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ABSTRACT

Science education standards are criteria by which to judge the quality of what students know and are able to do, of the science programs that provide the opportunity for students to learn science, of science teaching, of the system that supports science teachers and programs, and of assessment practices and policies. This document summarizes the Draft National Science Education Standards and discusses goals for school science and principles underlying the national science education standards. Also included are brief descriptions of the teaching, professional development, assessment, content, program, and system standards for K-12 science. (MKR)

ED 384 503

Draft National Science Education Standards

Summary

National Research Council

1994

WHY NATIONAL SCIENCE EDUCATION STANDARDS?

The term "standards" has multiple meanings. Science education standards are criteria by which to judge the quality of what students know and are able to do, of the science programs that provide the opportunity for students to learn science, of science teaching, of the system that supports science teachers and programs, and of assessment practices and policies. Science education standards also provide a vision of learning and teaching science in a system that promotes science education. As criteria and vision, science education standards provide a concrete expression of national goals and a banner around which reformers rally.

A hallmark of American education is local control, where boards of education and teachers make decisions about what their students will learn. National standards present criteria by which judgments can be made by state and local school personnel and communities. They are based on a vision, and they address a range of characteristics of school science so that people can decide which curriculum, staff development activity, or assessment is appropriate. National standards provide assistance in making decisions and policies that will bring coordination, consistency, and coherence to the improvement of science education.

The National Science Education Standards are criteria to guide a multitude of other choices. Science teachers might use the Standards to argue convincingly for a better system of assessment. The Standards might be used by teachers in discussions with textbook publishers to make wise selections among the array of material in current K-12 science curricula. Science education standards allow everyone to move in the same direction, with the assurance that the risks they take in the name of improving science education will be supported by policies and practices throughout the system.

The Standards help to chart the course into the future. They build on the best of current practice, yet take us beyond the constraints of present structures of schooling, toward a shared vision.

This summary was developed from the Draft National Science Education Standards which was published November, 1994. Copies available upon request.

GOALS FOR SCHOOL SCIENCE

The goals for school science that underlie the National Science Education Standards are to educate students who are able to:

- use scientific principles and processes appropriately in making personal decisions;
- experience the richness and excitement of knowing about and understanding the natural world;
- increase their economic productivity; and
- engage intelligently in public discourse and debate about matters of scientific and technological concern.

Achieving these primary goals of science education also should result in students who are aware of careers in science, technology and the health professions.

Achieving these goals is possible when all citizens are scientifically literate. The standards for content define what the scientifically literate person should understand and be able to do after 13 years of schooling.

The standards for assessment, teaching, program, and system describe the conditions necessary to achieve the goal of scientific literacy for all students, including opportunities for students to learn and for teachers to teach.

Implementation of the standards calls for schools to be centers for inquiry and for an educational system that supports such schools and teachers.

PRINCIPLES UNDERLYING THE NATIONAL SCIENCE EDUCATION STANDARDS

- All students, regardless of gender, cultural or ethnic background, physical or learning disabilities, aspirations, or interest and motivation in science, should have the opportunity to attain higher levels of scientific literacy than they do currently. This is a principle of equity.
- All students will learn all science in the content standards.
- All students will develop science knowledge as defined in the content standards and an understanding of science that enables them to use their knowledge as it relates to scientific, personal, social, and historical perspectives.
- Learning science is an active process.
- For all students to understand more science, less emphasis must be given to some science content and more resources, such as time, personnel, and materials must be devoted to science education.
- School science must reflect the intellectual tradition that characterizes the practice of contemporary science.
- Improving science education is part of systemic education reform.

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TEACHING STANDARDS

Science Teaching Standards provide criteria to be used in making judgments about the quality of classroom science teaching.

Teaching Standard A -- Planning a Science Program: Teachers of science plan an inquiry-based science program for their students. In doing this, they should incorporate the elements discussed below.

- Teachers develop a framework of yearlong and short-term goals for students.
- Teachers select science content and adapt and design curricula to meet the particular interests, knowledge, skills, and experiences of students.
- Teaching strategies that support the development of student understanding and nurture a community of science learners are used.
- Teachers work together with colleagues within and across disciplines and grade levels.

Teaching Standard B -- Guiding and Facilitating Learning: Teachers of science guide and facilitate learning.

- Teachers of science focus and support inquiries as they interact with their students.
- Teachers orchestrate discourse among students about scientific ideas.
- Teachers challenge students to take responsibility for their own learning and to work collaboratively.
- Teachers recognize and respond to student diversity and encourage all students to participate fully in science learning.
- Teachers encourage and model the skills of scientific inquiry as well as the curiosity, openness to new ideas, and skepticism that characterize science.

Teaching Standard C -- Assessing Learning and Teaching: Teachers of science engage in ongoing assessment of their teaching and of student learning.

- Teachers systematically gather data on students and their development.
- Teachers analyze assessment data to guide teaching.
- Teachers guide students in self assessment.
- Teachers use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice.

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Teaching Standard D -- Designing and Managing the Physical Environment: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

- Teachers structure the time available so that students are able to engage in extended investigations.
- Teachers create a setting for student work that is flexible and supportive of science inquiry.
- Teachers ensure a safe working environment.
- Teachers make the available science tools, materials, print resources, and technological resources accessible to all students.
- Teachers identify and use resources outside the school.
- Teachers engage students in designing the learning environment.

Teaching Standard E -- Building Learning Communities: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

- Teachers display and demand respect for the ideas, skills, and experiences of all students.
- Teachers give students a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community.
- Teachers nurture collaboration among students.
- Teachers structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.
- Teachers model and emphasize the skills, attitudes, and values of scientific inquiry.

Teaching Standard F -- School Planning: Teachers of science actively participate in the ongoing planning and development of the school science program.

- Teachers plan and develop the school science program.
- Teachers have a voice in decisions concerning allocation of time and other resources to the science program.
- Teachers plan and implement professional growth and development strategies for themselves and their colleagues.

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PROFESSIONAL DEVELOPMENT STANDARDS

Professional Development Standards provide criteria to be used in making judgments about the quality of professional development opportunities for teachers of science. These standards present a view of professional development that will help practicing and prospective teachers of science gain the knowledge, understanding, and ability to implement the vision of the National Science Education Standards.

Professional Development Standard A -- Learning Science Content: The professional development of teachers of science requires learning science content through the perspectives and methods of inquiry.

- Science learning experiences involve teachers in actively investigating scientific phenomena, interpreting results, and making personal sense of findings consistent with currently accepted scientific understanding.
- Learning experiences address issues, events, problems, or topics significant in science and of interest to participants.
- Teachers are introduced to scientific literature, media and technological resources that expand their science knowledge and their ability to access further knowledge.
- Experiences build on the teacher's current science knowledge, skills, and attitudes.
- Learning experiences incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.
- Teachers are to be encouraged and supported in efforts to collaborate.

Professional Development Standard B -- Learning to Teach Science: Professional development of teachers of science requires integrating knowledge of science, learning, pedagogy, and students and applying that understanding to science teaching. Learning experiences for teachers of science incorporate the following aspects.

- Experiences connect and integrate all aspects of science and science education.
- Learning to teach science takes place in actual classrooms to illustrate and model effective science teaching and permit teachers to struggle with real situations, practice, and expand knowledge and skills in an appropriate context.
- Learning experiences address teachers' developmental needs and build on their current knowledge of science content, teaching, and learning.

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- Teachers use inquiry, reflection, interpretation of research papers, modeling, and guided practice to build understanding and skill in science teaching

Professional Development Standard C -- Learning to Learn: The professional development of teachers of science enables them to build the knowledge, skills, and attitudes needed to engage in lifelong learning. Science learning experiences for teachers encompass the elements below.

- Regular, frequent opportunities are provided for individual and collegial examination and reflection on classroom and institutional practice.
- Opportunities are provided for teachers to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.
- Experiences provide opportunities for teachers to learn and use various tools and techniques for self and collegial reflection, such as peer coaching, portfolios, and journals.
- Sharing of teacher expertise is supported by preparing and using mentors, teacher advisors, coaches, lead teachers, and resource teachers to provide professional development opportunities
- Opportunities are provided to know and have access to existing research and experiential knowledge.
- Opportunities are provided to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.

Professional Development Standard D -- Developing Professional Development Programs: Preservice and inservice professional development programs for teachers of science are coherent and integrated. Quality programs have the following characteristics.

- Clear and shared goals based on a vision of science learning, teaching, and teacher development congruent with the National Science Education Standards are essential.
- Program components are integrated and coordinated so that understanding and skills can be built over time, reinforced continuously, and practiced in a variety of situations.
- The programs have options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.
- The people involved in programs, including teachers, teacher educators, scientists, administrators, policymakers and business people must collaborate -- with clear respect for the unique perspectives and expertise of each.
- The history, culture, and organization of the school environment are recognized.
- Continuous program assessment is required that captures the perspectives of all those involved, uses a variety of formal and informal strategies, focuses on the process and effects of the program, and feeds directly into program improvement and evaluation.

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ASSESSMENT STANDARDS

The Assessment Standards provide criteria to judge the quality of the assessment practices used by teachers and state and federal agencies to measure student achievement and the opportunity provided students to learn science. By identifying essential characteristics of exemplary assessment practices, the standards serve as guides for those developing assessment practices and policies.

Assessment Standard A -- Coordination with Intended Purposes: Assessments are consistent with the decisions they are designed to inform.

- Assessments are deliberately designed.
- Assessments have explicitly stated purposes.
- The relationship between the decisions and the data should be clear.
- Assessments procedures are internally consistent.

Assessment Standard B -- Measuring Student Achievement and Opportunity to Learn: Achievement and opportunity to learn science must both be assessed.

- Achievement data collected focuses on the science content that is most important for students to learn.
- Opportunity-to-learn data collected focuses on the most powerful indicators of the students' opportunity to learn.
- Equal attention must be given to the assessment of opportunity to learn and to the assessment of student achievement.

Assessment Standard C -- Matching Technical Quality of Data with Consequences: The technical quality of the data collected is well matched to the consequences of the decisions and actions taken on the basis of its interpretation.

- The feature that is claimed to be measured is actually measured.
- Assessment tasks are authentic.
- An individual student's performance is the same on two or more tasks that claim to measure the same aspect of student achievement.
- Students have adequate opportunity to demonstrate their achievements.
- Assessment tasks and methods of presenting them provide data that are sufficiently stable to lead to the same decision if used at different times.

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Assessment Standard D -- Avoiding Bias: Assessment practices must be fair.

- Assessment tasks must be reviewed for the use of stereotypes, for assumptions that reflect the perspectives or experiences of a particular group, for language that might be offensive to a particular group, and for other features that might distract students from the intended task.
- Large-scale assessments must use statistical techniques to identify differential performance among subgroups that signal potential bias.
- Assessment tasks must be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities or limited English proficiency.
- Assessment tasks must be set in a variety of contexts, engaging to students with different interests and experiences and must not assume the perspective or experience of a particular gender, racial, or ethnic group.

Assessment Standard E -- Making Sound Inferences: The inferences made from assessments about student achievement and opportunity to learn must be sound.

- When making inferences from assessment data about student achievement and opportunity to learn science, explicit reference needs to be made to the assumptions on which the inferences are based.

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CONTENT STANDARDS

The Standards presented in this chapter outline what students should know, understand, and be able to do in natural science. The standards were designed and developed as one component of the comprehensive vision of science education presented in the National Science Education Standards. The eight categories are:

- Science as Inquiry
- Physical Science
- Life Science
- Earth and Space Science
- Science and Technology
- Science in Personal & Social Perspectives
- History and Nature of Science
- Unifying Concepts and Processes

These content standards cannot be used effectively without also using the standards described in the teaching, professional development, assessment, program, and system standards; nor will implementation be successful if only a subset of these standards is used, such as implementing only the subject matter standards of physical, life and earth science.

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CONTENT STANDARDS: *SCIENCE AS INQUIRY*

(the numbered points following each bulleted item are samples of these standards -- more detailed information is available in the Draft)

Grades K-4

- Abilities necessary to do scientific inquiry

1. Ask a question about objects, organisms, and events in the environment.
2. Plan and conduct a simple investigation.
3. Employ simple equipment and tools to gather data and extend the senses.

- Understanding about scientific inquiry

1. Scientific investigations involve asking and answering a question and comparing the answer to what scientists already know about the world.
2. Scientists use different kinds of investigations depending on the questions they are trying to answer.
3. Simple instruments, like magnifiers, thermometers, and rulers provide more information than scientists obtain using only their senses.

Grades 5-8

- Abilities of scientific inquiry

1. Identify questions that can be answered through scientific investigations
2. Design and conduct a scientific investigation.
3. Use appropriate tools and techniques to gather, analyze, and interpret data.

- Understanding about scientific inquiry

1. Different kinds of questions suggest different kinds of scientific investigations.
2. Current scientific knowledge and what scientists understand guide scientific investigations.
3. Technology used in data gathering enhances accuracy and allows scientists to manipulate and quantify results of investigations.

Grades 9-12

- Abilities of scientific inquiry

1. Identify questions and concepts that guide scientific investigations.
2. Design and conduct scientific investigations.
3. Use technology to improve investigations and communications.

- Understanding about scientific inquiry

1. Scientists usually base their investigations on existence questions or causal-functional questions.
2. Scientists conduct investigations for a variety of reasons, such as exploration of new areas, discovery of new aspects of the natural world, confirmation of prior investigations, prediction of current theories, and comparison of models and theories.
3. Scientists rely on technology to enhance the gathering and manipulation of data.

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CONTENT STANDARDS: *PHYSICAL SCIENCE*

Grades K-4

- Properties of objects and materials
- Position and motion of objects
- Light, heat, electricity, and magnetism

Grades 5-8

- Properties and changes of properties in matter
- Motions and forces
- Transformations of energy

Grades 9-12

- The structure of atoms
- Structure and properties of matter
- Chemical reactions
- Forces and motions
- Conservation of energy and the increase in disorder
- Interactions of energy and matter

CONTENT STANDARDS: *LIFE SCIENCE*

Grades K-4

- The characteristics of organisms
- Life cycles of organisms
- Organisms and environments

Grades 5-8

- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Grades 9-12

- The cell
- The molecular basis of heredity
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization of living systems
- Nervous system and the behavior of organisms

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CONTENT STANDARDS: *EARTH AND SPACE SCIENCE*

Grades K-4

- Properties of Earth materials
- Objects in the sky

Grades 5-8

- Structure of the Earth system
- Earth's history
- Earth in the solar system

Grades 9-12

- Energy in the Earth system
- Geochemical cycles
- The origin and evolution of the Earth system
- Origin and evolution of the universe

CONTENT STANDARDS: *SCIENCE AND TECHNOLOGY*

(the numbered points following each bulleted item are samples of these standards -- more detailed information is available in the Draft)

Grades K-4

- **Abilities to distinguish between natural objects and objects made by humans**

  1. Some objects occur in nature while others have been designed and made by people to solve human problems.
  2. Objects can be categorized into two groups, natural and designed.

- **Abilities of technological design**

  1. Identify a simple problem.
  2. Propose a solution.
  3. Implementing proposed solutions.

Grades 5-8

- **Abilities of technological design**

  1. Identify appropriate problems for technological design.
  2. Design a solution or product.
  3. Implement a proposed design.

Grades 9-12

- **Abilities of technological design.**

  1. Identify a problem or design an opportunity.
  2. Propose designs and choose between alternative solutions.
  3. Implement a proposed solution.

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CONTENT STANDARDS: *SCIENCE AND TECHNOLOGY CONT'D*

(the numbered points following each bulleted item are samples of these standards -- more detailed information is available in the Draft)

Grades K-4

- **Understanding about science and technology.**

1. Scientists and engineers often work in teams with different individuals doing different things that contribute to the results.
2. Women and men of all ages, backgrounds, and groups engage in the varieties of scientific and technological work.
3. Tools help scientists make better observations, measurements, and equipment for investigations.

Grades 5-8

- **Understanding about science and technology**

1. Scientific inquiry and technological design have similarities and differences.
2. Many different people in different cultures have made and continue to make contributions to science and technology.
3. Science helps drive technology, as it provides knowledge for better understanding, instruments and techniques.

Grades 9-12

- **Understanding about science and technology.**

1. Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.
2. Scientists and engineers can only conduct research on human subjects if they have the consent of the subjects.
3. Science often advances with the introduction of new technologies and solving technological problems often results in new scientific knowledge.

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CONTENT STANDARDS: *SCIENCE IN PERSONAL & SOCIAL PERSPECTIVES*

Grades K-4

- Personal health
- Characteristics and changes in populations
- Types of resources
- Changes in environments
- Science and technology in local challenges

Grades 5-8

- Personal health
- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

Grades 9-12

- Personal and community health
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global changes

CONTENT STANDARDS: *HISTORY AND NATURE OF SCIENCE*

Grades K-4

- Science as a human endeavor

Grades 5-8

- Science as a human endeavor
- Nature of science
- History of science

Grades 9-12

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

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CONTENT STANDARDS: *UNIFYING CONCEPTS AND PROCESSES*

Grades K-12

- Order and organization
- Evidence, models, and explanation
- Constancy, change, and measurement
- Evolution and equilibrium
- Form and function

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PROGRAM STANDARDS

Program Standards provide criteria for judging the quality of and conditions for school science programs. They focus on issues at the school and district level that relate to opportunities for students to learn and opportunities for teachers to teach science as described in the Standards.

Program Standard A -- Consistency in Program: All elements of the K-12 science program are consistent with the other National Science Education Standards and with one another and are articulated within and across grade levels to meet a clearly stated set of goals. An effective science program encompasses the elements described below.

- A set of clear goals and expectations for students is used to guide the design, implementation, and assessment of all elements of the science program.
- A curriculum framework is used to guide the selection and development of units and courses of study.
- Teaching practice is consistent with the goals and curriculum framework.
- Assessment policies and practices are aligned with goals, student expectations, and curriculum frameworks.
- Support systems and formal and informal expectations of teachers are aligned with the goals and expectations for students, and with curriculum frameworks.
- Responsibility is clearly defined for determining, supporting, and maintaining all elements of the science program.

Program Standard B -- Curriculum: The curriculum in science for all students in grades K-12 contain the aspects described below.

- All the content standards are included and embedded in a variety of curriculum patterns that are developmentally appropriate, interesting, and relevant to student's lives.
- Inquiry is emphasized as a tool for learning science.
- The curriculum connects to other school subjects.

Program Standard C -- Mathematics and Science: The science program should be coordinated with the mathematics program to enhance student use and understanding of mathematics in the study of science and to improve student understanding of mathematics overall.

Program Standard D -- Resources: The K-12 science program gives students access to appropriate and sufficient resources, including time, materials and equipment, space, teachers, and community.

- Time is a major resource in a science program.
- Conducting scientific inquiry requires that students have easy and frequent opportunities to use a wide range of equipment, materials, supplies, and other resources for experimentation and direct investigation of phenomena.

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- Collaborative inquiry requires space as well as time.
- The most important resource is personnel.
- Good science programs require access to the world beyond the classroom.

Program Standard E -- Equity and Excellence: All students in the K-12 science program must have equitable access to opportunities to achieve the National Science Education Standards.

Program Standard F -- Schools as Communities of Learners: Schools are communities that encourage, support and sustain teachers as they implement an effective science program.

- Schools explicitly support reform efforts in an atmosphere of openness and trust that encourages collegiality.
- Regular time is provided and teachers encouraged to discuss, reflect, and conduct research around science education reform.
- Teachers are supported in creating and being members of networks of reform.
- An effective leadership structure that includes teachers is in place.

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SYSTEM STANDARDS

System Standards provide criteria for judging the performance of the components of the science education system responsible for providing schools with the financial and intellectual resources necessary to achieve the vision contained in the program, teaching, professional development, assessment, and content standards.

System Standard A -- Common Vision: Policies that influence the practice of science education must be consistent with the program, teaching, professional development, assessment, and content standards while allowing for adaptation to local circumstances.

System Standard B -- Coordination: Policies that influence science education should be coordinated within and across agencies, institutions, and organizations.

System Standard C -- Continuity: Policies need to be sustained over sufficient time to provide the continuity necessary to bring about changes required by the Standards.

System Standard D -- Resources: Policies must be supported with resources.

System Standard E -- Equity: Science education policies must be equitable.

System Standard F -- Unanticipated Effects: All policy instruments must be reviewed for possible unintended effects on the classroom practice of science education.

System Standard G -- Individual Responsibility: Responsible individuals take the opportunity afforded by the standards-based reform movement to achieve the new vision of science education portrayed in the Standards.

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How to Reach Us

To receive more information on the science education standards, or to be placed on our mailing list please:

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We look forward to hearing from you!

ATTENTION, Science Educators

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The National Science Teachers Association is preparing three documents to accompany the release of the National Science Education Standards.

- **Compatibility Guidelines for High School Teachers**
- **Compatibility Guidelines for Middle Level Teachers**
- **Compatibility Guidelines for Elementary Teachers**

The Compatibility Guidelines will provide examples, teaching scenarios, and resources designed to help teachers put the National Science Education Standards into practice.

Put your name on our mailing list to receive more information about the NSTA Compatibility Guidelines:

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Name:

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Grades Taught:

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