2009 NAEP Science Framework

Teresa Neidorf
NAEP Education Statistics Services Institute (NAEP ESSI)
Outline

- 2009 NAEP Framework Overview
- Comparison Between 2005 and 2009
- Examples of Generating and Interpreting Items
- 2009 NAEP Science Assessment
- Comparing NAEP and state assessments
NAEP Frameworks are assessment frameworks **NOT** curricular frameworks.
Defining the Assessment

- Detailed descriptions of the content and cognitive dimensions
- Distribution of items across content and cognitive dimensions
- Item and response formats
- Scoring criteria
- Example items
- Assessment design
- Administration procedures
- Achievement level descriptions
A History of NAEP Science Frameworks

• Previous science framework
  – Developed under contract to CCSSO
  – Approved by the Governing Board in 1991
  – Used for 1996, 2000 and 2005 assessments

• New science framework for 2009
  – Developed under contract to WestEd and CCSSO
  – Approved by the Governing Board in 2005
  – Posted in 2006 (pre-publication edition)
  – Published in September 2008
  – Based on national and state science standards
  – Informed by international assessment frameworks
  – Reflects advances in science and cognitive research

- New trend line for 2009 -
<table>
<thead>
<tr>
<th>Science Content</th>
<th>Science Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key science principles as well as facts, concepts, laws, and theories to be assessed in NAEP</td>
<td>What students should be able to do with the science content in the NAEP assessment</td>
</tr>
</tbody>
</table>
NAEP
NATIONAL ASSESSMENT
OF EDUCATIONAL
PROGRESS

Science Content
Organization of Science Content

- **Content areas**
  - ✓ Physical Science
  - ✓ Life Science
  - ✓ Earth & Space Sciences

- **Topics**

- **Subtopics**

- **Grade-specific content statements**
<table>
<thead>
<tr>
<th>Physical</th>
<th>Life</th>
<th>Earth/Space</th>
</tr>
</thead>
</table>
| **Matter**
  -- Properties of matter
  -- Changes in matter | **Structures and Functions of Living Systems**
  -- Organization and development
  -- Matter and energy transformations
  -- Interdependence | **Earth in Space and Time**
  -- Objects in the universe
  -- History of Earth |
| **Energy**
  -- Forms of energy
  -- Energy transfer and conservation | **Changes in Living Systems**
  -- Heredity and reproduction
  -- Evolution and diversity | **Earth Structures**
  -- Properties of Earth materials
  -- Tectonics |
| **Motion**
  -- Motion at the macroscopic level
  -- Forces affecting motion | | **Earth Systems**
  -- Energy in Earth systems
  -- Climate and weather
  -- Biogeochemical cycles |
<table>
<thead>
<tr>
<th>Grade 4</th>
<th>Grade 8</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Earth Systems</strong> (FW p. 61)</td>
<td><strong>Climate and Weather:</strong> From local weather (4) to global weather patterns (8) to systems that influence climate (12).</td>
<td></td>
</tr>
<tr>
<td><strong>E4.8:</strong> Weather changes from day to day and over the seasons.</td>
<td><strong>E8.13:</strong> Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate because water in the oceans holds a large amount of heat.</td>
<td><strong>E12.10:</strong> Climate is determined by energy transfer from the sun at and near Earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover, atmospheric gases, and Earth's rotation, as well as static conditions such as the positions of mountain ranges and of oceans, seas, and lakes.</td>
</tr>
</tbody>
</table>
## Content Progressions

<table>
<thead>
<tr>
<th>Physical</th>
<th>Life</th>
<th>Earth/Space</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Changes in Matter</strong></td>
<td><strong>Evolution &amp; Diversity</strong></td>
<td><strong>Objects in the Universe</strong></td>
</tr>
<tr>
<td><strong>Grade 4:</strong> Changes of state</td>
<td><strong>Grade 4:</strong> Differences and adaptations of organisms</td>
<td><strong>Grade 4:</strong> Patterns in the sky</td>
</tr>
<tr>
<td><strong>Grade 8:</strong> Physical &amp; chemical changes and conservation of mass</td>
<td><strong>Grade 8:</strong> Preferential survival and relatedness of organisms</td>
<td><strong>Grade 8:</strong> Model of the solar system</td>
</tr>
<tr>
<td><strong>Grade 12:</strong> Particulate nature of matter, unique characteristics of water and changes at atomic/molecular level during chemical change</td>
<td><strong>Grade 12:</strong> Mechanisms of evolutionary change and history of life on Earth</td>
<td><strong>Grade 12:</strong> Vision of the universe</td>
</tr>
</tbody>
</table>
Science Practices

**Identifying Science Principles**

*Demonstrates knowledge of science principles*

**Using Science Principles**

*Focuses on what makes science knowledge valuable*

**Using Scientific Inquiry**

*Focuses on key inquiry practices that are practical to measure*

**Using Technological Design**

*Involves systematic process of applying science principles and skills to solve design problems in a real-world context*
<table>
<thead>
<tr>
<th>General Performance Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Identifying Science Principles</strong></td>
</tr>
<tr>
<td>• Describe, measure or classify observations</td>
</tr>
<tr>
<td>• State or recognize correct science principles</td>
</tr>
<tr>
<td>• Demonstrate relationships among closely related science principles</td>
</tr>
<tr>
<td>• Demonstrate relationships among different representations of principles</td>
</tr>
<tr>
<td><strong>Using Science Principles</strong></td>
</tr>
<tr>
<td>• Explain observations of phenomena</td>
</tr>
<tr>
<td>• Predict observations of phenomena</td>
</tr>
<tr>
<td>• Suggest examples of observations that illustrate a science principle</td>
</tr>
<tr>
<td>• Propose, analyze, and/or evaluate alternative explanations or predictions</td>
</tr>
</tbody>
</table>
General Performance Expectations

Using Scientific Inquiry

- Design or critique aspects of scientific investigations
- Conduct scientific investigations using appropriate tools and techniques
- Identify patterns in data and/or relate patterns in data to theoretical models
- Use empirical evidence to validate or criticize conclusions about explanations and predictions

Using Technological Design

- Propose or critique solutions to problems given criteria and scientific constraints
- Identify scientific tradeoffs in design decisions and choose among alternative solutions
- Apply science principles or data to anticipate effects of technological design decisions
Item Types

- Multiple Choice Items
- Constructed Response Items
  - Short
  - Extended
- Combination Items
  - Item clusters
  - Predict-observe-explain item sets
- Assessment time – approximately 50% constructed response
- Hands-on performance tasks
- Interactive computer tasks
## Distribution of Items by Content Area

### Target Percentage of Student Response Time

<table>
<thead>
<tr>
<th></th>
<th>Grade 4 (%)</th>
<th>Grade 8 (%)</th>
<th>Grade 12 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>33.3</td>
<td>30.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Life</td>
<td>33.3</td>
<td>30.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Earth/Space</td>
<td>33.3</td>
<td>40.0</td>
<td>25.0</td>
</tr>
</tbody>
</table>
# Distribution of Items by Science Practice

## Target Percentage of Student Response Time

<table>
<thead>
<tr>
<th>Science Practice</th>
<th>Grade 4 (%)</th>
<th>Grade 8 (%)</th>
<th>Grade 12 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying Science Principles</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Using Science Principles</td>
<td>30</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Using Scientific Inquiry</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Using Technological Design</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Cognitive Demand

- **Knowing That** (*declarative knowledge*)
- **Knowing How** (*procedural knowledge*)
- **Knowing Why** (*schematic knowledge*)
- **Knowing When and Where to Apply Knowledge** (*strategic knowledge*)

- Used as a lens to facilitate item development
- Provide framework to analyze student responses
- One or more cognitive demand associated with each Science Practice
- Balance across the Science Practices ensures a range of cognitive demands will be covered in items
Comparison Between 2005 and 2009
### Comparison Between 2005 and 2009

<table>
<thead>
<tr>
<th>2005</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fields of Science</strong></td>
<td><strong>Content Areas</strong></td>
</tr>
<tr>
<td>– Physical Science</td>
<td>– Physical Science</td>
</tr>
<tr>
<td>– Life Science</td>
<td>– Life Science</td>
</tr>
<tr>
<td>– Earth Science</td>
<td>– Earth &amp; Space Sciences</td>
</tr>
<tr>
<td>• Equal weight across fields of science–grades 4 and 12</td>
<td>• Equal weight across content areas–grade 4</td>
</tr>
<tr>
<td>• More emphasis on Life Science–grade 8</td>
<td>• Emphasis on Earth &amp; Space Sciences–grade 8</td>
</tr>
<tr>
<td>• Themes</td>
<td>• Emphasis on Physical &amp; Life Sciences–grade 12</td>
</tr>
<tr>
<td></td>
<td>• Crosscutting content</td>
</tr>
<tr>
<td></td>
<td>• Changes in subtopics</td>
</tr>
</tbody>
</table>
## Comparison Between 2005 and 2009

<table>
<thead>
<tr>
<th>2005</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowing &amp; Doing Science</strong></td>
<td><strong>Science Practices</strong></td>
</tr>
<tr>
<td>– Conceptual Understanding</td>
<td>– Identifying Science Principles</td>
</tr>
<tr>
<td>– Scientific Investigation</td>
<td>– Using Science Principles</td>
</tr>
<tr>
<td>– Practical Reasoning</td>
<td>– Using Scientific Inquiry</td>
</tr>
<tr>
<td>• 45% conceptual understanding – all grades</td>
<td>– Using Technological Design</td>
</tr>
<tr>
<td>• More emphasis on Scientific Investigation–grade 4</td>
<td></td>
</tr>
<tr>
<td>• Increased emphasis on Practical Reasoning–grades 8 and 12</td>
<td></td>
</tr>
<tr>
<td>• 60% conceptual understanding – all grades</td>
<td>• 30% Scientific Inquiry–all grades</td>
</tr>
<tr>
<td></td>
<td>• 10% Technological Design–all grades (new area)</td>
</tr>
</tbody>
</table>
## Comparison Between 2005 and 2009

<table>
<thead>
<tr>
<th>2005</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hands-on Performance Tasks</strong></td>
<td><strong>Hands-on Performance Tasks</strong></td>
</tr>
<tr>
<td>• 20 min. at grade 4</td>
<td>• 40 min. at grades 4, 8 &amp; 12</td>
</tr>
<tr>
<td>• 30 min. at grades 8 &amp; 12</td>
<td>• More open process</td>
</tr>
</tbody>
</table>

### Part of main scale

### Separate special report

**Interactive Computer Tasks**
- Information search & analysis
- Empirical investigation
- Simulation
- Concept mapping
Examples of Generating and Interpreting Items
Framework & Specifications Examples

• Commentary
  – Clarification/interpretation of content statements
• Performance expectations
  – Combining content statements with practices
• Item suggestions
• Illustrative items
On a hot, humid day the air contains a lot of water vapor. What happens to the water vapor in the air when the air becomes very cold?

Correct: Refers to a change of state (condensation, freezing, cloud formation, precipitation).
Which of the following graphs shows how the rate of evaporation changes with changes in water temperature?

Key: C

Source: Adapted from NAEP 1996
The graph below shows the distance traveled over time by a student walking down a hall.

A. During which time interval was the student moving the fastest?  

- A  
- B  
- C  
- D  

Key: D

B. What was the average speed of the student from 0 seconds to 5 seconds?  

Average speed: ____________________  

Answer: 2 m/s
Look at the food web above. If the corn crop failed one year what would most likely happen to the robin population? Explain your answer.

Correct: Makes a prediction (increase, decrease, stay same) supported by explanation based on prey/predator relationships in the food web.
Propose a testable hypothesis to explain why squirrels that live in a city tend to live shorter lives than squirrels that live in a forest.

Interpretation: In order to come up with a reasonable hypothesis, students need to recognize ways in which natural systems provide the conditions that animals need to survive and that some of these conditions may not be present in cities. In addition, students should be able to state their hypothesis in testable terms that can be objectively and quantitatively observed and recorded.
Two different varieties of grass – one better adapted to full sunlight and one better adapted to shade – are each grown in sunlight and in shade.

1. Given a data table showing the mass of grass plants of each type grown in the sunlight and shade, draw conclusions about which variety of grass is better adapted to each condition.

2. List other variables that should be controlled in order to feel confident about your conclusions.

Interpretation: Based on content statement about importance of light for plants (producers). Requires students to interpret data to draw conclusion about varying needs among different types of plants. Requires additional knowledge of plant growth to identify relevant variables that should be controlled.
In order to reduce the use of fossil fuels, the National Park Service is considering building a dam and hydroelectric power station in a national forest. Opponents of the plan have noted that when the dam is built it would flood a river valley and form a human-made lake. What are the scientific trade-offs that the National Park Service should consider before going ahead with the plan?

Interpretation: In order to describe advantages of the proposed dam, students must understand how burning of fossil fuels can contribute to global warming. In order to describe disadvantages, students must understand how the natural ecosystem that will be submerged provides services to humans and other plant/animal life.
2009 NAEP Science Assessment
2009 Assessment Design

- **Paper and pencil assessment**
  - Multiple choice and constructed response items

- **Items**
  - 143 at grade 4
  - 162 at grade 8
  - 179 at grade 12

- **Questionnaires** - Student, teacher and school

- **Each student takes**
  - Two 25 minute item blocks (only a portion of the entire assessment)
  - 10 minute questionnaire
Student Samples

- Main paper/pencil assessment
  - National and state at grades 4 and 8
  - Trial Urban District at grades 4 and 8
  - National at grade 12

- Separate national samples of students took hands-on tasks or interactive computer tasks
Composite scale scores

Subscales by content area
- Physical Science, Life Science, Earth & Space Sciences

Achievement levels
- Basic, Proficient, Advanced

Item maps

Released items
- 32 at grade 4, 17 at grade 8, 34 at grade 12

Hands-On and Interactive Computer Tasks
- Separate special report
- Not part of main 2009 release
How does NAEP compare to my state assessments?
Comparing Content

- Definition of the subject area domain
  - Content
  - Practices
- Grade level expectations
- Content boundaries (*Specifications*)
- Item pool
  - Item distributions - content and practices
  - Item formats
  - Scoring
  - Cognitive demands
Some Considerations

- Crosscutting content
- Role of inquiry
- Role of technological design
- Use of empirical data
- Achievement levels
- Released items
- Contextual data from questionnaires
For more information

http://nces.ed.gov/nationsreportcard/

http://www.nagb.org/