Insights into the Next Generation Science Standards

A Vision for Science Education

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Peter McLaren, President Council of State Science Supervisors
Brett Moulding, Director Partnership for Effective Science Teaching and Learning
Overview

- NRC Framework for K-12 Science Education
- A Vision for Science Education
- Three Dimensions of Science
- Science Performances
  - Constructing Explanations
  - Using Technology in Science Performances

Closure and Discussion
Vision for Science Teaching and Learning
Building Capacity in State Science Education

Builds upon the Research on Learning the Ideas of Science
A Natural Progression

Science for All Americans
NSES and Benchmarks

Research (i.e. Taking Science to School and Ready, Set, Science!)

Framework for K-12 Science Education
Next Generation Science Standards
Goals for Science Education

The Framework’s vision takes into account two major goals for K-12 science education:

(1) Educating all students in science and engineering.
(2) Providing the foundational knowledge for those who will become the scientists, engineers, technologists, and technicians of the future.

The Framework principally concerns itself with the first task—what all students should know in preparation for their individual lives and for their roles as citizens in this technology-rich and scientifically complex world.
Outcomes for Science Instruction

All students will:

- Value and use science as a process of obtaining knowledge based upon observable evidence.

All students will gain skills and knowledge to:

1. Gathering - Obtain and evaluate information
2. Reasoning – Construct explanations to make sense of phenomena
3. Communicating – Communicate explanations using evidence to support scientific arguments
The Framework is Designed to Help Realize a Vision of Science Education

- A vision of science education in which all students’ experiences over multiple years foster progressively deeper understanding of science.
- Students actively engage in scientific and engineering practices in order to deepen their understanding of crosscutting concepts and disciplinary core ideas.
- In order to achieve the vision embodied in the Framework and to best support students’ learning, all three dimensions should to be integrated into the system of standards, curriculum, instruction, and assessment.
Structure/Dimensions of Framework

- Science and Engineering **Practices**
- Disciplinary Core **Ideas**
- Crosscutting **Concepts**

“The three dimensions of the Framework, which constitute the major conclusions of this report, are presented in separate chapters. However, in order to facilitate students’ learning, the dimensions must be woven together in standards, curricula, instruction, and assessments.

When they explore particular disciplinary ideas from Dimension 3, students will do so by engaging in practices articulated in Dimension 1 and should be helped to make connections to the crosscutting concepts in Dimension 2.”

*NRC Framework Pages 29 - 30*
3-D Model = Science Performance at the Intersection

- Science and Engineering Practices
- Student Performance
  - Instruction Assessment
- Disciplinary Core Ideas
- Crosscutting Concepts
Crosscutting Concepts

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change
The Framework has identified seven key Crosscutting Concepts that serve a variety of purposes in science. This is one way to organize them for instruction.
Systems
Scale and Proportion
Change and Stability
Matter and Energy
Structure and Function

Causality
Cause and Effect
Structure and Function

Patterns
Science and Engineering Practices

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Framework Pages 41-82
Communicate Using Arguments & Models

Construct Explanations and Problems for the Cause/Effect relationship of Phenomena

Define Systems Identify Patterns Develop & Use Models Use Core Ideas

Ask Questions Analyze Data Use Mathematics Plan & Carry out Investigations Evaluating Information Use Core Ideas
Science and Engineering Practices

Performance: Explanations Using Evidence
Performance

Group Performance
Investigate how water moves from one cup to another through a paper towel.
1. Explore – place water in one cup, place an empty cup next to it. Connect them with a small piece of towel.
2. Formulate questions and investigate explanations for how the water moves from one cup to the other cup.
3. Develop evidence to support your explanations.

Individual Performance
4. Write in your journal or on note paper your explanation that may be used to explain this phenomena to others. Include the evidence to support your explanation for how the water moves from one cup to the other.

Reflection
5. Reflection on the nature of science instruction that leads students to develop explanations based upon evidence and the role of teacher preparation in developing teachers with the skills, knowledge and dispositions to engage students in constructing explanations from evidence.
Evidence to Support Explanations

• What distinguishes science from other ways of knowing is the reliance on evidence as central to science.

• Value and use science as a process of obtaining knowledge based on empirical evidence.
Making Sense

Science is about making sense of things.

• Crosscutting Concepts such as Structure and Function provide the tools for students to make sense of things and construct understanding.

• Patterns can be used to support explanations and develop questions and support explanations.
Disciplinary Core Ideas

Physical Science
- PS1: Matter and Its Interactions
- PS2: Motion and Stability: Forces and Interactions
- PS3: Energy
- PS4: Waves and Their Applications in Technologies for Information Transfer

Life Science
- LS1: From Molecules to Organisms: Structure and Processes
- LS2: Ecosystems: Interactions, Energy, and Dynamics
- LS3: Heredity: Inheritance and Variation of Traits
- LS4: Biological Evolution: Unity and Diversity
Disciplinary Core Ideas

Earth and Space Science
- ESS1: Earth’s Place in the Universe
- ESS2: Earth’s Systems
- ESS3: Earth and Human Activity

Engineering, Technology, and Applications of Science
- ETS1: Engineering Design
- ETS2: Links Among Engineering, Technology, Science, and Society
Teachers Teaching with Technology

• Where and how does technology best fit into this new vision for science education?
Performance – Using Technology to__________

Group Performance
Investigate how______________________________________
1. Explore___________________________________________
2. Formulate questions and investigate explanations for how___________
   _____________________________________________. Using __________________ to___________________________
3. Develop evidence to support your explanations.

Individual Performance
4. Write in your journal or on note paper your explanation that may be used to explain this phenomena to others. Include the evidence to support your explanation for how the ________________________________

Reflection
5. Reflection on the nature of science instruction that leads students to develop explanations based upon evidence and the role of technology in gathering and analyzing data to engage students in constructing explanations from evidence and communicate their ideas.
Implications for Teaching and Learning

• Discussion
Technology

• NAEP ICTs This page provides a link to Interactive Computer Tasks at NAEP


- The use of these types of simulations is one way that technology may be used to engage students in constructing explanations.
What Did Students Do?

In 2009, NAEP administered TWO types of innovative science assessments that invited students to put their science knowledge into practice:

- **Hands-on tasks (HOTs)** provided students an opportunity to demonstrate how well they are able to plan and conduct scientific investigations, reason through complex problems, and apply their scientific knowledge in real-world contexts. Three HOTs have been released to the public. For more information on the released HOTs, see the complete task library.

- **Interactive computer tasks (ICTs)** required students to solve scientific problems in a computer-based environment, either a natural or laboratory setting. These tasks provided students an opportunity to demonstrate a broad range of skills involved in doing science, but without many of the logistical constraints associated with the hands-on tasks. A total of nine ICTs have been released to the public. All nine interactive computer tasks are available below.

Select an **interactive computer task** below, answer the questions, and compare your results to students in the nation.

- **Grade 4**
  - Cracking Concrete
  - Here Comes the Sun
  - Mystery Plants

- **Grade 8**
  - Bottling Honey
  - Playground Soil
  - Planning a Park

- **Grade 12**
  - Energy Transfer
  - Starlight
  - Phytoplankton Factor

SEE NON-FLASH VERSION
What’s Different about the Next Generation Science Standards?
MS.PS-SPM  Structure and Properties of Matter

Students who demonstrate understanding can:

a. **Construct and use models to show examples of atoms combining to form a variety of molecules, or extended structures, with varying complexity.** [Clarification Statement: Student-provided examples should vary in complexity. Models can include diagrams and 3D structures. Examples of atoms combining can include Hydrogen and Oxygen combining to form hydrogen peroxide or water, sodium and chlorine to form an extended structure, or carbon to form a diamond. Subunits are atoms, e.g. crystals or metals. An example of subunits could include sodium and chloride, which form crystals.] [Assessment Boundary: Valence electrons and bonding energy are not addressed. When complex structures are made of subunits of ionic natures, discussing the ionic nature of the subunits is not required.]

b. **Plan and carry out an investigation to generate evidence supporting the claim that one pure substance can be distinguished from another based on characteristic properties.** [Clarification Statement: Properties of substances can include melting and boiling points, density, solubility, reactivity, reaction with oxygen, and phase at a given temperature.] [Assessment Boundary: Limited to simple common substances such as sodium chloride, sugar, sodium bicarbonate, calcium chloride, water, methane, propane, hydrogen, oxygen, steam.]

c. **Analyze observations from simulations to determine the effect on the speeds and positions of atoms and molecules of a solid liquid or gas when the temperature of the system is raised by adding thermal energy.** [Clarification Statement: Simulations would allow students to manipulate the temperature by heating up the container and estimate changes in speed and relative positions of the particles in the material. Simulations can include both electronic and physical simulations.] [Assessment Boundary: The use of mathematical formulas is not intended.]

d. **Construct a model to explain that adding or removing thermal energy to a given pure substance can result in a change of state.** [Clarification Statement: Models can include drawings and diagrams, substances can include water, propane, metals] [Assessment Boundary: The use of mathematical formulas is not intended.]
Analyze observations from simulations to determine the effect on the speeds and positions of atoms and molecules of a solid liquid or gas when the temperature of the system is raised by adding thermal energy.

PRACTICE: Use graphical displays (e.g., maps) of large data sets to identify temporal and spatial relationships.

CCC: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

DCI:

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The term “heat” as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures.
- Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
Tri-Dimensional Fused Knowledge (Songer, 2012)

**Core Disciplinary /Crosscutting:** the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

**Science Practice:** Pose models to describe mechanisms at unobservable scales.

**Fused Knowledge (C+SP):** Students use a simulation model to address the question, How does the energy of a system affect the temperature of a substance?
The second draft of the NGSS is ready for your review before January 29.

Review the standards and provide feedback.

About NGSS

Next Generation Science Standards for Today’s Students and Tomorrow’s Workforce: Through a collaborative, state-led process managed by Achieve, new K–12 science standards are being developed that will be rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. The NGSS will be based on the Framework for K–12 Science Education developed by the National Research Council.

Latest News

NGSS Second Public Draft will be Released January 2013
November 28, 2012

As education standards shift, schools rediscover science class
November 12, 2012

Upcoming NSTA Web Seminars on Preparing for the Next Generation Science Standards—

Resources

Watch a webinar about the NGSS
Discussion