Overview of National Science Content Standards

Excerpts from the National Science Education Standards
http://stills.nap.edu/html/nses/html

The content standards outline what students should know, understand, and be able to do in natural science. The content standards are a complete set of outcomes for students; they do not prescribe a curriculum. These standards were designed and developed as one component of the comprehensive vision of science education presented in the *National Science Education Standards* and will be most effective when used in conjunction with all of the standards. Furthermore, implementation of the content standards cannot be successful if only a subset of the content standards is used (such as implementing only the subject matter standards for physical, life, and earth science).

The eight categories of content standards are

- Unifying concepts and processes in science.
- Science as inquiry.
- Physical science.
- Life science.
- Earth and space science.
- Science and technology.
- Science in personal and social perspectives.

Conceptual and procedural schemes unify science disciplines and provide students with powerful ideas to help them understand the natural world. Because of the underlying principles embodied in this standard, the understandings and abilities described here are repeated in the other content standards. Unifying concepts and processes include:

- Systems, order, and organization.
- Evidence, models, and explanation.
- Change, constancy, and measurement.
- Evolution and equilibrium.
- Form and function.

In the vision presented by the *Standards,* inquiry is a step beyond "science as a process," in which students learn skills, such as observation, inference, and experimentation. The new vision includes the "processes of science" and requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science. Engaging students in inquiry helps students develop:

- Understanding of scientific concepts.
- An appreciation of "how we know" what we know in science.
- Understanding of the nature of science.
- Skills necessary to become independent inquirers about the natural world.
- The dispositions to use the skills, abilities, and attitudes associated with science.

Science as inquiry is basic to science education and a controlling principle in the ultimate organization and selection of students' activities. The standards on inquiry highlight the ability to conduct inquiry and develop understanding about scientific inquiry. Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments.

To read more about the ***National Science Education Standards*** go to the website at *http://stills.nap.edu/html/nses/html* .

CHANGING EMPHASES	
The *National Science Education Standards* envision change throughout the system. The science content standards encompass the following changes in emphases:	
LESS EMPHASIS ON	**MORE EMPHASIS ON**
Knowing scientific facts and information	Understanding scientific concepts and developing abilities of inquiry
Studying subject matter disciplines (physical, life, earth sciences) for their own sake	Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
Separating science knowledge and science process	Integrating all aspects of science content
Covering many science topics	Studying a few fundamental science concepts
Implementing inquiry as a set of processes	Implementing inquiry as instructional strategies, abilities, and ideas to be learned
CHANGING EMPHASES TO PROMOTE INQUIRY	
LESS EMPHASIS ON	**MORE EMPHASIS ON**
Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
Investigations confined to one class period	Investigations over extended periods of time
Process skills out of context	Process skills in context
Emphasis on individual process skills such as observation or inference	Using multiple process skills — manipulation, cognitive, procedural
Getting an answer	Using evidence and strategies for developing or revising an explanation
Science as exploration and experiment	Science as argument and explanation
Providing answers to questions about science content	Communicating science explanations
Individuals and groups of students analyzing and synthesizing data without defending a conclusion	Groups of students often analyzing and synthesizing data after defending conclusions
Doing few investigations in order to leave time to cover large amounts of content	Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content
Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
Management of materials and equipment	Management of ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates

The *National Science Education Standards* envision change throughout the system. To read further, go to the website http://stills.nap.edu/html/nses/html/3.html#changing .

Performance Standards for Science

New Standards Performance Standards, National Center on Education and the Economy and the University of Pittsburgh, 1997.

The Framework For The Science Performance Standards Reflects New Standards Partner Representatives' Distillation Of These Several Sources Of Guidance:
• Physical Sciences Concepts (Table 1) • Life Sciences Concepts (Table 2) • Earth and Space Sciences Concepts (Table 3) • Scientific Connections and Applications (Table 4)

Complementing The Conceptual Understanding Standards, The Following Focus On Areas Of The Science Curriculum That Need Particular Attention And A New Or Renewed Emphasis:
• Scientific Thinking (Table *5)* • Scientific Tools and Technologies (Table 6) • Scientific Communication (Table 7) • Scientific Investigation (Table 8)

Table 1

Physical Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding-explaining and representing-are required to meet this standard.

The student produces evidence that demonstrates the understanding of:

A. Properties of objects and materials, such as similarities and differences in the size, weight, and color of objects; the ability of materials to react with other substances; and different states of materials.

B. Position and motion of objects, such as how the motion of an object can be described by tracing and measuring its position over time; and how sound is produced by vibrating objects.

C. Light, heat, electricity, magnetism, such as the variation of heat and temperature; how light travels in a straight line until it strikes an object or how electrical circuits work.

Table 2

Life Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding-explaining and representing-are required to meet this standard.

The student produces evidence that demonstrates the understanding of:

A. Characteristics of organisms, such as survival and environmental support; the relationship between structure and function; and variations in behavior.

B. Life cycles of organisms, such as how inheritance and environment determine the characteristics of an organism; and that all plants and animals have life cycles.

C. Organisms and environments, such as the interdependence of animals and plants in an ecosystem; and populations and their effects on the environment.

D. Change over time, such as evolution and fossil evidence depicting the great diversity of organisms developed over geologic history.

Table 3

Earth and Space Science Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding-explaining and representing-are required to meet this standard.

The student produces evidence that demonstrates the understanding of:

A. Properties of Earth materials, such as water and gases; and the properties of rocks and soils, such as texture, color, and ability to retain water.

B. Objects in the sky, such as Sun, Moon, planets, and other objects that can be observed and described; and the importance of the Sun to provide the light and heat necessary for survival.

C. Changes in Earth and sky, such as changes caused by weathering, volcanism, and earthquakes; and the patterns of movement of objects in the sky.

Table 4

Scientific Connections and Applications

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding-explaining and representing-are required tomeet this standard.

The student produces evidence that demonstrates the understanding of:

A. Big ideas and unifying concepts, such as order and organization; models, form and function; change and constancy; and cause and effect.

B. The designed world, such as development of agricultural techniques; and the viability of technological designs.

C. Personal health, such as nutrition, substance abuse, and exercise; germs and toxic substances; personal and environmental safety.

D. Science as a human endeavor, such as communication, cooperation, and diverse input in scientific research; and the importance of reason, intellectual honesty, and skepticism.

Table 5

Scientific Thinking

The student demonstrated scientific inquiry and problem-solving by using thoughtful questioning and reasoning strategies, common sense and conceptual understanding from Science Standards 1 to 4, and appropriate methods to investigate the natural world; that is, the student:

A. Asks questions about natural phenomena; objects and organisms; and events and discoveries.

B. Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

C. Uses evidence from reliable sources to construct explanations.

D. Evaluates different points of view using relevant experiences, observations, and knowledge; and distinguishes between fact and opinion.

E. Identifies problems; proposes and implements solutions; and evaluates accuracy, design, and outcomes of investigations.

F. Works individually and in teams to collect and share information and ideas.

Table 6

Scientific Tools and Technologies

The student demonstrates competence with the tools and technologies of science by using them to collect data, make observations, analyze results, and accomplish tasks effectively; that is, the student:

A. Uses technology and tools (such as rulers, computers, balances, thermometers, watches, magnifiers, and microscopes) to gather data and extend the senses.

B. Collects and analyzes data using concepts and techniques in Mathematics Standard 4, such as average, data displays, graphing, variability, and sampling.

C. Acquires information from multiple sources, such as experimentation and print and non-print sources.

Table 7

Scientific Communication

The student demonstrates effective scientific communication by clearly describing aspects of the natural world using accurate data, graphs, or other appropriate media to convey depth of conceptual understanding in science; that is, the student:

A. Represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams, and artwork; and technical and creative writing.

B. Uses facts to support conclusions.

C. Communicates in a form suited to the purpose and the audience, such as writing instructions that others can follow.

D. Critiques written and oral explanations, and uses data to resolve disagreements.

Table 8

Scientific Investigation

The student demonstrates scientific competence by completing projects drawn for the following kinds of investigations, including at least one full investigation each year and , over the course of elementary school, investigations that integrate several aspects of Science Standards 1 to 7 and represent all four of the kinds of investigation:

A. An experiment, such as conducting a fair test.

B. A systematic observation, such as a field study.

C. A design, such as building a model or scientific apparatus.

D. Non-experimental research using print and electronic information, such as journals, video or computers.

A single project may draw on more than one kind of investigation. A full investigation includes:

- Questions that can be studied using the resources available.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.
- Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify and analyze using skills expected at this grade level (see also Mathematics Standard 4).
- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.
- Acknowledgment of references and contributions of others.
- Results that are communicated appropriately to audiences.
- Reflection and defense of conclusions and recommendations for other sources and peer review.