, and 9-12 and are referred to as content standards A-G. The National
Standards emphasizes the importance of the development of all standards for the achievement of scientific literacy:

The sequence of the seven grade-level content standards is not arbitrary: Each standard subsumes the knowledge and skills of other standards. Students' understandings and abilities are grounded in the experience of inquiry, and inquiry is the foundation for the development of understandings and abilities of the other content standards. The personal and social aspects of science are emphasized increasingly in the progression from science as inquiry standards to the history and nature of science standards. Students need solid knowledge and understanding in physical, life, and earth and space science if they are to apply science. (p. 104)

The following tables outline the topics covered under each content standard for K-4 and 5-8:

<table>
<thead>
<tr>
<th>UNIFYING CONCEPT AND PROCESSES</th>
<th>SCIENCE AS INQUIRY</th>
<th>PHYSICAL SCIENCE</th>
<th>LIFE SCIENCE</th>
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<tbody>
<tr>
<td>Systems, order, and organization</td>
<td>Abilities necessary to do scientific inquiry</td>
<td>Properties of objects and materials</td>
<td>Characteristics of organisms</td>
</tr>
<tr>
<td>Evidence, models, and explanation</td>
<td>Understandings about scientific inquiry</td>
<td>Position and motion of objects</td>
<td>Life cycles of organisms</td>
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<tr>
<td>Change, constancy, and measurement</td>
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<td>Light, heat, electricity, and magnetism</td>
<td>Organisms and environments</td>
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<td>Evolution and</td>
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<tr>
<td>EARTH AND SPACE SCIENCE</td>
<td>SCIENCE AND TECHNOLOGY</td>
<td>SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES</td>
<td>HISTORY AND NATURE OF SCIENCE</td>
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<tr>
<td>Properties of earth materials</td>
<td>Abilities of technological design</td>
<td>Personal health</td>
<td>Science as a human endeavor</td>
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<tr>
<td>Objects in the sky</td>
<td>Understandings about science and technology</td>
<td>Characteristics and changes in populations</td>
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<tr>
<td>Changes in earth and sky</td>
<td>Abilities to distinguish between natural and man-made objects</td>
<td>Types of resources</td>
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**CONTENT STANDARDS FOR 5-8**

<table>
<thead>
<tr>
<th>UNIFYING CONCEPTS AND PROCESSES</th>
<th>SCIENCE AS INQUIRY</th>
<th>PHYSICAL SCIENCE</th>
<th>LIFE SCIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems, order, and organization</td>
<td>Abilities necessary to do scientific inquiry</td>
<td>Properties and changes of properties in matter</td>
<td>Structure and function in living systems</td>
</tr>
<tr>
<td>Evidence, models, and explanation</td>
<td>Understandings about scientific inquiry</td>
<td>Motions and forces</td>
<td>Reproduction and heredity</td>
</tr>
<tr>
<td>Change, constancy, and measurement</td>
<td>Transfer of energy</td>
<td>Regulation and behavior</td>
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<tr>
<td>Evolution and equilibrium</td>
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<td>Form and function</td>
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<table>
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<tr>
<th>EARTH AND SPACE SCIENCE</th>
<th>SCIENCE AND TECHNOLOGY</th>
<th>SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES</th>
<th>HISTORY AND NATURE OF SCIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure of the earth system</td>
<td>Abilities of technological design</td>
<td>Personal health</td>
<td>Science as a human endeavor</td>
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<tr>
<td>Earth’s history</td>
<td>Understandings about science and technology</td>
<td>Populations, resources, and environments</td>
<td>Nature of science</td>
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<tr>
<td>Earth in the solar system</td>
<td>Natural hazards</td>
<td>History of science</td>
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<td>Risks and benefits</td>
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<td></td>
<td>Science and technology in society</td>
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For state governments and school districts interested in adopting the concepts laid out in the National Standards, NRC stresses the fact that the document is not a science curriculum. The purpose of the National Standards is to organize and emphasize content so that students will be able to acquire the understanding and abilities need for scientific literacy. The National Standards also states that no standard should be eliminated from a curriculum because the standards are designed to work together for a comprehensive understanding of science. Science content can be added however to establish connections that will enrich and add depth to a science curriculum. The National Standards also states the importance of reforming teaching and assessment techniques so that they will complement the goal of the science standards by promoting inquiry, investigation, cooperation, and problem-solving.

The program goals for the North Carolina Standards are as follows:

1. Understand the nature of science

2. Become proficient in using science process skills to solve problems and make decisions.

3. Develop skills to manipulate and/or operate science equipment.
4. Develop responsible attitudes toward the environment, science, technology, and society.

5. Understand basic scientific concepts and principles.

The first goal is to have students understand the nature of science. This corresponds directly with Content Standard G of the National Standards (history and nature of science). According to the North Carolina Standards, the scientifically literate person will understand that science is public, historic, replicable, tentative, and probabilistic. In understanding that science is public, the student will have knowledge that scientific information is available in more than 70,000 journals and publications and is constantly being presented to the general public through various forms of media. Students will understand the historical context of science and its progression to the present. Students will understand that in order for scientific discoveries and theories to be valid, they must be replicable under similar circumstances. Students should understand that science is tentative in that it is always expanding and changing and should never be considered as fixed and absolute. The Content Standard G of the National Standards also emphasizes the importance of students understanding the tentative nature of science:
It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (p. 171).

The next major goal of the North Carolina Standards is to have students develop and use process skills while engaging in problem-solving. The process skills are divided into two categories: Basic and integrated. The North Carolina Standards defines the skills in stating that the "basic skills provide the intellectual groundwork in this problem-solving endeavor. The integrated skills serve as the immediate tools for solving a problem."
The following tables list both skills and their relevance to the primary and middle grade levels:

**BASIC PROCESS SKILLS**

<table>
<thead>
<tr>
<th>OBSERVING</th>
<th>CLASSIFYING</th>
<th>USING NUMBERS</th>
<th>COMMUNICATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-8</td>
<td>K-8</td>
<td>K-8</td>
<td>K-8</td>
</tr>
<tr>
<td>MEASURING</td>
<td>INFERRING</td>
<td>PREDICTING</td>
<td>USING TIME/SPACE</td>
</tr>
<tr>
<td>K-8</td>
<td>K-8</td>
<td>K-8</td>
<td>2-8</td>
</tr>
</tbody>
</table>

**INTEGRATED PROCESS SKILLS**

<table>
<thead>
<tr>
<th>INTERPRETING DATA</th>
<th>DEFINING OPERATIONALLY</th>
<th>EXPERIMENTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-8</td>
<td>2-8</td>
<td>2-8</td>
</tr>
<tr>
<td>CONTROLLING VARIABLES</td>
<td>FORMULATING HYPOTHESIS</td>
<td>FORMULATING MODELS</td>
</tr>
<tr>
<td>3-8</td>
<td>3-8</td>
<td>3-8</td>
</tr>
</tbody>
</table>

The third goal of the North Carolina Standards is to have students develop manipulative skills. Manipulative skills include learning safe laboratory practices, choosing the appropriate scientific equipment for investigation, manipulating scientific equipment and materials which includes computers and software, properly caring for scientific equipment, and properly handling and caring for living organisms used in the study of science. The overall purpose of this goal is to teach students the importance of safe scientific practices in a laboratory setting.
The fourth goal of the North Carolina Standards is to ensure that students develop positive attitudes towards science and its contribution to the world. The ultimate goal is to have students develop positive attitudes towards learning and experiencing science, conservation and preservation of natural resources, scientific inquiry and problem solving, and the effect of technology on society. Although assessment of the goal can be difficult, the hope is that students will acquire more positive attitudes towards science as reform in science education creates a learning atmosphere that is interesting and engaging for all students.

The fifth goal of the North Carolina Standards is to have three general divisions within the science curriculum: Earth, life, and physical science concepts. The concepts will permeate the curriculum and will be studied in a unified format so that topics from each concept will complement each other. The National Standards also advocates for a unified presentation of these three science concepts. The following table compares the topic outlines of both documents:

<table>
<thead>
<tr>
<th>CONTENT TOPICS COVERED K-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTH CAROLINA STANDARD COURSE OF STUDY</td>
</tr>
<tr>
<td>Needs of living organisms</td>
</tr>
<tr>
<td>Life cycles</td>
</tr>
<tr>
<td>Environmental adaptations</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Chemical substances and the body</td>
</tr>
<tr>
<td>Weather and related cycles</td>
</tr>
<tr>
<td>Prehistoric life</td>
</tr>
<tr>
<td>Interdependence of plants and animals</td>
</tr>
<tr>
<td>Earth cycles</td>
</tr>
<tr>
<td>Rocks and soil</td>
</tr>
<tr>
<td>Energy systems</td>
</tr>
<tr>
<td>Solutions and mixtures</td>
</tr>
<tr>
<td>Nutritional patterns</td>
</tr>
<tr>
<td>Animal grouping and behavior</td>
</tr>
<tr>
<td>Solar systems</td>
</tr>
<tr>
<td>Interactions of matter and energy</td>
</tr>
<tr>
<td>Heat energy transfer</td>
</tr>
<tr>
<td>Simple machines</td>
</tr>
</tbody>
</table>

**CONTENT TOPICS COVERED 5-8**

<table>
<thead>
<tr>
<th>NORTH CAROLINA STANDARD COURSE OF STUDY</th>
<th>NATIONAL SCIENCE EDUCATION STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant communities</td>
<td>Structure and function in living systems</td>
</tr>
<tr>
<td>Sources and forms of energy</td>
<td>Reproduction and heredity</td>
</tr>
<tr>
<td>Natural resource preservation</td>
<td>Regulation and behavior</td>
</tr>
<tr>
<td>Wise use of natural resources</td>
<td>Populations and ecosystems</td>
</tr>
<tr>
<td>Earth over time</td>
<td>Diversity and adaptations of organisms</td>
</tr>
<tr>
<td>Weather and climate</td>
<td>Properties and changes of properties in matter</td>
</tr>
<tr>
<td>Physical fitness energy</td>
<td>Motions and forces</td>
</tr>
<tr>
<td>Similarities and differences of living organisms</td>
<td>Transfer of energy</td>
</tr>
<tr>
<td>Growth patterns</td>
<td>Structure of the earth system</td>
</tr>
<tr>
<td>Populations, communities, ecosystems</td>
<td>Earth's history</td>
</tr>
<tr>
<td>Heat, light, and sound</td>
<td>Earth in the solar system</td>
</tr>
<tr>
<td>Interactions of the sun, moon, earth, and planets</td>
<td></td>
</tr>
<tr>
<td>Matter, motion, and energy transformation</td>
<td></td>
</tr>
<tr>
<td>Weather, landforms, and geologic time</td>
<td></td>
</tr>
<tr>
<td>Systems of organisms</td>
<td></td>
</tr>
<tr>
<td>Inheritance and cell process</td>
<td></td>
</tr>
<tr>
<td>Electricity, magnetism, and gravity</td>
<td></td>
</tr>
<tr>
<td>Conservation of matter</td>
<td></td>
</tr>
<tr>
<td>Adaptation and evolution</td>
<td></td>
</tr>
</tbody>
</table>
One can see that there are many similarities between the national outline for studying physical, earth, and life science and North Carolina's outline for covering the same concepts. Although the North Carolina outline does not strictly follow the guidelines established by the National Standards, one must keep in mind however that the National Standards was not designed as a curriculum model; its main purpose is to outline topics and areas of science that should be study together so that students can see patterns of integration throughout the science curriculum. The importance of integration throughout the curriculum is emphasized in the North Carolina Standards:

National and state educational goals recognize the need for integration between and within subjects in order to increase relevance and promote understanding and reasoning skills in students. Science, from the earliest years to the culmination of the high school experience, should be presented through reasonable degrees of integrated learning. (p. 13).

The conclusion that one can draw from the comparison is that North Carolina is certainly making the attempt to utilize the reform efforts of national organizations in order to improve its own science education.
program. However, the North Carolina Standards does not address such important issues as assessment, science teaching standards, and standard for promoting the professional development of science teachers. The absence of these elements suggests that North Carolina has not completely adopted the reform efforts of the National Research Council. In the National Standards, much emphasis is placed on reforming assessment and teaching standards to reflect and complement the inquiry-based nature of the science education standards and content. Certainly the question arises as to how a state can expect to implement an inquiry-based science curriculum without reforming its systems of assessment and without investing in teacher training and development. Although not as comprehensive an effort towards science education reform, the North Carolina Standards does promote the basic concepts of science education reform advocated by the National Standards.
CHAPTER FIVE

Conclusion and Discussion

On the national front, science education reform is still being initiated by the Project 2061 staff. The team is planning to publish two more documents in the upcoming year that will serve to unite the visions of Science for All Americans and Benchmarks for Scientific Literacy. The ultimate goal of Project 2061, is that these publications will make implementation of national science education reform a much easier task. By unifying the vision of reform with concrete examples of curriculum design and staff training and support, Project 2061 can be a useful tool for state and local governments as they begin the awesome task of science education reform.

The reform of elementary science education has really just begun. The difficult task of implementation will stretch on for decades. The national government has begun to recognize that it must take the lead in initiating educational reform in this country. With national support and leadership, states, such as North Carolina, will continue to make much needed progress toward attaining the national vision of science education reform.
References


American Association for the Advancement of Science. (1989). *Project 2061: Science for all americans.* Washington, DC.


### Data From North Carolina

**Percentage of Teachers Indicating Their Students Performed Each Activity at Least Once a Week, by Teacher Type**

<table>
<thead>
<tr>
<th>Activity</th>
<th>6th (N=20)</th>
<th>7th (N=13)</th>
<th>Total (N=33)</th>
<th>Control (N=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students develop hypotheses</td>
<td>90%</td>
<td>85%</td>
<td>88%</td>
<td>69%</td>
</tr>
<tr>
<td>Students collect data</td>
<td>90%</td>
<td>92%</td>
<td>91%</td>
<td>63%</td>
</tr>
<tr>
<td>Students write about their learning</td>
<td>95%</td>
<td>92%</td>
<td>94%</td>
<td>58%</td>
</tr>
<tr>
<td>Students explore through hands on</td>
<td>100%</td>
<td>92%</td>
<td>97%</td>
<td>79%</td>
</tr>
<tr>
<td>Students work in cooperative group³</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>79%</td>
</tr>
<tr>
<td>Students use a computer</td>
<td>21%</td>
<td>23%</td>
<td>22%</td>
<td>5%</td>
</tr>
<tr>
<td>Students relate science to societal issues</td>
<td>75%</td>
<td>62%</td>
<td>70%</td>
<td>68%</td>
</tr>
<tr>
<td>Students read a textbook</td>
<td>5%</td>
<td>15%</td>
<td>9%</td>
<td>74%</td>
</tr>
<tr>
<td>Students read science articles</td>
<td>55%</td>
<td>54%</td>
<td>55%</td>
<td>68%</td>
</tr>
<tr>
<td>Students are given at-home activities</td>
<td>35%</td>
<td>0%</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>Students listen to a lecture</td>
<td>20%</td>
<td>30%</td>
<td>24%</td>
<td>53%</td>
</tr>
</tbody>
</table>
Appendix B

Percentage of Teachers Indicating They Had Made Changes in an Area in the Past 2 Years, by Teacher Type

<table>
<thead>
<tr>
<th>Area</th>
<th>6th (N=20)</th>
<th>7th (N=13)</th>
<th>Project Total (N=33)</th>
<th>Control (N=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum materials</td>
<td>88%</td>
<td>90%</td>
<td>88%</td>
<td>81%</td>
</tr>
<tr>
<td>Instructional methods</td>
<td>88%</td>
<td>83%</td>
<td>86%</td>
<td>94%</td>
</tr>
<tr>
<td>Student assessment</td>
<td>63%</td>
<td>55%</td>
<td>72%</td>
<td>50%</td>
</tr>
<tr>
<td>Use of technology</td>
<td>50%</td>
<td>83%</td>
<td>64%</td>
<td>63%</td>
</tr>
<tr>
<td>Parent involvement</td>
<td>69%</td>
<td>42%</td>
<td>57%</td>
<td>69%</td>
</tr>
<tr>
<td>Use of cooperative learning</td>
<td>81%</td>
<td>77%</td>
<td>79%</td>
<td>75%</td>
</tr>
</tbody>
</table>