

Science Standards Introduction

Science education provides an important basis for our understanding of the world and our life in it. The skills and knowledge of science that students now can acquire are drawn from areas of inquiry where the progress of human knowledge has been especially clear and striking, and represent an enormous resource for improving American students' individual and social well-being. It doesn't take a rocket scientist to see the value of scientific understanding for the ordinary citizen's life, nor does it take one to appreciate the value of having a few rocket scientists. The science standards provide sound guidance for both those students who need a practical understanding of how nature works and those who may eventually choose to pursue scientific learning for loftier purposes.

These standards and benchmarks are based on *Benchmarks for Science Literacy*, a publication of the AAAS's Project 2061, which offers recommendations for what all American students should know and be able to do. Project 2061's publications – especially *Science for All Americans* – present a unified and coherent picture of expectations for student learning in the natural sciences, social sciences, mathematics, and technology and include several different products designed to strengthen standards-based science education.

Habits of Mind

1. Students will be aware of the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
2. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
3. Students will be able to use tool and instruments for observing, measuring, and manipulating objects in scientific activities.
4. Students will be able to use the ideas of system, model, change, and scale in exploring scientific and technological matters.
5. Students will be able to communicate scientific ideas and activities clearly.
6. Students will be able to question scientific claims and arguments effectively.

The Nature of Science

7. Students will be familiar with the character of scientific knowledge and how it is achieved.
8. Students will understand important features of the process of scientific inquiry.

The Physical Setting

9. Students will be familiar with current scientific views of the universe and how those views evolved.
10. Students will understand how the position and motion of the earth in the solar system determine seasons and phases of the moon, and know how key features of the earth influence climate and weather.
11. Students will be familiar with the scientific view of how the earth's surface is formed and how that view came about.
12. Students will be familiar with the scientific view of the nature of matter and with how that view evolved.
13. Students will be familiar with the forms and transformations of energy and with the significance of energy in understanding the structure of matter and the universe.
14. Students will be familiar with the wave nature of sound and electromagnetic radiation, and understand the relationship between force, mass, and the motion of objects.
15. Students will recognize gravitational, electrical, and magnetic forces as major kinds of forces acting in nature.

The Living Environment

16. Students will be aware of the diversity of living organisms and how they can be compared scientifically.
17. Students will understand how biological traits are passed on to successive generations.
18. Students will be familiar with the structure, functions, and reproduction of living cells.
19. Students will be aware of the dependence of all organisms on one another and their environments.
20. Students will understand the cycling of matter and the flow of energy through systems of living things.
21. Students will be familiar with the evolution of life on earth and understand the arguments for natural selection as a scientific explanation of biological evolution.

Human Organisms and Society

22. Students will be aware of the biological, cultural, and social explanations for why human beings have important traits in common yet differ from one another.
23. Students will be familiar with important aspects of human development from fertilization to death.
24. Students will understand the basic functions of the human body.
25. Students will be familiar with what influences learning in human beings.
26. Students will understand how diet, exercise, disease and toxic substances influences the physical health of individuals.

27. Students will be aware of physiological and cultural factors that affect individuals' mental health.
28. Students will be familiar with how groups, cultural beliefs, and social settings influence individual behavior.

Technology and Its Applications

29. Students will understand how technologies are developed and used to investigate and change the world.
30. Students will understand how technology shapes social, cultural, economic, and ecological aspects of human life and has influenced history.
31. Students will be familiar with important aspects of the agricultural and manufacturing revolutions.
32. Students will be familiar with the various sources of energy and with their uses and conservation.
33. Students will understand the nature of information and communications technologies and their impact on human life.
34. Students will be aware of the advantages and limitations of health technologies and the social and moral issues they raise.

NATIONAL SCIENCE EDUCATION STANDARDS TEACHING STANDARDS

Teaching Standard A:

Teachers of science plan an inquiry-based science program for their students. In doing this, teachers

- Develop a framework of yearlong and short-term goals for students.
- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.
- Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners.
- Work together as colleagues within and across disciplines and grade levels.

Teaching Standard B:

Teachers of science guide and facilitate learning. In doing this, teachers

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.
- Challenge students to accept and share responsibility for their own learning.

- Recognize and respond to student diversity and encourage all students to participate fully in science learning.
- Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

Teaching Standard C:

Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers

- Use multiple methods and systematically gather data about student understanding and ability.
- Analyze assessment data to guide teaching.
- Guide students in self-assessment.
- Use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice.
- Use student data, observations of teaching, and interactions with colleagues to report student achievement opportunities to learn to students, teachers, parents, policy makers, and the general public.

Teaching Standard D:

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

- Structure the time available so that students are able to engage in extended investigations.
- Create a setting for student work that is flexible and supportive of science inquiry.
- Ensure a safe working environment.
- Make the available science tools, materials, media, and technological resources accessible to students.
- Identify and use resources outside the school.
- Engage students in designing the learning environment.

Teaching Standard E:

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. In doing this, teachers

- Display and demand respect for the diverse ideas, skills, and experiences of all students.
- Enable students to have 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.
- Nurture collaboration among students.
- Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.
- Model and emphasize the skills, attitudes, and values of scientific inquiry.

Teaching Standard F:

Teachers of science actively participate in the ongoing planning and development of the school science program. In doing this, teachers

- Plan and develop the school science program.
- Participate in decisions concerning the allocation of time and other resources to the science program.
- Participate fully in planning and implementing professional growth and development strategies for themselves and their colleagues.

PROFESSIONAL DEVELOPMENT STANDARDS

Professional Development Standard A:

Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must

- Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.
- Address issues, events, problems, or topics significant in science and of interest to participants.
- Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.
- Build on the teacher's current science understanding, ability, and attitudes.
- Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.
- Encourage and support teachers in efforts to collaborate.

Professional Development Standard B

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must

- Connect and integrate all pertinent aspects of science and science education.
- Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.
- Address teachers' needs as learners and build on their current knowledge of science content, teaching, and learning.
- Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.

Professional Development Standard C:

Professional development for teachers of science requires building understanding and ability for lifelong learning. Professional development activities must

- Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.
- Provide opportunities for teachers to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.
- Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios, and journals.
- Support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.
- Provide opportunities to know and have access to existing research and experiential knowledge.

- Provide opportunities 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:

Professional development programs for teachers of science must be coherent and integrated. Quality pre-service and in-service programs are characterized by

- Clear, shared goals based on a vision of science learning, teaching, and teacher development congruent with the National Science Education Standards.
- Integration and coordination of the program components so that understanding and ability can be built over time, reinforced continuously, and practiced in a variety of situations.
- 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.
- Collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each.
- Recognition of the history, culture, and organization of the school environment.
- Continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into program improvement and evaluation.

Science Assessment Standards

Assessment Standard A:

Assessments must be 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 is clear.
- Assessment procedures are internally consistent.

Assessment Standard B:

Achievement and opportunity to learn science must be assessed.

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

Assessment Standard C:

The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.

- The feature that is claimed to be measured is actually measured.
- Assessment tasks are authentic.
- An individual student's performance is similar 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 decisions if used at different times.

Assessment Standard D:

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 potential bias among subgroups.
- 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, be 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:

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.

SCIENCE CONTENT STANDARDS: K-4

Science as Inquiry

Content Standard A:

As a result of activities in grades K-4, all students should develop

- Abilities necessary to do scientific inquiry.
- Understanding about scientific inquiry.

Physical Science

Content Standard B:

As a result of the activities in grades K-4, all students should develop an understanding of

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

Life Science

Content Standard C:

As a result of activities in grades K-4, all students should develop understanding of

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

Earth and Space Science

Content Standard D:

As a result of their activities in grades K-4, all students should develop an understanding of

- Properties of earth materials.
- Objects in the sky.
- Changes in earth and sky.

Science and Technology

Content Standard E:

As a result of activities in grades K-4, all students should develop

- Abilities of technological design
- Understanding about science and technology.
- Abilities to distinguish between natural objects and objects made by humans.

Science in Personal and Social Perspectives

Content Standard F:

As a result of activities in grades K-4, all students should develop understanding of

- Personal health.
- Characteristics and changes in populations.

- Types of resources.
- Changes in environments.
- Science and technology in local challenges.

History and Nature of Science

Content Standard G:

As a result of activities in grades K-4, all students should develop understanding of

- Science as a human endeavor.

SCIENCE CONTENT STANDARDS: 5-8

Science as Inquiry

Content Standard A:

As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Physical Science

Content Standard B:

As a result of their activities in grades 5-8, all students should develop an understanding of

- Properties and changes of properties in matter.
- Motions and forces.
- Transfer of energy.

Life Science

Content Standard C:

As a result of their activities in grades 5-8, all students should develop understanding of

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

Earth and Space Science

Content Standard D:

As a result of their activities in grades 5-8, all students should develop an understanding of

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

Science and Technology
Content Standard E:

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design.
- Understandings about science and technology.

Science in Personal and Social Perspectives
Content Standard F:

As a result of activities in grades 5-8, all students should develop understandings of

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

History and Nature of Science

Content Standard G:

As a result of activities in grades 5-8, all students should develop understanding of

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

SCIENCE CONTENT STANDARDS: 9-12

Science as Inquiry

Content Standard A:

As a result of activities in grades 9-12, all students should develop

- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Physical Science

Content Standard B:

As a result of their activities in grades 9-12, all students should develop an understanding of

- Structure of atoms.
- Structure and properties of matter.
- Chemical reactions.
- Motions and forces.
- Conservation of energy and increase in disorder.
- Interactions of energy and matter.

Life Science

Content Standard C:

As a result of their activities in grades 9-12, all students should develop understanding of

- The cell
- Molecular basis of heredity.
- Biological evolution.
- Interdependence of organisms.
- Matter, energy, and organization in living systems.
- Behavior of organisms.

Earth and Space Science

Content Standard D:

As a result of their activities in grades 9-12, all students should develop an understanding of

- Energy in the earth system.
- Geochemical cycles.
- Origin and evolution of the earth system.
- Origin and evolution of the universe.

Science and Technology

Content Standard E:

As a result of activities in grades 9-12, all students should develop

- Abilities of technological design.
- Understandings about science and technology.

Science in Personal and Social Perspectives

Content Standard F:

As a result of activities in grades 9-12, all students should develop understanding of

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

History and Nature of Science

Content Standard G:

As a result of activities in grades 9-12, all students should develop understanding of

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