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ABSTRACT

A Science Curriculum Study Committee was appointed in 1980 to thoroughly review and study the status of the North Carolina science program and to develop recommendations which, upon implementation, would significantly improve the quality of the total state K-12 science program. The committee was organized into three subcommittees with the following areas of responsibility: (1) curriculum; (2) facilities and materials; and (3) competent staffing. This document is the committee's report. Chapter 1 discusses the organization of the study. Chapter 2 highlights the background status of science education, discussing the five major concerns which were the base from which the committee launched its study of the state's science curriculum. The remaining chapters focus on the problems and challenges associated with the three major areas of the science program: curriculum (chapter 3); facilities, equipment, and materials (chapter 4); and staff (chapter 5), including a profile of the North Carolina Science teacher and addressing preservice/inservice and certification issues. Each chapter includes recommendations and rationale for these recommendations. An executive summary is found at the beginning of the report, listing the 23 recommendations and the expected improvements in the state's science programs should the recommendations be accepted and implemented. (Author/JN)

Curriculum Study: Science

A Report from the Science Curriculum Study Committee To the North Carolina State Board of Education

North Carolina Department of Public Instruction
Raleigh/1982

FOREWORD

A committee composed of students, parents, teachers, administrators, college/university persons, and industry representatives has studied the science curriculum in our public schools and made the recommendations contained in this report. These recommendations, if implemented, will improve science education at all levels in the state. This report should serve us well, giving direction as we move forward together. It contains a compilation of ideas, suggestions, and information resulting from a serious examination of our present science program and the literature.

The fine work done by the Study Committee and various members of the Department of Public Instruction is gratefully acknowledged and appreciated. Their hard work and dedication are exemplified in the excellence of this report.

It is a first step to stimulate all of us who are responsible for the various facets of science education to assess our programs and strive for excellence. I encourage you to use it and other resources to plan and implement better science programs at all educational levels. Our State Department of Public Instruction staff stands ready to assist you in these efforts.

A. Craig Phillips
State Superintendent of Public Instruction

ACKNOWLEDGMENTS

In the process of conducting any major study and producing a supporting document, much work and sacrifice is usually involved on the part of many individuals. Certainly that is the case with this Science Curriculum Study. It is appropriate, therefore, that appreciation be expressed to all those who labored and/or supported the study so diligently.

Gratitude is expressed to the Committee members and consultants for the long hours and hard work they contributed. Gratitude is also expressed to: State Superintendent A. Craig Phillips, Deputy State Superintendent Jerome Melton, and Assistant State Superintendent for Instructional Services George Kahdy for their encouragement and support; Deputy Assistant State Superintendent for Instructional Services Jerry Beaver for his leadership and direction; the Special Assistants in the Instructional Services Area--Wayne Dillon, William McMillan, Betty Moore, and Mary Purnell for their participation and contributions; and the Division of Science staff--David Mallette, William Spooner, and Ann Watkins for serving as consultants and Committee staff.

Special appreciation is expressed to Paul Taylor, Director of the Division of Science, for his encouragement, support, contributions, and many hard hours solving administrative problems and editing this report. Special appreciation also is expressed to Ruth Lawson and Patricia Smith, secretaries in the Division of Science, for all they did from arranging meeting facilities and recording all minutes to volumes of typing, including this final report.

Ira Trollinger, Chairman
Clinton (Jake) Brown, Coordinator
Science Curriculum Study Committee

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Summary of Recommendations and Rationales

RECOMMENDATION 1. *The Committee recommends that science be considered basic to the curriculum and receive the equivalent of a full year of instruction each year in each grade K-8. It is also recommended that science courses be offered each year for students in grades 9-12.*

Rationale: The Committee feels that science should be considered a basic component of the curriculum because of its multidisciplinary nature, motivational potential, career importance, and emphasis on thinking skills. There is evidence to suggest that science is not given its proportionate share of instructional time in both the elementary and middle schools. The Committee feels that steps should be taken to ensure that science is taught on a systematic basis and as a year's equivalent. A year's equivalent may be defined as not less than 135 hours of instruction in grades 7-8 and not less than 150 hours of instruction at grades 9-12.

RECOMMENDATION 2. *The Committee recommends that The Principals' Institute provide staff development activities which identify alternatives for organizing and scheduling a balanced program in which science is assured the time and attention it deserves as one of the basics.*

Rationale: Elementary schools are placing heavy emphasis on reading and mathematics with the prime time of the instructional day given to these instructional areas. Curriculum schedule models of the elementary instructional day should be studied and models developed that emphasize the appropriate coverage of science in the instructional day as well as all other program areas.

At the middle school and high school level many laboratory science courses require flexible scheduling. Laboratory activities often require a longer period of time than the normal 55-minute period. Effective use of block scheduling of a two-hour period should be studied along with other alternatives to ensure adequate time for proper science instruction.

RECOMMENDATION 3. *The Committee recommends that science be included in the annual testing program in grades 3, 6, and 9.*

Rationale: The Committee feels that there are specific, basic skills associated with science instruction that should be mastered by all students by grades 3, 6, and 9. Many of these skills involve decision-making and problem-solving modes of instruction rather than memorization of science facts. The Committee feels that the inclusion of science in the annual testing program will help elementary teachers restructure their priorities and understand the importance of science instruction. The statewide evaluation program would allow science educators to focus on the important concepts and processes in science and would provide feedback to teachers and administrators as to the effectiveness of their programs.

RECOMMENDATION 4. *The Committee recommends that three units of science be required for high school graduation. These should include one unit of a life science or biology, one unit of a physical science (i.e., earth science, physical science, chemistry, physics), and one additional unit of a life science, a physical science, or an applied science (i.e., electronics, horticulture, or other technically-oriented vocational courses).*

Rationale: The Committee feels that by increasing the graduation requirements of high school science courses, students will demonstrate improved performance on science achievement tests. Increasing the number of required science courses will also keep the 50% of all high school graduates who do not take a science course beyond the 10th grade actively involved in the science program for an additional year. By allowing one of the requirements to be an applied science course, new career opportunities may also be presented to students. Additionally, increasing the science requirements is in keeping with the trend set by other industrialized nations such as West Germany, Japan, and the Soviet Union, who are placing emphasis on science training for all citizens and not just a small elite group.

RECOMMENDATION 5. *The Committee recommends that the science course of study for grades K-8 for all schools be a program covering the life sciences, the earth sciences, and the physical sciences.*

Rationale: The Committee is recommending that all science in grades K-8 be of a basic nature surveying the major areas of science. This would alleviate many of the problems experienced with the life and earth science programs. The K-8 grades would feature a general course of study. Each year, students would study concepts of life, earth, and physical science. The instructional techniques employed to teach these courses would include such things as "hands-on" experimentation and demonstrations as well as textbooks. The curriculum would have many forces helping to shape it including: science concepts, principles, and facts; inquiry and investigative processes; emphasis on the interaction of science and society; the development of favorable attitudes toward science; career knowledge; and relationships of self and the environment.

RECOMMENDATION 6. *The Committee recommends that the science course of study for grades 9-12 be composed of two types of courses: 1) a group covering a broad range of applied and technological courses, and 2) a group covering a broad range of rigorous academic courses.*

Rationale: The high school with such a science curriculum would permit students with different interests and abilities to select their own courses of study to fit their educational and vocational objectives. Hopefully, such a broad range of courses would attract more students, especially girls and minorities, into the science classes.

The applied and technological courses would stress the application of science to everyday problems and to the world of work. Mathematics would not be overemphasized in these courses.

The academic courses would be of a more abstract nature and be suitable for the student interested in pursuing a science-related career above the technical level. Considerable emphasis will be placed on mathematics in these courses.

Both groups will contain the traditional science courses (earth science, physical science, biology, chemistry, physics) usually offered in grades 9-12. The main difference will be content depth, emphasis on mathematics, and the emphasis given to application in regard to the world of work. Other courses included in the academic group may be advanced (2nd year) courses, advanced placement courses, and a variety of other electives. Other courses included in the applied/technological group may be a variety of courses of an exploratory nature and/or related to the world of work.

By increasing the number of science course requirements and by making the courses more relevant to the abilities of the students, the Committee believes that science achievement, science attitudes, and interests in science careers will improve.

RECOMMENDATION 7. The Committee recommends that specifications be developed by the State Department of Public Instruction which identify adequate facilities for all children for K-12 laboratory-oriented science instruction.

Rationale: The Committee recognizes that most school systems do not employ a full-time person for the planning of facilities. Therefore, key specifications of the design of adequate science facilities for all children (including handicapped) should be put in writing and reviewed by architects and school personnel. Federal and state laws should be incorporated into the specifications where appropriate.

RECOMMENDATION 8. The Committee recommends that all plans and specifications for new or renovated science facilities be approved by the Divisions of School Planning and Science of the State Department of Public Instruction.

Rationale: The Committee feels that the Division of School Planning and the Division of Science should cooperate fully to ensure that building plans meet key standards that would enhance the science instructional program. The review of plans for new or renovated buildings by someone with the expertise in both facilities and science instruction would help eliminate the building of inadequate and nonfunctional facilities.

RECOMMENDATION 9. The Committee recommends that adequate facilities be provided in every school for laboratory-oriented science instruction in grades K-12.

Rationale: The Committee feels that school systems should review the requirements for adequate science facilities and develop a plan of improvement for their schools. Priorities should be specified and a yearly plan of action designated. Each year the priorities should be reviewed and evaluated. This process should show gradual improvement of science facilities across the state and, in turn, help enhance a laboratory-oriented science curriculum.

RECOMMENDATION 10. The Committee recommends that additional state funds be appropriated on a per pupil basis (K-12) for the purchase of science laboratory equipment, materials, and supplies and for the maintenance and repair of equipment.

Rationale: The Committee recognizes that a laboratory science program is one of the more expensive components of the curriculum. The inflationary rate, coupled with the reduction of federal funds, could cut into the schools' purchasing power. The studies of Coble and Rice (1) and Weiss (28) indicate the following factors as giving the greatest degree of difficulty in teaching science: a) lack of supplies and equipment, b) insufficient funds, and c) not enough materials to individualize instruction. The Committee feels strongly that additional financial support from the state is necessary during these inflationary times if a laboratory program is to be maintained. The dollar amount of such support should be determined by school needs, inflationary trends, and state assets.

RECOMMENDATION 11. The Committee recommends that an annual inventory of science equipment, materials, and supplies be made in each school and be accessible ~~to~~ all teachers responsible for science instruction.

Rationale: Weiss (28) has found that some types of equipment are available in many schools but are used in relatively few classes. The Committee feels that this recommendation will encourage the use of the equipment by all staff members. The tendency for certain staff members to store pieces of equipment in their classrooms and to use these items exclusively should be addressed in each school and avoided. The inventory also would help new staff members become acquainted with the school's resources. It would help science faculties in planning for future purchases and repair of equipment and in setting priorities for spending limited funds.

RECOMMENDATION 12. The Committee recommends that adequate textbook funds be provided in grades 9-12 to ensure that every science student is provided a science textbook from the most recently state-adopted list.

Rationale: Eight dollars per student per year is not sufficient to purchase the needed textbooks at the high school level. Many high school science texts cost as much as twelve dollars. Some schools are having to use local funds or to use previously adopted books for some of their courses. The Committee feels that implementation of the above recommendation would ensure that the most current textbooks would be utilized in every science course.

RECOMMENDATION 13. The Committee recommends that:

a) *emphasis be placed on safety standards in each science teacher training program.*

b) *provisions for current safety standards be emphasized in planning all science laboratory facilities.*

c) *each LEA designate key personnel at the school level and system level to be responsible for the organization and implementation of a science safety program.* (Continued)

d) *each LEA conduct an annual science safety inventory of facilities, equipment, materials, and supplies.*

e) *efforts be made to limit each laboratory science class to a maximum of 24 students, grades 7-12.*

f) *a plan for the disposal of hazardous substances in schools be developed by the State Department of Public Instruction and coordinated with other branches of State Government.*

Rationale: Data show that a majority of science teachers have had little or no safety training in their preservice education. The Committee feels that science education professors have an obligation to review all commonly known safety standards and practices with their students. This, in turn, should reduce the number and seriousness of laboratory accidents.

Architects and school planners should think of certain safety standards, over and above the ones prescribed by law, when designing new science facilities. It is believed that the implementation of this recommendation will reduce the number and seriousness of laboratory accidents.

The Committee feels that the only way to achieve a safe laboratory environment is to constantly give attention to keeping the program and facilities safe. It is recommended that LEAs focus on safety in two ways: 1) by having a key person in charge of conducting a safety program and 2) by conducting an annual safety inventory of facilities, equipment, materials, and supplies. These recommendations should produce a greater sensitivity to safety in the laboratory on the part of administrators, teachers, and students and a reduction in the number and seriousness of laboratory accidents.

The National Science Teachers Association has determined that no more than 24 students can participate safely in a laboratory situation. It is particularly important to note that some of the introductory courses in physical science and biology may have 30 to 35 students in a class. The Committee feels that this is unsafe and that such a large number of students in one class should be avoided, if at all possible.

Many schools have dangerous chemicals in their science stockrooms. Many of these chemicals have been identified as possible carcinogens. Others are known to be highly explosive. The question in the minds of many school administrators is how to dispose properly of such chemicals.

RECOMMENDATION 14. *The Committee recommends that salaries be increased for appropriately certified science teachers who have a majority of teaching responsibilities in science to levels more competitive with comparable positions in industry and government.*

Rationale: The National Education Association states that in 1978-79 a person with a bachelor's degree in math/science could receive a third more pay from private industry than from teaching. The Committee feels that the state should look at supply and demand when paying science and mathematics teachers. The increase in pay plus other incentives should help to attract and retain competent science teachers. Increased pay will help stop the exodus of the better qualified science teachers to industry and help to relieve the teaching shortages, particularly in the physical sciences.

RECOMMENDATION 15. *The Committee recommends that science teachers be provided more employment opportunities such as 12-month employment, summer school teaching, consultative services, and/or extended day activities, and be compensated at their regular monthly salary rate.*

Rationale: The Committee feels that many science teachers could be utilized in educationally-sound ways to extend their term of employment beyond the normal 10-month period. Twelve-month employment could be utilized to write curriculum, seek additional training, and organize materials for teaching. Many teachers could be used to teach summer courses for regular summer school programs. Others could be used to provide enrichment science courses for gifted students. Still others could be used on a consultative basis by parks, zoos, nature museums, and businesses to develop informative materials for the general public. The Committee urges that an organized effort be initiated to utilize the expertise of science teachers in order to extend their time of employment.

RECOMMENDATION 16. *The Committee recommends that the establishment of more scholarships by government, business, and industry to support undergraduate and graduate students in science education be encouraged.*

Rationale: The Committee feels that a scholarship/loan program would help to defray costs of college programs. The program could possibly help retain some of the 30% of the first-year teachers who are lost to other professions. Most students would be under a four-year commitment to teach after having received four years of financial assistance. The Committee feels that the program should be extended to include graduate-level science programs since only

25% of the state's science teachers have master's degrees compared with 50% of science teachers nationwide. The scholarship program would be another incentive to attract competent people to the science teaching field.

RECOMMENDATION 17. *The Committee recommends improving science teaching in grades 7-12 by:*

a) *providing time for all science teachers to set up and manage safe laboratory activities.*

b) *scheduling for all science teachers a minimum of course preparations, preferably two.*

c) *providing each science teacher clerical help when needed.*

d) *providing aides in each science class when needed.*

Rationale: Small salary incentives are not enough to maintain consistently-high science teacher morale. The Committee recognizes that improved working conditions must also be a part of the plan to attract and keep competent teachers. The Committee feels that the assignment of teaching loads is of prime importance to a successful science program. Too many course preparations can affect a teacher's ability to plan and conduct desirable laboratory-oriented courses. The Committee also recognizes that laboratory courses require additional time for planning, setting up, and conducting. A planning period during the school day is highly desirable. Unencumbered time before and after school should also be considered. A person who is chairing a Science Department should be given additional time to conduct the chairperson's duties and responsibilities. Clerical assistants and laboratory aides could also play a major role in making science teaching more desirable. If funds are limited, then an organized program utilizing advanced high school students should be developed.

RECOMMENDATION 18. *The Committee recommends that in-service programs:*

a) *receive increased emphasis for the improvement of K-12 science teachers' competencies in subject matter, teaching methodology, and learning theories.*

b) *be planned and implemented by persons and institutions recognized as having professional and academic qualifications and resources essential to professional quality.*

c) *be designed to provide for continuous training, ultimately meeting specific needs and interests of educators.*

d) *be conducted on a continuing basis for administrators of each LEA, concerning trends and issues in science education.*

Rationale: In her national study of science teachers, Weiss (28) claims that areas in which a sizable number of teachers would like additional assistance include: obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using manipulative or "hands-on" materials. The Committee feels that the general thrusts of staff development should be in the direction to produce science teachers who are competent in subject matter, teaching methodology, and learning theories.

The Committee feels that in-service programs should be conducted by professionals who have the academic qualifications, as well as the essential resources, to make the program one of highest quality. Systems should avoid taking the "cheapest" way out by hiring a less qualified individual when a better qualified person is available. Also, systems should avoid selecting in-service leaders at the "last minute." This usually brings about a reduction in quality of the program. Master teachers should be utilized whenever possible.

The NSF Review (26) states that "in-service programs and activities appear in many instances to be developed to meet a specific need at a particular time with little thought to sequence and continuity of in-service programs. The net effect is often of the patchwork or band-aid variety with little or no evaluation of programs and activities being done." The Committee feels that in-service activities should be conducted to meet the identified needs of science teachers. The in-service program should emphasize the continuous growth of the professional science teacher and help transform this person into a master teacher. Credit should not be given to teachers for courses that are not related directly to their teaching assignments.

The Committee also recognizes the importance of keeping administrators abreast of the most current trends in science education. Administrators are the instructional leaders and evaluators, and often control the funding levels of instructional supplies. Administrators must, therefore, be made aware of the major trends and needs in science education.

RECOMMENDATION 19. The Committee recommends that additional preservice and in-service programs include training in the use of appropriate technologies.

RECOMMENDATION 20. The Committee recommends that each LEA seek help and cooperation from industry in providing science programs which make use of current technology.

Rationale: The question arises as to whether science personnel of North Carolina are prepared and trained to capitalize on the use of innovative technologies for science instruction. Preliminary sketches of information seem to indicate that training in the use of calculators and computers is usually based on personal interests of science teachers rather than on a well-coordinated plan of training and usage. Weiss (28) indicated in her 1976-77 study that while 36% of all 10-12 schools surveyed had computers, only 9% of 10-12 science classes ever used them. The Committee feels that the leadership of the Governor, SDPI, and key universities should be utilized to train hundreds of additional science teachers in the use of innovative technologies. It also feels that industry can play a key role in providing expertise and equipment for such an endeavor.

RECOMMENDATION 21. The Committee recommends that the State Department of Public Instruction (Division of Science) appoint and work with a committee to study the levels of, and requirements for, science certification and to present recommendations to the Division of Teacher Education Standards and Certification.

RECOMMENDATION 22. The Committee recommends that subject matter competencies be listed for each level of certification.

Rationale: The Committee feels that certification levels should be more refined than in the past. Each level has specific subject matter competencies and professional competencies that could and should be clearly delineated for students and institutions alike. The Committee feels that, in many instances, the science backgrounds of the 4-6 and 6-9 teachers of science should be broadened in the various areas of science. At the same time, the uniqueness of the students at these age levels makes an increase in competencies in learning theories and methodology also appropriate.

The Committee also feels that an increase in subject matter competencies should be required for the 300 certification, which allows a teacher to teach all sciences. The subject matter competencies should include study in the four major areas of earth science, biology, chemistry, and physics as opposed to concentrating most of the science course work in just one area. Hopefully, this will provide a teacher with a broader base of science subject matter.

RECOMMENDATION 23. The Committee recommends:

a) the employment of a science specialist (supervisor, coordinator, consultant) at each Local Education Agency to work with the teachers at the school level to implement and maintain the science curriculum in North Carolina.

b) the employment of science consultants for the eight state regional centers to work with central office staff and teachers in the local school systems to implement and maintain the science curriculum in North Carolina.

Rationale: The Committee feels that the employment of science specialists at the regional centers and in LEAs is mandatory if the schools are expected to implement the other recommendations in this study. Of the 143 LEAs in North Carolina, only seven have full-time science supervisors while eight other LEAs have supervisors with dual responsibilities, usually science/math. Additional personnel with science expertise will be required if the science program revision is to be a success. This is particularly true at the elementary level and middle school level.

Results from Implementation of Recommendations

The Science Curriculum Study Committee, in planning and organizing for the study of the state science program, divided the study into three major areas: curriculum; facilities, equipment, and materials; and staff. Each area of the science program must be strengthened in order to achieve excellence. Improvements in the curriculum would not likely be effective if changes are not made in the staffing of this program. Likewise, changes in the area of facilities alone are not enough to ensure a quality science program. The success of improvements in one area of this study is dependent upon the improvements being made in the other two areas.

If the recommendations of this Committee are accepted and implemented, the following improvements will be expected in the science program:

1. Increased science achievement of students at all levels.
2. Increased enrollment in science courses.
3. Increased instructional time allotted to the teaching of science.
4. Improved and more comprehensive course of study.

5. Improved evaluation of basic science skills at grades 3, 6, and 9.
6. Improved science facilities for science laboratory instruction.
7. Additional science equipment, materials, and supplies.
8. Sufficient secondary level textbooks to ensure each science student a current science textbook.
9. A systematic approach to equipment repair and maintenance.
10. Better use of science equipment and materials by science staffs.
11. Better acquisition and use of current technologies such as computers in the science program.
12. A greater emphasis on safety in the science laboratory.
13. More competent science teachers with proper certification.
14. Improved conditions of the science teaching profession, making it more attractive.
15. Improved preservice and in-service programs for science teachers, administrators, and other school personnel.
16. A more scientifically-literate society.

All of the above improvements are worthy of consideration. The Committee feels that the State Board should direct the Division of Science to develop a plan of action, including a time line, to implement the needed improvements. This plan of action should be adhered to in order to ensure an orderly and progressive improvement of science education across the State of North Carolina.

CHAPTER 1

ORGANIZATION OF THE STUDY

Formation

The Science Curriculum Study Committee was appointed by Dr. A. Craig Phillips, State Superintendent of Public Instruction, in late April 1980 after the State Board of Education approved the study. The Committee was formed in response to a need to study the total science program as observed and expressed by educators in all capacities and at all levels throughout North Carolina.

Purpose

The purpose of the Science Curriculum Study Committee was to thoroughly review and study the status of the state science program and to develop recommendations which, upon implementation, would significantly improve the quality of the total science program in North Carolina, grades K-12.

Committee

The Science Curriculum Study Committee was composed of 24 members representing various groups and backgrounds as follows:

- Six teachers--one K-3, one 4-6, one life science, one earth science, one biology, and one chemistry/physics
- Four local supervisors--one half-time science, half-time teacher; two science/math; one general
- Three principals--one elementary, one middle, one high school
- Three university science educators
- One assistant superintendent
- One university scientist
- Two industrial scientists
- Two parents
- Two students.

State geographical representation was evident in the Committee with members from the mountains to the coast and the Virginia State line to the South

Carolina State line. Also evident was the composition of the Committee by race and sex, with 16 white and 8 minority members; 17 male and 7 female members.

Support Staff

In addition to the Committee, members of the Department of Public Instruction played an active role in working with and providing assistance to the Science Curriculum Study Committee. The following DPI staff were involved, to varying degrees, in the study:

State Superintendent
Deputy State Superintendent
Assistant State Superintendent for Instr. Services
Deputy Asst. Superintendent for Instr. Services
Special Assistants for Instructional Services
- Elementary Education
- Middle Grades Education
- Secondary Education
- Curriculum & Administration

Division of Science Staff
- Director
- Assistant Director
- Consultants (3)
- Secretaries (2).

Pre-Committee Work

Once the decision had been made to conduct the Curriculum Study, with State Board of Education approval, a Coordinator within the Division of Science was chosen. The Coordinator, Division Director, Division staff, Asst. State Superintendent, and Deputy Asst. Superintendent, after much work and discussion, decided on the Committee composition. A recommended list of possible Committee members was compiled and then prospective members were individually invited to serve on the Committee. After all had accepted, one member was asked to serve as Chairman.

Committee Organization

Prior to the first Committee meeting, a form was given to local science supervisors and university science educators at their annual meeting requesting a list of major issues and questions facing science education, both nationally and statewide, which the Committee should address. The Division of Science staff also completed this form. A compilation of responses from the form led to a list of 20 major questions that fell into three major categories: Curriculum, Facilities, and Staff. The Committee was then organized into three subcommittees with the following areas of responsibility:

Curriculum	Scope Sequence
Facilities	Facilities Equipment Materials
Staff	Preservice/In-service Certification.

Procedure

Each subcommittee functioned under the leadership of a Chairperson with assistance from one member of the Division of Science staff. The subcommittees worked independently on their areas of responsibility. However, at the conclusion of each work session, subcommittees reported on their work and progress to the full Committee. The procedural plan of study of each subcommittee was:

1. Identification of major questions
2. Identification of related subquestions
3. Collection of background information and data pertaining to these questions
4. Analysis and discussion of data and information
5. Development of recommendations for science education
6. Identification of possible outcomes if recommendations are implemented.

Process

The first full meeting of the Science Curriculum Study Committee was held on January 5-6, 1981, with subsequent meetings averaging one per month through the last developmental meeting which was held June 23, 1981. Over the next several months, the Committee Chairman and Coordinator developed a full draft report from the work of the three subcommittees. Copies of the draft report were sent to each Committee member during the first week of January 1982.

Additionally, a summary of the draft report was sent to science supervisors and university science educators. Reactions to the draft were requested and received from these groups. The full Science Curriculum Study Committee met on February 3, 1982, for final revisions of this report. The completed report was then presented to the State Board of Education in the spring of 1982.

CHAPTER 2

BACKGROUND STATUS OF SCIENCE EDUCATION

Numerous national and world events in the mid to late 1950s reminded Americans that the United States was being challenged scientifically and technologically. The flurry of activity which followed for the next two decades in science education was unprecedented in the history of American education.

Activity began with numerous conferences to explore the possibilities for improving science education. These conferences were attended by a combination of prestigious research scientists, psychologists, science education professors, and public school educators. The mission of the participants in the conferences was to suggest ways and means of making the United States second to no other nation in the development of human potential in the technological race.

The ultimate outcome of conference deliberations was to attack the problems of science education on two fronts: 1) to update the K-12 science curriculum and 2) to train the teachers in how to teach the newly-developed programs. The federal government, primarily through the National Science Foundation, appropriated substantial funds for the development of major science curriculum projects at all levels. Major projects for elementary science, earth science, biological science, physical science, chemistry, and physics were all initiated and supported through federal funding. These curriculum developmental teams were comprised of research scientists, science education specialists, public school educators, psychologists, and learning theorists.

During the same period of time, millions of dollars also were spent in an attempt to train teachers to teach the newly-developed programs. Cooperative efforts among the National Science Foundation, colleges and universities, and the public school systems led to the development of academic year institutes, summer institutes, and leadership development conferences. Weiss (28) notes that attendance of teachers at National Science Foundation-sponsored workshops and institutes generally increased with increasing grade level, with almost half of all high school science teachers having participated.

The ERIC Clearinghouse for Science, Mathematics, and Environmental Education notes in its "Summary of NSF Literature Review in Science Education" (26) that the federal government also had a major part in funding science equipment and materials for public schools. The National Defense Education Act of 1958, the Vocational Education Act of 1963, the Economic Opportunity Act of 1964, and the Elementary and Secondary Education Act of 1965 permitted the use of federal dollars to purchase key support materials and equipment for science instruction. The report further indicates that 69% of the secondary schools and 66% of the elementary schools in an Ohio State University survey taken in the early 1970s used NDEA funds for the purchase of science equipment and supplies. The report concludes that since 1968, the financial assistance priorities established by federal programs and followed by states and most local schools have placed less emphasis on support for science education.

Based upon past program developments and the level of financial support, one might conclude that American science education would have an extremely high status when compared with other countries. In a report authored by Izaak Wirszup, professor of mathematics at the University of Chicago and an authority on Russian mathematics education, quite the contrary is true in regard to Russian education (30). Wirszup claims that every Russian youngster who completes 10 years of elementary and secondary schooling, as 98% reportedly do, has a thorough grounding in arithmetic, algebra, plane and solid geometry, plus two years of calculus, five years of chemistry, a year of astronomy, five and a half years of biology, and five years of geography.

By comparison, NSF studies found that only 9% of American high school graduates had one year of physics; 16%, one year of chemistry; 45%, one year of biology; and 7%, one year of general science. In 1976-77, over 56% of the districts responding to a NSF study indicated that they required no mathematics courses, or only one, for graduation from high school (24).

Efthalia and John Walsh in their article, "Crisis in the Science Classroom," claim that the Soviet's reform of science and math compulsory education and comparable efforts in other socialist countries and in friendly rivals such as Japan and Western Europe are seen as putting the U.S. future in question (27). The Russian's educational mobilization program in science and mathematics, now in its 16th year, is designed to prepare all Soviet youth to participate fully in an advanced technological society. The Walshs claim that the available data on the U.S. system of science education indicate that students "on the fast track, taking advanced courses," are as well or better prepared in science and math as American students have ever been (27). The problem comes in the under-representation of women and minority students in this select group and with the low level of competence in science among the large majority of students. The February 1, 1982, edition of Newsweek magazine (2) states:

> Students who know they want to specialize in science generally can find the training they need. It is the general students--tomorrow's businessmen, lawmakers, judges--whom the schools are failing. That widens the gap between the 3 million professional scientists and engineers and 224 million others who view technology as an undecipherable and threatening black box.

Based upon NSF-sponsored studies, two-thirds of the states require only one year of high school science for graduation, the other third require two years. Fifty percent of the high school students complete their science graduation requirement via a course in biology, usually in the 10th grade. There is, then, virtually no impact on these students relative to science in their last two years of high school. For most, their last physical science course is completed in junior high school.

Wirszup (30) concludes the following:

> The question is of a scientific elite. The United States has a superior elite in science and mathematics. But ours is a small elite, while the Soviets are training a new elite, a large elite, and the general population will be much more sophisticated in science and math than we are.

The challenge presented by other nations to the technological and scientific superiority of the United States citizenry is a critical reason for assessing the current status of science education in the United States and particularly in North Carolina.

Governor Hunt (5) recognized this challenge as an emerging crisis in his address to the Annual Meeting of the American Association for the Advancement of Science in January 1982 when he said:

> Much has been accomplished over the last 30 to 40 years by our prevailing structure of science and technology. Now, however, a crisis is emerging: U.S. output per man-hour has leveled off or declined in recent years. Results of basic research no longer percolate through our economy fast enough or effectively enough to increase productivity substantially. Education in the United States

> is less rigorous than that of several other nations. And we have not devised the organizational means to generate and use knowledge of how to manage land, water, and air resources properly and to minimize dangers associated with toxic, hazardous, and low-level radiation waste.
>
> In dealing with the emerging crisis, we must foster throughout society the creative potential of science and technology by technical and organizational innovation, which together constitute technological innovation . . . technological innovation must be construed as more than an end in itself. Its larger purpose is meeting the needs and desires of people. This is a function of values and beliefs and of political and economic processes. The emerging crisis I have mentioned is a reflection of such concerns. Government--particularly state government in partnership with academia, industry, and people--has a clear responsibility in resolving this crisis.

A second reason relates to the practical economic value of educating our citizenry so they are able to assume leadership and employment in higher paying technologically-based industries of the future. This has been repeatedly stated as a goal by Governor Hunt and Governors who preceded him.

The legislature responded to this need by providing funds to establish the North Carolina School of Science and Mathematics. However, a broad-based program for improving science and mathematics education in North Carolina is yet to be realized.

President Carter recognized the critical importance of studying our science and engineering educational programs in relation to their quality and in their ability to produce the number of graduates necessary to meet the long-term needs of our country. In February 1980, President Carter instructed the National Science Foundation and the Department of Education to collaborate on a study of the current state of science and engineering education in the United States.

The National Science Foundation and the Department of Education made their final report in October 1980 (24). Major areas of concern identified by NSF and DOE are as follows:

1. *The nationwide trend toward a reduction of time and courses devoted to science and technology taken by students during their K-12 education program.*

   This trend has been brought about as a result of several factors. At the elementary level, the focus on "basics" is having an impact on science teaching. Instructional time is devoted to the basic reading, language arts, and mathematics skills. Science is not viewed as basic. At the secondary level, school systems have reduced their high school graduation requirements in science with only one-third of the systems requiring more than one course to graduate.

2. *For students who are not interested in professional scientific and engineering careers, more emphasis needs to be placed on science curricula directed toward providing students with a better basis for understanding and dealing with the science and technology they encounter as citizens, workers, and private individuals.*

The earlier curriculum projects were developed around the "structure of the discipline--the concepts" and the scientific processes. These projects were designed to develop programs for future science and engineering majors. This mismatch of current courses in secondary science and the needs of a majority of our students must be rectified.

3. *More emphasis needs to be placed on electronic technologies and the role these technologies can play in addressing existing needs.*

Computers offer possibilities for more interactive instruction in science ranging from drill and practice to the simulation of complex problem situations. Computers might also afford more individualized diagnostic and performance testing that is more sophisticated than presently used multiple-choice techniques.

4. *Preparing and keeping an adequate number of science teachers to meet the personnel demands of the public schools.*

The report concluded that college students are not pursuing teaching careers or are leaving teaching careers shortly after entering, due to a lessening in the attractiveness of science teaching careers and because of more desirable employment outside of teaching. Based on the North Carolina Science Teacher Profile, Grades 7-12, 1980-81 (16), approximately one-third of the first-year secondary science teachers drop out during or immediately after their first year of teaching. The Profile further states that the "holding power" of the science teaching profession is greater for females than for males. Pay and benefits offered private sector employees, particularly in science-related fields, are often mentioned as major reasons for people leaving the teaching profession.

5. *Stopping the erosion of the teacher support system which helps to provide quality instruction to all students.*
There are many components of the teacher support system. The system includes the following: available support supervision to help answer certain pedagogical problems, adequate laboratory facilities and equipment, adequate textbooks, and adequate in-service and summer institutes for improving teacher competencies. In the past few years, financial support, particularly at the federal level, has declined drastically. Inflation has outpaced budget increases for equipment purchases and salary increases.

The five major areas of concern listed above formed the base from which the North Carolina Science Curriculum Study Committee launched its study of the science curriculum in the state's public schools.

The remaining chapters of this report focus on the problems and challenges associated with three major areas of the science program: 1) the science curriculum, 2) facilities and materials, and 3) competent staffing. All of the five areas of concern listed in the President's report are covered in one of the three major program areas listed above.

CHAPTER 3

CURRICULUM IN SCIENCE EDUCATION

The Purpose and Philosophy of Science Education (19)

The primary goal of science education is to ensure that each child who attends the public schools will become scientifically literate. Both the individual student and society are the beneficiaries when this is accomplished. Scientific literacy is imperative for the layperson as well as for the professional who chooses a career in science or in a science-related field.

The goal of science education may be realized through the accomplishment of the objectives of science instruction:

1. To learn certain scientific concepts and facts.
2. To develop the skill to manipulate and/or operate science equipment.
3. To become more proficient in science process skills such as: observing, predicting, interpreting data, classifying, controlling variables, inferring, formulating hypotheses, experimenting, measuring, and formulating models.
4. To acquire attitudes necessary for living successfully in and contributing positively to a technological society.
5. To foster intellectual development.
6. To develop an appreciation for the uses, benefits, and limitations of science to society.

Science is a basic and important aspect of everyone's intellectual endeavor. It is the underlying basis of technological advancements. Our way of life is constantly influenced by the end products of science. Our modern conveniences, our health, the basis of our economy, and our ability to wage war or encourage peace--all depend upon science in some way.

To many, the 20th century has come to be known as an age of science; it has been an era of constant change. Our young people must be prepared to meet the challenge of change. This challenge must be confronted with an innovative program supported by a competent staff, flexible and adaptable facilities, and an adequate budget.

All students must be provided science experiences that will assure them of developing concepts, attitudes, and skills which will enable them to live and function effectively in an everchanging scientific and technological society. Each student is an individual with individual interests, aspirations, and abilities--different from all others. Every child must succeed and find satisfaction in learning science. Opportunity for individual exploratory learning should be provided, as well as small-group and large-group learning situations, with a variety of teaching and learning media to suit individual needs.

A science program must recognize the interdisciplinary nature of science and allow students to see science as an entity as well as separate disciplines. Students also must see the relationship of science to mathematics, English, social studies, and other subjects in the curriculum. This can be accomplished by instructional programs which provide for proper correlation of science with other program areas. Emphasis on laboratory experiences is necessary for students to develop the skills of inquiry and an appreciation of the ways of science. The program should provide for an awareness of career opportunities in the field of science and how science is applied in the world of work. Valuable assistance can be obtained from industry and the community with this aspect of the program.

Project Synthesis, one of the most comprehensive studies of the status of science education as it exists in the U.S. at the precollege level, was recently presented to the National Science Foundation (3). A major task of the project was to identify, in very broad terms, the most basic goals or groups of goals (goal clusters) of science education. The goal clusters include learning outcomes related to 1) the individual, 2) societal issues, 3) academic preparation, and 4) career choice. They are defined here briefly:

> Goal Cluster I: Personal Needs. Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.
>
> Goals that fall into Category I focus on the needs of the individual. For example, there are facts and abilities one needs to be a successful consumer or to maintain a healthy body. One should have some idea of the many ways science and technology affect one's life. Knowing that is still not enough. Science education should foster attitudes in individuals which are manifested in a propensity to use science in making everyday decisions and solving everyday problems.

Goal Cluster II: Societal Issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

Category II goals relate to the needs of society. They pertain, for example, to the facts and skills a person needs to deal with the environmental and energy issues which affect society at large. In order to vote intelligently on science-related societal issues or participate in responsible community action, not only are specific facts and skills important, but also an understanding of the role of science in society, a knowledge of issues and how science relates to them, and a recognition that in providing the solution to one problem science can create new ones. Of course, to develop informed, concerned citizens and wise voters, science education also must be concerned with attitudes. It must instill in students a sense of responsibility, an appreciation of the potential of science to solve or alleviate societal problems and a sense of custodianship to protect and preserve that natural world with which science concerns itself.

A common element of personal and societal goals is the importance of the applications of science to problems of personal and societal relevance. In order for students to be able to apply science to such problems, it is necessary that they have an understanding of the problems, of the aspects of science which apply to the problems and of the relationship between science and these problems. Students should also have experience in the processes of applying science to the solutions of such problems.

Goal Cluster III: Academic Preparation. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

Goals in this category pertain to scientific ideas and processes which form a part of the structure of scientific disciplines, which may not be related easily to specific decisions about one's own life or about societal issues, yet which are necessary for any further study of science.

Goal Cluster IV: Career Education/Awareness. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.

Science classes in all disciplines and at all levels which prepare students to make informed career decisions regarding jobs related to science and technology would logically place emphasis on topics and learnings such as: awareness of the many possible roles and jobs available in science and technology including such careers as scientists, engineers, technicians, equipment designers, computer programmers, laboratory assistants, as well as in jobs which apply scientific knowledge in agriculture, nutrition, medicine, sanitation, conservation, etc.; awareness that persons of both sexes, all ethnic backgrounds, wide ranging educational and ability levels and various handicaps can and do obtain such jobs; awareness of the contributions persons in such jobs can make to society as a whole; knowledge of the specific abilities, interests, attitudes and educational preparation usually associated with particular jobs in which individual students are interested; a view of scientists as real people; a clear understanding of how to plan educational programs which open doors to particular jobs; a recognition of the need for science, mathematics and language arts coursework as well as a broad base in the social sciences to better understand the relationship between science and society; a knowledge of human and written sources for further information in all areas listed above.

Curriculum Recommendations and Rationales

RECOMMENDATION 1. The Committee recommends that science be considered basic to the curriculum and receive the equivalent of a full year of instruction each year in each grade K-8. It is also recommended that science courses be offered each year for students in grades 9-12.

John Dewey believed that the primary purpose of our schools is to develop in students the ability to think. In 1962, a National Education Association study entitled The Central Purpose of the School (9) made the following statement:

> The purpose which runs through and strengthens all other educational purposes--the common thread of education--is the development of the ability to think. We have assumed that a central purpose of the education is to contribute to the intellectual development of students and that the function of the curricula is to facilitate such development.

To think implies a learning process and that process requires students to read, write, compute, and use other skills. Thinking processes are well-retained once learned.

Based on current research of how students best learn, fundamental concepts of science must be experienced through "hands-on" activities which stress inquiry and thinking skills. Science, therefore, helps support the fundamental goal of American education. Lyle Jones (6), Director of the Thurstone Psychometric Laboratory at the University of North Carolina at Chapel Hill, has said, "Science may well be the subject best adapted to help younger children develop critical thinking abilities, positive attitudes toward their environment, and an understanding of the world they live in."

The Committee is concerned that science is not considered a basic course and, therefore, is not allocated an appropriate amount of the instructional day. According to the Beginning Teacher Evaluation Study commissioned by the National Institute of Education, the number of hours actually spent working influences pupils' learning more than any other factor, including methodology, educational philosophy, availability of technology, or classroom structure (7). Therefore, the amount of time actually spent teaching science is of prime importance.

According to a recent study (1) of North Carolina elementary science instruction, an average of 17.19 minutes per day is devoted to teaching science. This time is based on responses from teachers identified as the most effective teachers of science, K-6. Many supervisors of science think this average may be high if every elementary teacher were considered. It is feared that many elementary teachers do not teach science on a systematic basis. In many cases, science instruction is included only when reading, mathematics, language arts, and other disciplines have been covered.

Based on Coble and Rice (1), elementary teachers identified the following curriculum factors that give the greatest degree of difficulty in teaching elementary science:

1. Textbook too difficult for students.
2. Not enough time to teach science.
3. District/school emphasis on reading/math.

Weiss (28) concurs with her national study of science instruction. Curriculum factors affecting science instruction include:

1. Lack of materials for individualizing instruction.
2. Inadequate articulation of instruction across grade levels.
3. Lack of teacher planning time.
4. Belief that science and social studies are less important.
5. Inadequate time to teach the subject.
6. Inadequate teacher preparation and lack of teacher interest.
7. Inadequate student reading ability.

Additionally, the 1974-75 6th Grade State Assessment of Educational Progress in North Carolina indicated that lack of supplies and materials, poor facilities, and lack of teacher knowledge were the greatest handicaps to teaching science (15).

The Committee feels that science should be a basic component of a child's K-12 curriculum. Hounshell and Coble (4) argue this point in their article, "Science is Basic," in which they state:

> Science, too, is basic! It is basic because we live in an age of science and technology made possible through scientific discoveries. It is basic because we are, ourselves, exemplary scientific phenomena--a prime example of life itself. It is basic because our environment from Murphy to Manteo is science. It is basic because through science we can learn to think and to act rationally.

Many elementary teachers have stated they feel pressured to teach even more reading and mathematics which forces them to spend nearly all of the instructional time in these areas. Annual testing programs in mathematics, reading, and language arts ensure that students are screened for their progress in these areas. Teachers feel accountable to see that students make considerable gains in these disciplines.

Ironically, there is evidence that teaching more "hands-on" science experiences can result in improvements in reading, language development, and math. Wellman's research (29) led her to draw the following conclusions:

1. Active experience with science helps language and logic development.
2. Science instruction appears especially helpful for children who are considered physically or culturally "different."
3. Selected science activities accelerate reading readiness in young children.
4. Science activities provide a strong stimulus and a shared framework for converting experiences into language.
5. Reading skills stem from language and logic development, which comes after concepts are formed from repeated encounters with objects and events. Science experiences provide such encounters.

There are additional arguments for considering science a basic component of the curriculum. Elementary science can be a motivational tool for most students. Educators should capitalize on the student's innate interest in the things called science. Science experiences can be used as invitations to children to count, measure, read, write, and debate. Thus, science lessons can and should be truly multidisciplinary in design and may involve major skills in reading, language arts, mathematics, health, and social studies.

North Carolina educators must also do their best to help students develop the necessary science background that will allow them to consider the many career possibilities in the science and health fields. The career opportunities are numerous and are among some of the better paid career options. Job opportunities associated with aerospace technology, computers, medical research, nutrition and other health-related fields, energy alternatives and production, plant and animal research, and environmental management will certainly be among some of the more prestigious positions in future years. The reindustrialization and modernization of many of North Carolina's important industries, such as textiles and farming, also will rely heavily on more knowledgeable and skilled workers.

A background in elementary science, with its general coverage of earth, physical, and biological sciences, will allow students to consider the vast opportunities before them. By tapping the many science-related interests of elementary children, impetus will be provided for further study in science by students in their later years of schooling. Hopefully, the dominant trend today whereby one-half of all high school graduates do not take any math or science courses after the 10th grade and effectively eliminate themselves from the possibility of a science or engineering career will be reversed.

One of the major arguments for considering science as a basic component of the North Carolina curriculum is its emphasis on problem solving, decision making, and thinking skills. A democratic society depends upon a citizenry that is intelligent and has the ability to consider many alternative solutions to a problem. On a larger scale, citizens of our country will decide alternatives and solutions to such science-related issues as nuclear energy, worldwide hunger, waste disposal, environmental management, and space exploration. Our educational system must meet the challenge of preparing children to think in order to function effectively in a free society. In North Carolina, many science-related issues that will directly affect the nature of our future economic development need to be solved. Improvements in farming, mining, fishing, and textiles are needed to stay economically-competitive with other states and foreign nations. Concern for the sound management of our natural resources has to be addressed by a larger number of scientifically-literate citizens.

In summary, science should be considered a basic component of the curriculum because of its multidisciplinary nature, motivational potential, career importance, and emphasis on thinking skills.

The Committee believes that systems should take steps to ensure that science is taught on a systematic basis. The basic science curriculum should be agreed upon by each school system and a systemwide plan be developed to ensure that science instruction takes place in the elementary schools as well as at the secondary level. Key personnel to involve in such a plan include the teachers, principals, and key central office staff members.

In recent years, block scheduling has become a popular method of scheduling in the middle school. Steps should be taken to ensure that science is taught as a year's equivalent during the block time and that other disciplines are not given a disproportionate share of the instructional day. A year's equivalent may be defined as not less than 135 hours of instruction in grades 7-8 and not less than 150 hours of instruction at grades 9-12.

> RECOMMENDATION 2. *The Committee recommends that The Principals' Institute provide staff development activities which identify alternatives for organizing and scheduling a balanced program in which science is assured the time and attention it deserves as one of the basics.*

Elementary schools are placing heavy emphasis on reading and mathematics with the prime time of the instructional day given to these instructional areas. Curriculum schedule models of the elementary instructional day should be studied and models developed that emphasize the appropriate coverage of science in the instructional day as well as all other program areas.

At the middle school and high school level many laboratory science courses require flexible scheduling. Laboratory activities often require a longer period of time than the normal 55-minute period. Effective use of block scheduling of a two-hour period should be studied along with other alternatives to ensure adequate time for proper science instruction.

> RECOMMENDATION 3. *The Committee recommends that science be included in the annual testing program in grades 3, 6, and 9.*

The Committee feels that there are specific basic skills associated with science instruction that should be mastered by all students by grades 3, 6, and 9. These skills should be thoroughly designated and explained to the educators involved in science instruction. Many of these skills involve decision-making and problem-solving modes of instruction rather than memorization of a group of scientific facts. The thinking skills are important to the democratic process and thus to the students and their future lives and careers.

Hopefully, by testing for basic mastery of science skills, elementary teachers will restructure their priorities and understand the importance of science instruction. The statewide testing program would allow science educators to focus on the important concepts, facts, and processes in science and would provide feedback to teachers and administrators as to their programs' effectiveness.

> RECOMMENDATION 4. *The Committee recommends that three units of science be required for high school graduation. These should include one unit of a life science or biology, one unit of a physical science (i.e., earth science, physical science, chemistry, physics), and one additional unit of a life science, a physical science, or an applied science (i.e., electronics, horticulture, or other technically-oriented vocational courses).*

If this recommendation is implemented, it will give students more exposure to science concepts. This is particularly important to the 50% of all high school graduates who do not take a science course beyond the 10th grade. Hopefully, more exposure to the physical sciences will occur and achievement will improve.

By allowing one of the requirements to be an applied science course, new career opportunities will be presented to the students. The applied science courses will offer additional understandings of science concepts for the non-college bound student.

The Committee recognizes that there will always be a difference in the amount of science training acquired by those who are interested in a science career and those who are not; however, the Committee feels that steps should be taken to minimize the widening of this gap. Other industrialized nations, including the Soviet Union, are placing heavy emphasis on science training of all citizenry and not just a small elite group.

The decline of achievement test scores has been the subject of general discussion and debate. Jones, as cited in the "Summary of NSF Literature Review in Science Education" (26), confirms the general picture of modest declines in science achievements for the Nation's youth from the mid-1960s to the late 1970s. He notes that for national samples from the National Assessment of Education Progress, a mean performance decline occurred in test scores for physical science for 9-, 13-, and 17-year-olds, and in biology for 17-year-olds. Increases in mean performance occurred in the test scores for biology at ages 9 and 13.

When comparing the 1978 National Assessment of Educational Progress results for mathematics with the 1973 results, overall performance of 9-year-olds and 13-year-olds declined slightly while there was an appreciable decline for 17-year-olds (26). A review of specific test items indicates that students at all levels are able to add, subtract, and multiply whole numbers about as well as they always have; however, there is a sharp decline in students' abilities to do problem-solving skills.

The various analyses of the results of the national assessments of science and math show that white males generally perform better than females or minorities. Females are improving on the tests but are still behind males. One of the more revealing pieces of evidence from the test analyses shows that measures of socioeconomic status are highly correlated to test performance. The higher the socioeconomic status, the better the child performs on the national assessments. For example, 9- and 13-year-old blacks who are identified as high socioeconomically perform near or above the overall performance of their contemporaries nationwide.

The general decline in science and math achievement has been thoroughly documented. The evidence from the analyses suggests this decline is taking place primarily among those students who are not planning careers in a science-related field. In fact, there is little average change in achievement for the high school students who elected to take Advanced Placement Tests in science. These students are generally planning to enter a science-related program and hold a career associated with science.

President Carter's Committee on Science and Engineering Education (24) summarized their findings concerning science achievement as follows:

> There has been a decline in average science and mathematics achievement for the Nation's youth over the last 15 years. Performance remained stable for the best students. In science, the declines have been more pronounced in physical science than in biology. In mathematics, the declines have been more pronounced on exercises involving application of concepts and problem solving than on those involving simple computation with whole numbers. White males generally performed better than females and minorities.

Are there specific reasons which can be identified that are causing the declines? The Advisory Panel on the Scholastic Aptitude Test Score Decline, as cited by Walsh and Walsh, estimated that as much as 75% of the declines between 1963 and 1970 can be accounted for by compositional changes in the mix of the SAT-taking group (27). However, the panel pointed out that the compositional changes in the mix from 1970 onward was insignificant. The panel suggested a number of other factors that might be responsible for the decline. These included: 1) a diminished seriousness of purpose in the learning process, 2) grade inflation, 3) generally lowered standards, and 4) a diminution of learning motivation among students.

Harnischfeger and Wiley, as cited in Science and Engineering Education for the 1980's and Beyond (24), argue that one of the strongest contributors to pupil achievement ought to be the exposure to the curriculum subject(s). If students do not take science courses, they will not do well on science achievement tests.

Terleckyj, as cited in Science and Engineering Education for the 1980's and Beyond (24), examined national sources of enrollment figures and determined that the proportion of students (grades 7-12) enrolled in science courses peaked in 1970-71 at over 69% and declined to 67% in 1972-73. Similarly, Welch (24), in the Presidential report on science education, found that 48% of grades 9-12 students were enrolled in at least one science class in 1976-77. This is considerably below the peak of over 59% in 1960-61, but is close to the figures for 1972-73.

Harms, as cited in Science and Engineering Education for the 1980's and Beyond (24), found there were approximately 17 million students enrolled in science classes in 1977. Of these science enrollments, over 80% were in grades 7 through 10. About one-half of the student time reflected by these enrollments was spent in the life sciences, about one-fourth in the physical sciences, and about one-fourth in the earth sciences. After grade 10, the situation changed dramatically. Chemistry accounted for only 6.9% of total secondary science enrollment while physics accounted for 3.1% of the total enrollment. From this information, one can conclude that one-half of all high school graduates take no science beyond 10th grade and only one-half of the students entering college have had any significant exposure to physical science beyond the 10th grade.

Table I (16) gives the breakdown of classes, student membership, and average class size per subject during school years 1978-79, 1979-80, 1980-81 for the students of North Carolina who were enrolled in science in grades 7-12. Eighty-six percent of the students were enrolled each year in the first four courses (life science, earth science, physical science, biology). Life science, earth science, and biology (life science) are state-required courses for all students. Physical science is required by many local school administrative units. Two units of science (life science [biology] included) in grades 9-12 are required for graduation.

There were 570 fewer classes of science during the 1979-80 school year than the previous year. This represents a drop of 21,714 students or a 5.68% decrease. There appears to be a much higher decline in 7th and 8th grade science enrollment than expected based on overall school enrollment data. The 7th grade science enrollment dropped by 8.44% while the total 7th grade school enrollment dropped by only 1.31%. The 8th grade science enrollment decreased by 13.56% while the total 8th grade school enrollment declined only 6.12%.

There were 403 fewer classes of science during the 1980-81 school year than during 1979-80. This represents a drop of 11,540 students or a 3.2% decrease. There were 13,951 or 2.75% more students enrolled in grades 7-12 for the 1980-81 school year while the science enrollment decreased. Each grade level shows a total enrollment increase ranging from 1,070 to 4,557 students. The major drop in science enrollment is in earth science, physical science, and biology, with 1,986 less students, 3,392 less students, and 7,173 less students, respectively. If the science enrollment had increased proportionately with the increase in total enrollment, grades 7-12, there would have been 21,000 more students enrolled in science. It should be noted that physics and marine science enrollments did increase.

The Committee feels that certain steps need to be taken to improve the science achievement of our students and encourage more to enroll in science classes.

TABLE I

Subject and Student Membership Summary
For School Years 1978-79, 1979-80, 1980-81* (16)

Subjects	School Year	Number of Classes			Student Membership			Average Class+		
		1978-79	1979-80	1980-81	1978-79	1979-80	1980-81	1978-79	1979-80	1980-81
0092 Life Science		2,512	2,308	2,361	68,762	62,955	63,780	27	27	27
0092 Earth Science		2,869	2,517	2,431	78,884	68,183	66,197	27	27	27
3010 Physical Science		3,096	2,975	2,856	82,868	77,603	74,211	27	26	25
3111 Biology		3,769	3,876	3,609	100,637	101,570	94,397	27	26	26
3120 Advanced Biology		388	376	366	8,079	7,553	7,284	21	20	19
3210 Chemistry		1,010	1,001	1,012	24,076	23,756	24,068	23	24	23
3220 Advanced Chemistry		99	103	98	1,484	1,585	1,535	14	15	15
3310 Physics		363	369	382	6,857	6,839	7,049	18	19	18
3320 Advanced Physics		9	7	9	130	162	162	14	23	18
3600 Applied Science		45	51	55	983	1,148	1,281	21	23	23
3700 Marine Science		31	37	52	748	815	1,142	24	22	21
3990 Special Interest Science		174	160	166	3,914	3,347	3,303	22	21	19
3991 Environmental (Ecology)		112	120	105	2,827	2,843	2,559	25	24	24
3992 Anatomy & Physiology		75	86	80	1,760	2,043	1,871	23	24	23
3993 Aviation Science		11	7	8	223	116	139	20	17	17
		14,563	13,993	13,590	382,232	360,518	348,978	26#	26#	26#

*The figures in this summary were collected at the end of the first month of the school year and reported on the PPAR forms.

+Rounded to nearest whole number.

#Represents student membership divided by number of classes.

RECOMMENDATION 5. The Committee recommends that the science course of study for grades K-8 for all schools be a program covering the life sciences, the earth sciences, and the physical sciences.

The K-8 grades would feature a general course of study and should be transdisciplinary and highly activity-oriented. Each year students would study concepts of life, earth, and physical science. The instructional techniques employed to teach these courses would include such things as "hands-on" experimentation and demonstrations, as well as textbooks. The curriculum would have many forces helping to shape it including: science concepts, principles, and facts; inquiry and investigative processes; emphasis on the interaction of science and society; the development of favorable attitudes toward science; career knowledge; and relationships of self and the environment.

RECOMMENDATION 6. The Committee recommends that the science course of study for grades 9-12 be composed of two types of courses: 1) a group covering a broad range of applied and technological courses, and 2) a group covering a broad range of rigorous academic courses.

The high school with such a science curriculum would permit students with different interests and abilities to select their own courses of study to fit their educational and vocational objectives. Hopefully, such a broad range of courses would attract more students, especially girls and minorities, into the science classes.

The applied and technological courses would stress the application of science to everyday problems and to the world of work. Mathematics would not be overemphasized in these courses.

The academic courses would be of a more abstract nature and be suitable for the student interested in pursuing a science-related career above the technical level. Considerable emphasis will be placed on mathematics in these courses.

Both groups will contain the traditional science courses (earth science, physical science, biology, chemistry, physics) usually offered in grades 9-12. The main difference will be content depth, emphasis on mathematics, and the emphasis given to application in regard to the world of work. Other courses included in the academic group may be advanced (2nd year) courses, advanced placement courses, and a variety of other electives. Other courses included in the applied/technological group may be a variety of courses of an exploratory nature and/or related to the world of work.

By increasing the number of science course requirements and by making the courses more relevant to the abilities of the students, the Committee believes that science achievement, science attitudes, and interests in science careers will improve.

CHAPTER 4

FACILITIES, EQUIPMENT, MATERIALS IN SCIENCE EDUCATION

Complementing Instruction

Adequate facilities, equipment, and materials help to ensure the success of a strong curriculum program. Sufficient space for preparation, storage, and student experimentation is a cornerstone of success in conducting many of the newly-developed science curricula. Attempting to teach science in a social studies or English classroom without modifications or provisions to meet experimentation requirements (ventilation, electricity, water, storage, and counter space) is not likely to be successful.

The success of the "hands-on" elementary science programs such as SCIS, ESS, and SAPA is dependent upon the adequate provision of needed materials and supplies. Instructional supplies and materials must be maintained and furnished on a consistent basis year after year.

The success of the middle school and high school science laboratory programs also is dependent on the provision of key science equipment and materials. Equipment, such as balances and microscopes, also must be maintained and kept in working order.

Without the provision of adequate facilities, equipment, and materials, an exciting experimentally-based curriculum can become a textbook-oriented program whereby students read the textbook, answer questions at the end of the chapter, and discuss any questions that might arise. This type of instructional approach, even though useful at times, is not the type of exciting, experimentally-based program that should be offered the students of North Carolina.

Science teachers and administrators consider science facilities as an important variable in teaching science. Based on data from a series of surveys conducted in the early 1970s, 94% of respondents rated science facilities in one of the two highest categories of important factors for a quality science program (26). Recent studies by Coble and Rice (1) and Weiss (28) reveal similar results. In these studies, inadequate science facilities were listed as a major factor affecting the science instructional program. According to the 1974-75 6th Grade State Assessment of Educational Progress in

North Carolina, 21% of elementary principals believed the greatest handicap to science instruction was inadequate facilities (15). "Facilities" was the third most frequently mentioned obstacle to effective teaching in science according to the 1975-76 9th Grade State Assessment of Educational Progress (14).

Based on the "Summary of NSF Literature Review in Science Education," a survey of 850 schools in seven states showed that about one-half of the schools lacked adequate laboratory space and about one-third lacked adequate storage space (26). Rogers, as cited in the Presidential report on science education (24), reported that more than 25% of all junior high schools surveyed had no laboratory facilities. There are no data to indicate that these conditions have changed or are different for North Carolina schools.

Facilities, Equipment, Materials Recommendations and Rationales

RECOMMENDATION 7. The Committee recommends that specifications be developed by the State Department of Public Instruction which identify adequate facilities for all children for K-12 laboratory-oriented science instruction.

The Committee feels that schools should be given directions and guidance in key aspects of the design of facilities including:

1. proper heat and ventilation (including fume hoods where needed)
2. electrical outlets where needed
3. water faucets and sinks where needed
4. room darkening capability
5. adequate facilities for large and small group instruction
6. adequate space for student project work
7. adequate flat-top tables and surfaces for student experimentation
8. adequate space, tools, and materials for building and maintaining equipment
9. adequate space and equipment for maintaining living plants and animals where needed
10. adequate space for storing equipment and materials
11. adequate provisions for the safe and secure storage and handling of hazardous materials
12. readily-accessible first-aid and safety equipment
13. adequate facilities and directions for disposal of waste materials.

The Committee recognizes that most school systems do not employ a full-time person for the planning of facilities. The members of the Committee see a major need for a review process to occur prior to the building of a school's science facilities.

RECOMMENDATION 8. The Committee recommends that all plans and specifications for new or renovated science facilities be approved by the Divisions of School Planning and Science of the State Department of Public Instruction.

This recommendation is intended to complement and supplement North Carolina Public School Law 115-130 which states: (22)

> Boards of education shall not invest any money in any new building that is not built in accordance with plans approved by the State Superintendent as to structural and functional soundness, safety, and sanitation.

Every school system in the State of North Carolina cannot afford the luxury of having a full-time person with the expertise needed to ensure that every plan for a new facility or for the renovation of existing buildings meets key standards that would enhance the science instructional program. The Committee feels that the Division of School Planning and the Division of Science should cooperate fully to develop a review process of all new and renovated science building plans. In the past, many systems have not capitalized on the facility planning expertise at the state level. Many buildings have been built that have inadequate exhaust systems, poor plans for chemical storage, unsafe laboratory work space, and nonexistent safety equipment.

In many instances, these problems could have been avoided at little or no additional costs by having someone with necessary knowledge of facilities review the plans prior to building. If this recommendation is implemented, the state should see an improvement in the safety and use of all new and renovated science facilities.

RECOMMENDATION 9. The Committee recommends that adequate facilities be provided in every school for laboratory-oriented science instruction in grades K-12.

The Committee recognizes that the improvement of facilities will take an enormous amount of funds and several years to implement, particularly in the present period of "belt-tightening economics." However, the Committee feels that the improvement process must start immediately.

School systems should review the requirements for adequate science facilities at all grade levels, K-12, as identified by the State Department of Public Instruction. Utilizing the planning expertise of the Division of School Planning and the Division of Science, each system should develop a plan of improvement of their science facilities. Priorities should be specified and a yearly plan of action should be designated. Each year these priorities should be reviewed and evaluated. This process should show gradual improvement of science facilities across the state and, in turn, help enhance a laboratory-oriented science curriculum.

North Carolina Public School Law 115-132 is stated as follows: (22)

> It shall be the duty of county and city boards of education and tax-levying authorities to provide suitable supplies for the school buildings under their jurisdiction. These shall include . . . equipment for teaching the sciences.

Coble and Rice (1) listed the following factors as giving the greatest degree of difficulty in teaching elementary school science: a) lack of supplies and equipment, b) insufficient funds, and c) not enough materials. Weiss (28) and the NSF Literature Review (26) also identified "insufficient funds for purchasing equipment and supplies" and "lack of materials for individualizing instruction" as factors affecting science instruction.

Since these surveys were conducted in the mid- to late 1970s, little improvement has occurred to improve the financing of adequate science materials and equipment. In fact, the members of the Committee feel that the financial picture for science education may have grown worse. High inflation rates have drastically cut into the schools' purchasing power. By maintaining the same spending levels of dollars, fewer materials and supplies are being purchased.

NSF reported in the "Summary of NSF Literature Review in Science Education" that 69% of all secondary schools reported using NDEA funds for science equipment purchases (26). With the federal assistance to science education being reduced drastically and being incorporated into block grants, this could have a dramatic impact on the amount of science equipment, materials, and supplies purchased by individual schools.

RECOMMENDATION 10. The Committee recommends that additional state funds be appropriated on a per pupil basis (K-12) for the purchase of science laboratory equipment, materials, and supplies and for the maintenance and repair of equipment.

The Committee feels that school administrators, state legislators, and the general public should recognize that certain aspects of the school program are more expensive than other components. Supplies and equipment for the arts and sciences are two of the most expensive items in the year to year operation of the instructional program. The Committee feels that every effort should be made to maintain and/or improve a laboratory-oriented science program at all levels, K-12. Additional financial support from the state is necessary during these inflationary times if this is to be accomplished.

The Committee is not recommending a specific dollar amount for each student. Close scrutiny of school needs, inflationary trends, and state assets must be taken into account in order to settle on a needed amount. During the 1981-82 school year, a figure of five dollars might be adequate. Five years from this school year, a figure of ten dollars might be necessary.

RECOMMENDATION 11. The Committee recommends that an annual inventory of science equipment, materials, and supplies be made in each school and be accessible to all teachers responsible for science instruction.

The Committee feels that this recommendation would encourage the use of all science equipment by all science staff members of a school. The tendency for certain staff members to store pieces of equipment in their individual classrooms and to use these items exclusively should be addressed in each school and avoided by all science staffs.

There are additional advantages that an annual inventory of science equipment, materials, and supplies affords to an individual school staff. New staff members have a readily-accessible list of a school's science materials without having to go from room to room to discover items for themselves. Also, an annual inventory gives a staff a basis for planning future purchases of equipment and setting priorities for spending limited funds. The inventory further allows a staff to review needed equipment repairs that should be made before a new school year begins.

RECOMMENDATION 12. The Committee recommends that adequate textbook funds be provided in grades 9-12 to ensure that every science student is provided a science textbook from the most recently state-adopted list.

Coble and Rice (1) identified the fact that the science textbook was the most important factor affecting what is taught in the elementary science classroom. Of the teachers surveyed, 50% reported using a single textbook as their science program; 20% used a multiple textbook adoption; while 22% used a combination of a textbook supplemented with one of the elementary curriculums (SCIS and ESS).

Weiss (28) concluded that the textbook continues to play a central role in science classes. She found that virtually all science classes use published textbooks. Approximately one-third of K-3 science classes use no published textbook. Approximately two-thirds of all other science classes use a single textbook, while one-third use multiple textbooks.

A survey of the educational representatives (teachers, principals, professors, students, and supervisors) on the Committee identified a problem concerning the provision of secondary science textbooks. The teachers and principals claimed that the total allocation of eight dollars per pupil per year at the secondary level is not an adequate expenditure for the provision of textbooks. Many textbooks cost as much as twelve dollars on today's book market (17). Not every child takes a science course, but the eight dollars also includes the provision for all the other textbooks the student uses.

The principals and teachers have said that the present system of textbook provision forces them to utilize old texts for certain science courses. For instance, if the school cannot afford new textbooks for every science course offered, the school staff does one of two things. First, the school may use local funds, if available, to purchase the needed textbooks. A second option is the continued use of a previously adopted textbook. Unfortunately, the latter option often is chosen since it is less expensive.

RECOMMENDATION 13. The Committee recommends that:

a) emphasis be placed on safety standards in each science teacher training program.

b) provisions for current safety standards be emphasized in planning all science laboratory facilities.

c) each LEA designate key personnel at the school level and system level to be responsible for the organization and implementation of a science safety program.

d) each LEA conduct an annual science safety inventory of facilities, equipment, materials, and supplies.

e) efforts be made to limit each laboratory science class to a maximum of 24 students, grades 7-12.

f) a plan for the disposal of hazardous substances in schools be developed by the State Department of Public Instruction and coordinated with other branches of State Government.

The Committee is concerned about providing the safest possible environment for the teaching of laboratory science. The experimental nature of science, its equipment, and chemicals all help to make science instruction more dangerous than most other instructional programs. The Committee members are particularly concerned about the following safety aspects of the science program:

1. The teachers' knowledge of safety standards and the proper implementation of such standards in the classroom.
2. The individual school's plan(s) to ensure safety in the science classroom.
3. The corrections of existing science facilities that lend themselves to unsafe science practices, i.e., improperly installed exhaust systems, inadequate laboratory space, etc.
4. Overcrowding of laboratory courses, particularly introductory physical science, which causes unsafe laboratory conditions.
5. Disposal of hazardous substances produced or obtained by the schools.

As a result of the implementation of the recommendations above, a safer environment for the teaching of science at all levels would be provided. These recommendations should produce a greater sensitivity to safety in the laboratory on the part of administrators, teachers, and students and a reduction in the number and seriousness of laboratory accidents. Committee members hope that the safety habits developed by students in the science laboratories will transfer into their daily lives.

CHAPTER 5

STAFF IN SCIENCE EDUCATION

A Profile of the North Carolina Science Teacher - 1980-81 (16)

There was a total of 3,587 teachers who taught one or more science classes in grades 7-12 during the 1980-81 school year. Of this total, 54.1% were female while 45.9% were male. White teachers comprised 78.5% of the total while black teachers made up 20.2%. Hispanic, American Indian, and Asian teachers made up the remaining 1.3%. A total of 71.2% of the science teachers were certified in a science area while 28.8% were not certified in any science. A majority (74.9%) of teachers held bachelor degrees only while 23.8% also held the master's degree. Only 0.6% of science teachers held advanced or doctor's degrees. This information is summarized in Table II below. The data presented represent all science teachers who taught one or more science classes in grades 7-12 during 1980-81. The certification data address individuals only and are not concerned with whether the individual is appropriately certified for the specific assignment(s) held during 1980-81.

TABLE II

Basic Teacher Information[*] (16)

Teacher Information			Number	Percentage
Sex	Male		1,647	45.9[+]
	Female		1,940	54.1
		Total	3,587	
Race	Black		724	20.2
	White		2,816	78.5
	Hispanic		5	0.1
	American Indian		35	1.0
	Asian		6	0.2
		Total	3,587	
Certification	Certified in Any Science		2,554	71.20
	Not Certified in Any Science		1,033	28.80
		Total	3,587	
Degrees	Bachelor's		2,688	74.9
	Master's		852	23.8
	Advanced Degree		12	0.3
	Doctor's		10	0.3
	Below Bachelor's		5	0.1
	Unknown		20	0.6
		Total	3,587	

[*]There were 22 fewer secondary science teachers in 1980-81 than in 1979-80. There were no significant changes in teacher certification or degrees held.

[+]Male teachers dropped by 1.8% from the previous year.

Approximately 30% of the first-year secondary science teachers drop out during, or immediately after, their first year of teaching. The "holding power" of the science teaching profession is outlined in Table III.

The most obvious trend in regard to sex displayed in Table III is that the "holding power" of the science teaching profession is greater for females than for males. As beginning teachers, males and females are equal in number. By the 12th year of teaching, females are in the majority by approximately 13%. It is of interest to note that male teachers with 9-11 years teaching experience are in a slight majority. However, this majority has dropped from 5.2% for the 1979-80 school year to 1.8% for the 1980-81 school year. Females are in the majority in all year categories beyond 9-11 years. By the time 31 years of experience is realized, females are in the majority by 63.3% to 36.7% (16).

TABLE III

Teaching Experience by Sex* (16)

Years	Teachers	Percentage	
		Female	Male
0-2	652	50.0	50.0
3-5	509	52.3	47.7
6-8	510	55.3	44.7
9-11	446	49.1	50.9
12-15	484	56.4	43.6
16-20	418	58.1	41.9
21-25	287	55.7	44.3
26-30	202	59.9	40.1
31-99	79	63.3	36.7
	3,587+	54.1#	45.9#

*Male teachers with 9-11 years teaching experience were in a slight majority by approximately 1.8% compared to 5.2% for the 1979-80 school year.

+Actual number of teachers who taught one or more classes in grades 7-12.

#Represents percentages of actual number of teachers (3,587).

Decrease in Staff Support

The National Science Foundation and the Department of Education found that there was a serious erosion of the support system for science teachers (24). NSF states that there are relatively few persons available outside the classroom to assist teachers with pedagogical problems and to ensure quality control. NSF also feels that as a result of major shifts in their funding priorities, continuing educational opportunities for science teachers have been reduced. Summer institutes for science teachers have been drastically cut in funding by NSF. Of those institutes that have been funded, the financial rewards and incentives for teachers have been eliminated. No longer do NSF-sponsored institutes pay teachers to attend their programs and, in many instances, do not pay all the expenses involved in attending the institute. Now science teachers must attend these institutes on their own time without compensation and, in many instances, must pay partial expenses of the institute.

Staff Recommendations and Rationales

RECOMMENDATION 14. The Committee recommends that salaries be increased for appropriately certified science teachers who have a majority of teaching responsibilities in science to levels more competitive with comparable positions in industry and government.

The Committee feels that steps must be taken to retain competent science teachers and to make the science teaching profession more attractive to prospective science teaching personnel. It feels that the public school system should review the pay scales of our universities and colleges and see that in order to maintain competent staff in disciplines such as medicine, the natural sciences, and computer science, differential pay is common practice. The Committee feels that increased pay incentives for science teachers should be studied and, if feasible, implemented. It is hoped that by increasing the pay for science teachers more appropriately certified people will seek teaching positions when vacancies occur and help to reduce teacher shortages, particularly in the physical sciences.

Many critics of science education feel that the major challenges facing public education in the near future revolve around the problem of training and retaining competent staff members. Jerome Marco, principal of Walt

Whitman High School, whose student body annually produces a large number of National Merit Scholar Finalists, states: "You can have the greatest equipment and the greatest curriculum, but if you don't have people who can translate concepts into skills, well then, forget it" (27).

Some critics feel that the more competent science teachers are being drained from the teaching field by industry. Larger salaries, improved benefits, and better working conditions are among the many reasons often mentioned by teachers who are leaving the profession. The National Education Association reports that during 1978-79, a person with a bachelor's degree in mathematics/science could expect to receive only three-quarters as much salary as a teacher as he or she could receive from private industry (24). This disparity in salary certainly leads many dedicated professionals to review their career goals.

> RECOMMENDATION 15. *The Committee recommends that science teachers be provided more employment opportunities such as 12-month employment, summer school teaching, consultative services, and/or extended day activities, and be compensated at their regular monthly salary rate.*

The Committee feels that many science teachers could be utilized in educationally-sound ways to extend their term of employment beyond the normal 10-month period. Twelve-month employment could be utilized to write curriculum, seek additional training, and organize materials for teaching. Many teachers could be used to teach summer courses for regular summer school programs. Others could be used to provide enrichment science courses for gifted students. Still others could be used on a consultative basis by parks, nature museums, zoos, and businesses to develop informative materials for the general public. The Committee urges that an organized effort be initiated to utilize the expertise of science teachers in order to extend their time of employment.

> RECOMMENDATION 16. *The Committee recommends that the establishment of more scholarships by government, business, and industry to support undergraduate and graduate students in science education be encouraged.*

The Committee feels that a scholarship program similar to the North Carolina Prospective Teacher Scholarship/Loan Program should be initiated for science education and physical science teachers particularly. This program would pay a certain amount toward a student's college expenses each year for the duration of the student's program. The scholarship/loan would not have to be repaid if the student taught in the public schools for the same number of years as he/she received financial assistance. The Committee feels that the standards should be high for entry into the scholarship/loan program and that the amount offered each year should be a substantial amount of money to help defray college expenses.

The Committee feels that the program should be extended to include graduate-level science programs since only 25% of the state's science teachers have master's degrees compared with 50% of science teachers nationwide (16). A concerted program effort should help to narrow this disparity.

This type of scholarship/loan commitment could possibly help retain some of the 30% of the first-year teachers lost to other professions. Most students would be under a four-year commitment to teach after having received four years of financial assistance. Within four years, students should be able to work out many of the problems associated with the initial year of teaching.

The Committee would like to see business and industry encouraged to develop scholarship programs directed at developing prospective science teachers. Our nation has always remained strong because private enterprise has filled the needed financial voids of society. Our needs for increased science teaching personnel should be heavily publicized and promoted at the state and college levels. This promotion of our needs will help to guide the development of key industrial scholarship programs.

RECOMMENDATION 17. *The Committee recommends improving science teaching in grades 7-12 by:*

a) *providing time for all science teachers to set up and manage safe laboratory activities.*

b) *scheduling for all science teachers a minimum of course preparations, preferably two.*

c) *providing each science teacher clerical help when needed.*

d) *providing aides in each science class when needed.*

The assignment of teaching loads is of prime importance to a successful science program. If teachers, particularly beginning teachers, are given a large number of laboratory course preparations, this has to limit the amount of time a teacher can devote to planning each course. Too many course preparations could certainly affect a teacher's ability to plan and conduct a desirable lab-oriented course. The Committee feels that principals should schedule science teachers for a minimum number of course preparations--if possible, a maximum of two.

The Committee further feels that as much unencumbered time as possible should be provided for science teachers to set up and manage safe laboratory activities. A planning period during the school day is highly desirable. Unencumbered time before and after school should also be considered. A person who is chairing a Science Department should be considered for additional time to conduct the chairperson's duties and responsibilities.

Clerical help and aides could also play a major role in making science teaching more desirable. If finances are not available to provide adult aides and clerical assistants, then an organized program of advanced student laboratory aides and clerical assistants should be developed. These programs could be a part of the science or vocational curriculums at the high schools. As much time and consideration as possible should be provided to make this program beneficial to the science students, the aides and assistants, and the teachers involved.

RECOMMENDATION 18. The Committee recommends that in-service programs:

a) receive increased emphasis for the improvement of K-12 science teachers' competencies in subject matter, teaching methodology, and learning theories.

b) be planned and implemented by persons and institutions recognized as having professional and academic qualifications and resources essential to professional quality.

c) be designed to provide for continuous training, ultimately meeting specific needs and interests of educators.

d) be conducted on a continuing basis for administrators of each LEA, concerning trends and issues in science education.

The Committee feels that each system, under the guidance of local and state supervisors, should determine the needs and priorities of the science instructional staffs. In-service activities should be conducted to meet the identified needs. These activities should be conducted by competent professionals. The in-service program should emphasize the continuous growth of professional science teachers. Master teachers and their expertise should be utilized whenever possible.

The Committee feels strongly that in-service credit should not be given to science teachers for courses that are not related to their teaching assignments. It also feels that a commitment of providing quality in-service programs to all science teachers must be given high priority.

The Committee also recognizes the importance of keeping administrators abreast of the most current trends in science education. Administrators are the instructional leaders and evaluators, and often control the funding levels of instructional supplies. Administrators must, therefore, be made aware of the major trends and needs in science education.

As stated earlier, the federal government's role in in-service institutes has diminished greatly over the last 10 years. NSF claims that there has been research conducted that shows that at the elementary level, there was an increase in student activity in classes where teachers participated in in-service programs involving the use of science curriculum project materials (26).

Weiss (28) also claims that in her national study of science teachers that more than 75% of all science teachers indicated that they do not usually need assistance in lesson planning, actually teaching lessons, and maintaining discipline. Weiss claims that areas in which a sizable number of teachers would like additional assistance include obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using manipulative or "hands-on" materials.

NSF claims that in-service education means different things to different people (26). Several broad goals of in-service education are identifiable: knowledge acquisition, skill training, attitude change and development, general self-improvement, and program knowledge and implementation.

NSF further states the following about in-service activities: (26)

> Generally, in-service activities have been designed to help experienced teachers keep current in their content area or gain new skills. In-service education activities have tended to ignore the problems of beginning teachers and have failed to help beginning teachers become master teachers. Instead, in-service activities have, in addition to improving content knowledge, concentrated on helping teachers deal with the proliferation of educational hardware, function

adequately in relation to new educational tasks (such as mainstreaming), or become more aware of information related to learning and instructional theory. Programs and activities appear, in many instances, to be developed to meet a specific need at a particular time, with little thought to sequence and continuity of in-service programs. The net effect is often of the patchwork or band-aid variety, with little or no formative or summative evaluation of programs and activities being done.

RECOMMENDATION 19. The Committee recommends that additional preservice and in-service programs include training in the use of appropriate technologies.

RECOMMENDATION 20. The Committee recommends that each LEA seek help and cooperation from industry in providing science programs which make use of current technology.

The Committee feels that science educators should act instead of react to the computer age. School systems should take the lead in preparing their staffs to be technologically-literate. Area business resources should be utilized to achieve this goal.

The explosion of computer technologies has made available to the educational community a vast array of hand-held calculators and personal computers. The question arises as to whether science personnel of North Carolina are prepared and trained to capitalize on innovative technologies in information and communication.

Preliminary sketches of information seem to indicate that training in the use of calculators and computers is usually based on personal interests of science teachers rather than on a well-coordinated plan of training and usage. Weiss (28) indicated that while 36% of all 10-12 schools surveyed had computers, only 9% of 10-12 science classes ever use them. This study was conducted during 1976-77 and, hopefully, science usage of computers has increased since that date.

The Committee feels that North Carolina is one of the most forward-looking states when it comes to use of computers. Under the leadership of Governor James Hunt, the State Department of Public Instruction, key university leaders, and the North Carolina School of Science and Mathematics, hundreds of teachers have taken introductory training in the use of personal computers. The Committee feels that this training should continue for hundreds of additional teachers.

RECOMMENDATION 21. The Committee recommends that the State Department of Public Instruction (Division of Science) appoint and work with a committee to study the levels of, and requirements for, science certification and to present recommendations to the Division of Teacher Education Standards and Certification.

RECOMMENDATION 22. The Committee recommends that subject matter competencies and professional competencies be listed for each level of certification.

Certification is a legal prerequisite (G.S. 115-155) for employment in the North Carolina public schools in all professional positions. Certification is issued to individuals by the Division of Teacher Education Standards and Certification, North Carolina Department of Public Instruction, upon the recommendation of a college or university after the individual has successfully completed an approved teacher education program.

The Committee feels that certification levels should be more refined than in the past. Each level has specific subject matter competencies and professional competencies that could and should be clearly delineated for students and institutions alike. The Committee feels that, in many instances, the science backgrounds of the 4-6 and 6-9 teachers of science should be broadened in the various areas of science. At the same time, the uniqueness of the students at these age levels makes an increase in competencies in learning theories and methodology also appropriate.

The Committee also feels that an increase in subject matter competencies should be required for the 300 certification which allows a teacher to teach all sciences. The subject matter competencies should include study in the four major areas of earth science, biology, chemistry, and physics as opposed to concentrating most of the science course work in just one area. Hopefully, this will provide a teacher with a broader base of science subject matter.

Table IV portrays certification criteria used in defining certification in regard to the science subjects assigned to a teacher to teach. The designations in this table were used in determining the percentage of teachers who were appropriately and inappropriately certified to teach each subject.

TABLE IV

SUBJECT AND CERTIFICATION AREAS (16)

Subjects	Science 300	General Science 301	Earth Science 302	Physical Science 303	Biology 310	Physics 320	Chemistry 330
Life Science (7th)	X	X			X		
Earth Science (8th)	X		X				
Physical Science (9th)	X	X		X		X	
Biology (10th)	X				X		
Advanced Biology	X				X		
Chemistry	X			X			X
Advanced Chemistry	X			X			X
Physics	X			X		X	
Advanced Physics	X			X		X	
Applied Science	X	X	X	X	X	X	X
Marine Science	X				X		
Special Interest Science	X	X	X	X	X	X	X
Environ-mental (Ecology)	X	X			X		
Anatomy & Physiology	X				X		
Aviation Science	X			X		X	

The criteria used to establish Table IV are not correlated totally with state standards which govern who may teach what and be considered appropriately certified. For example: A teacher with intermediate certification may teach science in grades 7-8 and be considered appropriately certified according to state standards. In other words, a person who has an intermediate certificate with a concentration in mathematics might be teaching earth science at the 8th grade level. Table IV would indicate that this teacher is inappropriately certified to teach earth science since the teacher's concentration is not in science or earth science. According to state standards, this teacher would be considered appropriately certified since he/she holds an intermediate certificate.

Another fallacy in the current certification standards appears when considering an individual teacher who holds the science 300 certification, which represents the broadest and most comprehensive certification a teacher of science may hold. With this certification, teachers are considered appropriately certified to teach all sciences when, in actuality, they may have never received any formal training or course work in the area they are instructing. In the final analysis, the percentage of inappropriately certified science teachers is much higher than records indicate in the <u>North Carolina Science Teacher Profile</u>.

Table V shows a relationship between courses taught and certification of teachers who taught them during the school year 1980-81. When compared to upper level teachers, a large percentage of life, earth, and physical science teachers were inappropriately certified for their assignments. The percentage of appropriately certified teachers increased in 1980-81 by 0.3% for grades 7-12.

Only 52% of the teachers who taught science in grades 7-9 were appropriately certified for their assignments. It is interesting to note that 59% of the student science enrollment was in grades 7-9. Eighty-six percent of the teachers who taught science in grades 10-12 were appropriately certified. Approximately 98% of those who taught advanced biology were appropriately certified. Physics, environmental (ecology), and aviation science had the highest percentage of inappropriately certified teachers in grades 10-12 (16).

TABLE V

SUBJECTS AND CERTIFICATION (16)

Subjects	Teacher Count	Percentage	
		Appropriately Certified	Inappropriately Certified
0092 Life Science	881	53.8	46.2
0092 Earth Science	870	41.8	58.2
3010 Physical Science	1,018	60.2	39.8
3111 Biology	1,177	86.2	13.8
3120 Advanced Biology	265	97.7	2.3
3210 Chemistry	392	88.0	12.0
3220 Advanced Chemistry	83	95.2	4.8
3310 Physics	287	72.1	27.9
3320 Advanced Physics	8	100.0	0.0
3600 Applied Science	35	85.7	14.3
3700 Marine Science	28	89.3	10.7
3990 Special Interest Science	104	82.7	17.3
3991 Environmental (Ecology)	58	74.1	25.9
3992 Anatomy & Physiology	46	91.3	8.7
3993 Aviation Science	8	62.5	37.5
	5,260*	68.3+	31.7+

Table VI lists the total number of classes per subject taught. It also gives the percentage of classes per subject taught by appropriately certified teachers and the percentage of classes per subject taught by inappropriately certified teachers. The total number of classes taught in 1980-81 in grades 7-12 was 13,590. The display of data presents a clear picture of the relationship between classes taught and the certification of the teacher on a per class basis.

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*Considerable duplication exists in the 5,260 teacher count. In fact, 1,673 (5,260 - 3,587 = 1,673) of that number represent duplicated counts. This occurs when a teacher teaches more than one science course. For example, if a teacher teaches earth science and physical science, that person represents two of the 5,260 count--one for each course taught, regardless of the number of classes taught.

+Represents percentages of the teacher count (5,260).

TABLE VI

SUBJECTS AND CERTIFICATION PER CLASS (16)

Subjects	Classes	Percentages of Classes Taught by: Appropriately Certified Teachers*	Inappropriately Certified Teachers
0092 Life Science	2,361	62.2	37.8
0092 Earth Science	2,431	47.8	52.2
3010 Physical Science	2,856	66.8	33.2
3111 Biology	3,609	92.0	8.0
3120 Advanced Biology	366	97.5	2.5
3210 Chemistry	1,012	91.8	8.2
3220 Advanced Chemistry	98	95.9	4.1
3310 Physics	382	75.1	24.9
3320 Advanced Physics	9	100.0	0.0
3600 Applied Science	55	89.1	10.9
3700 Marine Science	52	88.5	11.5
3990 Special Interest Science	166	81.9	18.1
3991 Environmental (Ecology)	105	66.7	33.3
3992 Anatomy & Physiology	80	91.3	8.8
3993 Aviation Science	8	62.5	37.5
	13,590	73.0+	27.0+

In 1961, the National Association of State Directors of Teacher Education and the American Association for the Advancement of Science prepared a set of guidelines for the preparation of elementary and secondary school science teachers. These guidelines emphasized a thorough, college level study of the subject which the preservice student is preparing to teach, with a major in the subject area rather than in education. Appropriate methods courses were included in the preservice student's program.

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*The percentage of classes in 1980-81 being taught by appropriately certified teachers made a slight improvement of two-tenths of 1%.

+Represents percentages of the classes (13,590).

In 1971, the guidelines were revised to include 12 areas of concern: 1) humaneness, 2) societal issues, 3) nature of science, 4) science competencies, 5) mathematics for science teachers, 6) basic mathematics competencies, 7) algorithms and computing, 8) modeling in science, 9) communication of science, 10) learning conditions, 11) materials and strategies for teaching, and 12) continuous learning.

The 1971 guidelines had a broader focus than the subject matter requirements of the 1961 guidelines. They emphasized that teacher education should be liberal education and that teachers should be familiar with societal issues as well as subject matter competencies.

Trends in implementation of certification standards are difficult to identify. Certification standards are based upon competency statements following the "approved program" approach. Institutions tend to focus mainly on the number of hours of work completed in the area of certification. Under the approved program approach, each institution in the state preparing teachers works within the broad framework specified by the State Department of Public Instruction for certification and translates criteria into specific courses or preparation programs for a particular institution. The college or university is responsible for deciding if an individual meets the requirements for certification.

Based upon the "Summary of NSF Literature Review in Science Education" (26), the following trends were noted:

> Content requirements in science for certification of elementary school teachers appear to have changed little over the past two decades. While some states specifically indicate a certain number of credit hours/courses in science, others consider science only as a part of the general education component of a preservice student's undergraduate program.
>
> When secondary science teacher preparation requirements were considered, the picture changed. After Sputnik (1957), science content requirements for most state certification programs increased. This reversed a previous trend in which the number of credits for professional education courses frequently exceeded that of content hours in a subject to be taught. Certification patterns are still based largely on courses completed rather than on classroom performance.

RECOMMENDATION 23. The Committee recommends:

a) the employment of a science specialist (supervisor, coordinator, consultant) at each Local Education Agency to work with the teachers at the school level to implement and maintain the science curriculum in North Carolina.

b) the employment of science consultants for the eight state regional centers to work with central office staff and teachers in the local school systems to implement and maintain the science curriculum in North Carolina.

The local science supervisors would work closely with teachers, principals, and other central office staff to help ensure quality programs in the sciences. The eight regional center specialists would be close enough geographically to provide the assistance needed to implement the recommendations of this Committee. These specialists, working closely with the other division staff members, the local supervisors, and the teachers, would help ensure a quality science program for the students of North Carolina.

In 1978, the National Science Teachers Association adopted a resolution calling for local school districts to employ one or more science specialist(s) (supervisor, coordinator, consultant) to improve the quality of science education in the public schools of the United States (23). It is interesting to note that the number of science supervisors in the LEAs in North Carolina has decreased in the past few years. Many science specialists are being replaced by curriculum generalists. Weiss (28) notes the following on the national level:

> More than half of all school districts in the country, especially small districts and those in rural areas, have no persons responsible for districtwide supervision or coordination. And, while approximately 75% of schools with grades 10-12 have Science Department Chairmen, more than half of all elementary and junior high schools do not. Furthermore, while 90% or more of elementary school principals feel "adequately qualified" or "very well qualified" to supervise instruction in reading, math, and social studies, almost 20% feel "not well qualified" for science supervision. Thus, the elementary school teacher who feels inadequately prepared to teach science (and one out of six feels this way) may not be able to get help from the principal, and is unlikely to have a Science Department Chairman or a district science supervisor to turn to for help.

Of the 143 LEAs in North Carolina, only seven have full-time science supervisors while eight other LEAs have supervisors with dual responsibilities, usually science/math.

The Committee recognizes the valuable services that the members of the Division of Science of the State Department of Public Instruction provide the schools across the state. At the same time, the Committee recognizes that the limited staff of one Director, one Assistant Director, and two Consultants cannot hope to provide the daily assistance needed by many teachers.

A P P E N D I C E S

APPENDIX A

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SDPI STAFF FOR SCIENCE CURRICULUM STUDY COMMITTEE

Many members of the State Education Agency assisted the Science Curriculum Study Committee with their work. The following, however, met regularly with, and served as advisors and/or staff to, the Committee.

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William McMillan, Special Assistant
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Betty Moore, Special Assistant
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Mary Purnell, Special Assistant
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David L. Mallette, Assistant Director
Liaison Person - Staff Subcommittee

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Ruth Lawson, Secretary
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Patricia Smith, Secretary
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APPENDIX D

LOG OF SCIENCE CURRICULUM STUDY COMMITTEE MEETINGS

January 5-6, 1981

- Organization of Committee
- Charge and Remarks from State Superintendent, Deputy State Superintendent, Asst. State Superintendent for Instr. Services
- Historical Perspectives
- Science Teacher Profile
- Teacher Certification
- Science Textbooks
- Status of Science Education Nationally
- Status of Science Education in North Carolina
- Subcommittee Meetings

February 24, 1981

- Science Finances/State and Federal Funds
- Science Textbook Adoption
- Science Teacher Certification
- Subcommittee Meetings

April 9, 1981

- Statewide Testing in Science
- Coordination of Math and Science Curriculum
- Subcommittee Meetings

May 12, 1981

- Problems with Earth Science
- Subcommittee Meetings
- Subcommittee Presentations to Full Committee

June 2-3, 1981

- Staff Subcommittee Meeting

June 16, 1981

- Curriculum Subcommittee Meeting

June 16, 1981

- Facilities Subcommittee Meeting

June 23, 1981

- Subcommittee Meetings
- Staff Subcommittee Report to Full Committee and Reactions
- Curriculum Subcommittee Report to Full Committee and Reactions
- Facilities Subcommittee Report to Full Committee and Reactions

February 3, 1982

- Consideration of Draft of Final Report
- Approval of Major Recommendations and Suggestions for Refinement of Report
- Opportunities to Present Minority Opinions
- Appointment of Committee Chairman and Coordinator for Final Editing and Production of Report

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