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The National Academy of Sciences Workshop on Assessments in Science Courses

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Information for DBER Group Discussion on 2012-10-04

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Title:
The National Academy of Sciences Workshop on Assessments in Science Courses

Information:
The Next Generation Science Standards (NGSS), which have undergone the first stage of public review and are currently under development, address not only content knowledge but also scientific skills. As such, the National Academy of Sciences (NAS) Committee on Developing Assessments of Science Proficiency in K-12 envisions the NGSS motivating change in the way that science is taught in the United States. A critical part of science instruction as it is envisioned with the NGSS involves using assessments. This DBER presentation will report on the latest NAS views regarding science proficiency assessments, as they were shared at all-day workshop on September 13th, 2012. Although the Committee’s remarks were aimed at K-12 levels, they are both transferable to and have implications for post-secondary science education.
A Report on the NAS Workshop:
“Developing Assessments to Meet the Goals of the 2012 Framework for K-12 Science Education”

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NAS Workshop on Developing Assessments to Meet the Goals of the 2012 Framework for K-12 Science Education

- **Who:** NAS Committee on Developing Assessments of Science Proficiency in K-12
- **What:** Workshop = Forum
- **Where:** NAS Building in D.C.
- **When:** Thursday, September 13\(^{th}\), 2012
- **Why:** Share current thinking about assessments for K-12 science education in light of the 2012 Framework

Credit: The information contained in this report comes from the workshop presenters, the Framework, and their supporting websites.

Disclaimer: I am *not* an expert on the publications and projects covered in this report.
The Larger Context: Science Education Reform
The Larger Context: Science Education Reform

National Research Council
National Science Teachers Association
American Association for the Advancement of Science
Achieve

1. Identified a need to update standards Need
Why is there a need to update the K-12 science standards now?

• Quality science education:
  – Is based on standards that are rich in content and practice
  – Demonstrates alignment in curricula, pedagogy, assessment, and teacher preparation and development

• *When was the last time the standards were revised?*

• These changes need to be reflected in the state standards.
Revising standards requires vision and planning.

1. Identified a need to update standards
2. Developed “The Framework”
The “Framework” provides the foundation for the Next Generation Science Standards (NGSS).

- 18 authors + 4 design teams
  - Physical science
  - Life science
  - Earth & space science
  - Engineering
- July 2010: draft released for public review
- This year: copyrighted and available
The Framework ...

- Draws on current research, inc. research on the ways that students learn science effectively
- Provides a sound evidence-based foundation for standards
- Identifies the science all K-12 students should know
The Framework presents a vision for science education unprecedented at the national level.

- Focuses on student *competence*. *New definition* reflects the intersection of knowledge involving 3 dimensions:
  - Developing over time
  - Increasing in power and sophistication with *coherent curriculum and instruction across multiple school years*

- Views competence as:

  - Disciplinary practices
  - Core disciplinary ideas
  - Crosscutting concepts
  - Performance expectations
The Framework is now being used as the foundation for the Next Generation Science Standards (NGSS).

1. Identified a need to update standards

2. Developed “The Framework” Vision

3. Developing Next Generation Science Standards (NGSS) Standards
The NGSS are being prepared through a collaborative, state-led process that is managed by Achieve*.

- Fall 2012: draft released for public comment
- Currently: being revised
- ~Winter 2013: released for adoption

*Achieve: created in 1996 by the nations’ governors and corporate leaders. Independent, bipartisan, non-profit education reform organization that helps states raise academic standards and graduation requirements, improve assessments, and strengthen accountability.
"The standards are written as student performance expectations...These statements each incorporate a practice, a disciplinary core idea, and a crosscutting concept. The performance expectations are the assessable components of the NGSS architecture."
Adopting new standards is one of the first steps on the path to transforming K-12 science education.
What types of assessments will support the Framework’s vision for teaching and learning?
What challenges will there be in developing them?

1. Identified a need to update standards
2. Developed “The Framework” Vision
3. Developing Next Generation Science Standards (NGSS) Standards
4. Design assessments in keeping with the Framework’s vision and aligned with the standards

Beyond ...
Unlike other NAS workshops, Committee members, instead of outside speakers, presented.

“The Committee is still working through things, and nothing is final. [This workshop] is an initial conversation. We will not provide an answer for you to take home.”
--Stuart Elliot, Board of Testing and Assessment

“We want the Framework to change the way we teach in the United States and maybe even in other countries.”
--Martin Storksdieck, Director of Board on Science Education

“There are more than a dozen [state Collaboratives on assessment and student standards], including one in science. People look forward to teaching with the new Framework, but [the needed] assessments have not yet been addressed by psychometricians.”
--David Heil, Collaborative Mentor for CCSSO’s State Collaborative on Assessment and Student Standards (SCASS) in Science

“We want to explore different aspects of assessment.”
--Mark Wilson, Committee Co-Chair, UC-Berkeley
The workshop consisted of presentations by 21 speakers and 15 respondents.

“It’s easy to test factual knowledge” [but the Framework envisions moving teaching & learning away from] “knowing to understanding.”

-- Helen Quinn, Committee member, Stanford University

**Thread 1**
Challenges Associated with Developing These Assessments

**Thread 2**
Exploring Alternatives: Strategies for Assessing Learning as Envisioned in the Framework

**Thread 3**
Developing Systems of Assessment
Thread 1: Development Challenges

1. The assessments must address three dimensions of learning.
2. Multi-dimensional assessments pose challenges:
   a. Reading complexity
   b. Time to complete & time to score
   c. Reliability & validity
3. Assessments are not “one size fits all.”
   a. Purpose: formative, P&T, accreditation, int’l comparisons
   b. Grain size: classroom, department/unit, program, nation
   c. Time scale: WRT learning event, WRT taking action
4. Need to connect learning theory with measurement theory
5. Need to explore technology uses for science assessment
6. Need to develop systems of assessment across grains & scales
Thread 2: Alternative Assessment Strategies

1. Large-scale assessments

2. Hands on tasks

3. Computer assisted tasks

4. Assessments embedded in curricular units
Example of Large-Scale Assessment:
College Board’s Advanced Placement Tests in Biology

- **Exam**
  - Standardized national assessment in support of student application for higher ed credit and/or placement considerations
- **More than 190,000 test takers in 2012**

**The Exam Administration**
- Secure proctored school-day administration
- Administered by high schools
- Designated date and time (May 13, 2013; 8 am)
- Paper and Pencil
- 3 hours
  - 90-minute multiple-choice section
    - 63 Multiple Choice
    - 6 Grid-in
  - 90-minute free-response section
    - 2 Long (e.g., 10 point)
    - 6 Short (e.g., 4 point)

**Assessment of Content Knowledge and Science Practices**
- Experts with disciplinary content knowledge unpacked the domains, resulting in the content outline
  - Big Ideas (level 1)
  - Enduring Understandings (level 2)
  - Essential Knowledge (level 3)
Example of Hands on Task:
IQWST Project out of Michigan State University

Example: Student Pre and Posttest

Shayna had a small bottle of Bromine gas. The bottle was closed with a cork. She tied a string to the cork, and then placed the bottle inside a larger bottle. She sealed the large bottle shut. (See Figure 1.) Next, Shayna opened the small bottle by pulling the string connected to the cork. Figure 2 shows what happened after the cork of the small bottle was opened.

First, draw a model that shows what is happening in this experiment. Second, explain in writing what is happening in your model.

Pretest

In my model, the cork has been pulled and the gas in the small bottle escapes and fills the large bottle.

Posttest

First, draw a model that shows what is happening in this experiment. Second, explain in writing what is happening in your model.

In my model, the small bottle has just been opened and the bromine gas is moving out of the, then small bottle and into the big bottle. Each molecule is moving in straight lines until they bumped into something, change directions, and continue in another straight line. The bromine gas is filling the whole big jar.
Example of Hands-On & Interactive Computer Tasks: NAEP 2009 Science Assessment

NAEP Components

- Multiple-choice items
- Short constructed response items
- Extended (long) constructed-response items
- Hands-on tasks
- Interactive computer tasks (ICTs)

NAEP Interactive Computer Task (ICT)
Grade 4 – Mystery Plants

Mapping of NAEP Framework & Assessment

Framework
- Practices
- Content Areas

- Technology and Society
  - 42 Discrete
    - 36 (9) SBT
    - 71 Total
  - 34 Discrete
    - 30 (13) SBT
    - 64 Total

- Design and Systems
  - 43 Discrete
    - 40 (7) SBT
    - 91 Total

- Technology and Engineering Literacy
  - 139 Discrete
    - 132 (21) SBT
    - 321 Total

- ICT
  - 51 Discrete
    - 46 (6) SBT
    - 117 Total

Assessment
- Cognitive Items
- Background Questions

Understanding Technological Principles
- 15 Discrete
  - 30 (6) SBT
  - 41 Total

Developing Solutions and Achieving Goals
- 11 Discrete
  - 24 (5) SBT
  - 44 Total

Communicating and Collaborating
- 11 Discrete
  - 16 (6) SBT
  - 23 Total

ICT
- 51 Discrete
  - 46 (6) SBT
  - 117 Total

Understanding Technological Principles
- 6 Discrete
  - 12 Total

Developing Solutions and Achieving Goals
- 29 Discrete
  - 41 (6) SBT
  - 79 Total

Communicating and Collaborating
- 15 Discrete
  - 16 (5) SBT
  - 35 Total

10
28
16
1
10
46
47
12
31
34
30
85
Example of Interactive Computer Tasks & Embedded Assessment: SimScientists

Technology Affordances

- Animations of dynamic system phenomena
  - Can observe and review
- Simulation-based investigations
  - Iterative design
  - Virtual data collection
  - Conducting and saving multiple trials
  - Multimodal information and data displays
- Multiple, overlapping, simultaneous representations
- Scientific “tools of the trade”
  - Simulations, graphs, tables, zoom, drawing, highlighting
- Immediate, contingent feedback and hints
- Bayes Nets within simulations to assess proficiencies

Embedded Assessment

In an experiment, you need to change the variable you are testing.

When driving, it is important to know how soon you can stop.

Three variables that might affect the truck’s stopping time are: Added Mass, Test Speed, and Backward Force. The Fire Chief wants to know how backward forces affect the truck’s stopping times.

Design an experiment to test how the magnitude of a backward force affects the truck’s stopping time.

- Use the sliders to choose the values of Added Mass, Test Speed and Backward Force.
- Click RUN to see what happens.
- Save three trials that show how different backward forces affect the truck’s stopping time.
Thread 3: Systems of Assessment

**Systems Serving Multiple Purposes**

1. Formative: Integrate instruction and assessment to facilitate significant science learning
2. Summative: multiple measures to provide comprehensive, standards-based view
3. Multi-level: feedback to serve accountability and improvement for multiple stakeholders

**An international perspective in four cases**

1. Germany: The problem
2. Finland: An extreme approach
3. Australia: Towards a solution
4. The Netherlands: A vision

**An Integrated System**

- Coordinated across levels
- Unified by common learning goals
- Synchronized by unifying progress variables

**Multilevel Assessment System**
Returning to the Larger Context

Thank you for lending your ear! 😊

Questions?
Potential Implications?

1. Identified a need to update standards

2. Developed “The Framework” Vision

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4. Design assessments in keeping with the Framework’s vision and aligned with the standards

beyond …
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
Crosscutting Concepts

1. Patterns
2. Cause and effect: mechanism and explanation
3. Scale, proportion and quantity
4. Systems and system models
5. Energy and matter: flows, cycles and conservation
6. Structure and function
7. Stability and change
Core Disciplinary Ideas: **Physical Sciences**

- **PS1** Matter and its interactions
- **PS2** Motion and stability: Forces and interactions
- **PS3** Energy
- **PS4** Waves and their applications in technologies for information transfer

Core Disciplinary Ideas: **Life Sciences**

- **LS1** From molecules to organisms: Structures and processes
- **LS2** Ecosystems: Interactions, energy, and dynamics
- **LS3** Heredity: Inheritance and variation of traits
- **LS4** Biological evolution: Unity and diversity
Core Disciplinary Ideas: Earth & Space Sciences

- **ESS1** Earth’s place in the universe
- **ESS2** Earth’s systems
- **ESS3** Earth and human activity

Core Disciplinary Ideas: Engineering, Technology and Applications of Science

- **ETS1** Engineering design
- **ETS2** Links among engineering, technology, science and society