Next Generation Science Assessment

Developing Assessments in Physical Science Across Three Dimensions

NSF PI Meeting
Tuesday, August 5, 2014

UIC LEARNING SCIENCES RESEARCH INSTITUTE

CREATE for STEM Institute

SRI Education

The Concord Consortium

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NGSS Implementation Challenges Addressed by Our Project: Practice & Theory

EDUCATION AT THE NATIONAL RESEARCH COUNCIL
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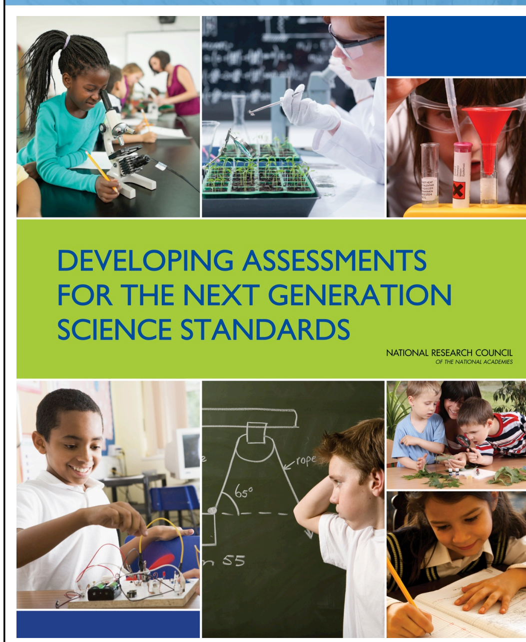

Committee on the Assessment of K-12 Science Proficiency

Board on Testing and Assessment

and

Board on Science Education

National Academy of Sciences

Problem of Practice: Assessment Designed to Support Instruction

- To develop the skills and dispositions to use scientific and engineering practices needed to further their learning and to solve problems, students need to experience instruction in which they
  - use multiple practices in developing a particular core idea and
  - apply each practice in the context of multiple core ideas.
- Effective use of the practices will require that they be used in concert with one another, such as in supporting explanation with an argument or using mathematics to analyze data
- Assessments will be critical supports for this instruction.

Problem of Theory: Principled Design of Assessment Tasks

- Designing assessment tasks and assembling them into functional instruments will require a careful approach to assessment design.
- Some currently used approaches, such as ***evidence-centered design*** and ***construct modeling***, reflect a principled design process and begin with cognitive research and theory about science knowledge and learning as the starting place of the design process, consistent with core principles from ***KWSK***.
- With these approaches, the selection and development of assessment tasks, as well as the scoring rubrics and criteria for scoring, are guided by the construct to be assessed and the best ways of eliciting evidence about student's proficiency with that construct.

Addressing Challenges: Coordinating Contributions to Practice & Theory

Pluses & Minuses of Relying on Performance Expectations

+ Avoid vague cognitive verbs – “know” & “understand”
+ Stated as claims about students in terms of what they are supposed to be able to do to demonstrate their knowledge
+ Identify progressions as part of expectations
- Don’t tell us how to get there – curriculum materials and instructional practices
- Need to be “unpacked” in terms of the forms of evidence needed to support the student claim

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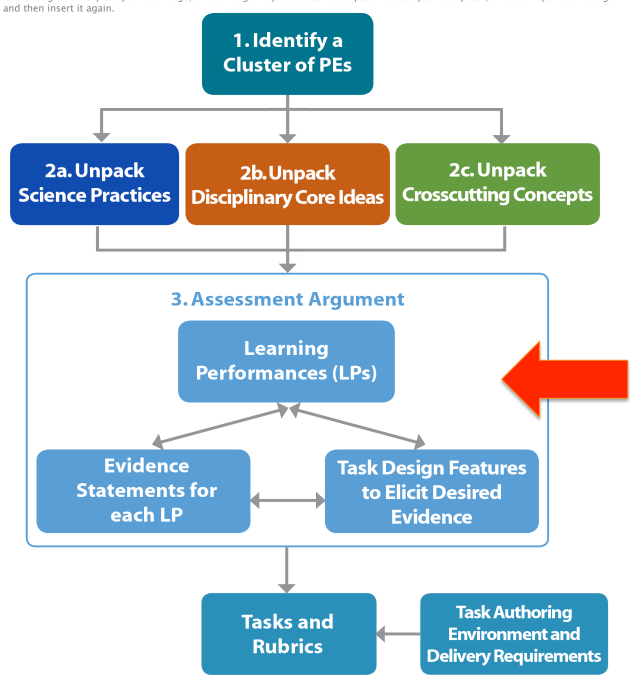
Overview of Our General Approach to the Assessment Design & Validation Process

For Details See Our Project Poster Later Today!!!



Focus on Two Science and Engineering Practices

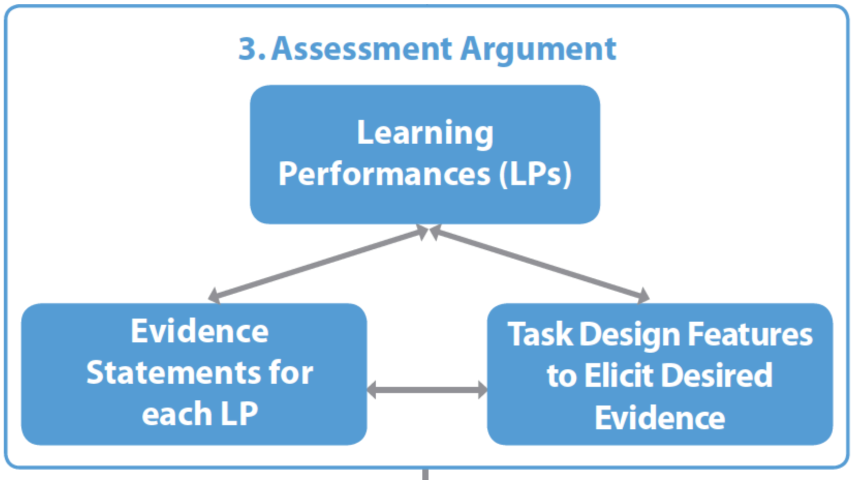
1. Asking questions and defining problems
2. **Developing and using models**
3. Planning and carrying out investigations and designing solutions
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. **Constructing explanations and designing solutions**
7. Engaging in argument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

Focus on Two Physical Science Disciplinary Core Ideas – MS Level

Life Science	Physical Science
LS1: From Molecules to Organisms: Structures and Processes	PS1: Matter and Its Interactions
LS2: Ecosystems: Interactions, Energy, and Dynamics	PS2: Motion and Stability: Forces and Interactions
LS3: Heredity: Inheritance and Variation of Traits	PS3: Energy
LS4: Biological Evolution: Unity and Diversity	PS4: Waves and Their Applications in Technologies for Information Transfer
Earth & Space Science	**Engineering & Technology**
ESS1: Earth's Place in the Universe	ETS1: Engineering Design
ESS2: Earth's Systems	ETS2: Links Among Engineering, Technology, Science, and Society
ESS3: Earth and Human Activity	

Progress Made to Date in Addressing the Challenges of Practice and Theory

Why Learning Performances?



Qualities of a "Good" Learning Performance

- Blends disciplinary core ideas and practices
- Functions in relation to other learning performances to identify "what it takes" to make progress toward meeting a standard (e.g., NGSS performance expectations)
- Helps to identify an important opportunity that teachers should attend to and assess ***before*** the end of a unit
- Assessable in a task (likely scenario-based with multiple items)

From a Performance Expectation to Learning Performances

MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

We determined from unpacking the disciplinary core idea that students need to know that

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it
- "Properties of substances" are the quality or condition of substances that can be observed or measured
- "Characteristic properties" are properties that are independent of the amount of the sample and can be used to identify substances

Example: From a Performance Expectation to Learning Performances

MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

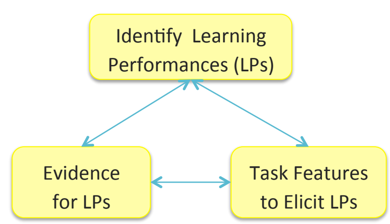
Learning Performance: Students should be able to construct an explanation (including claims, evidence, and reasoning) in which substances are identified based upon characteristic properties

We have developed several such learning performances linked to Performance Expectations for the DCIs in Physical Science

Applying ECD Design Principles: Claims, Evidence and Task Features

ECD in Three Basic Questions

- What **claims** do we want to be able to make about what students know and can do? (Student Model)
- What kinds of **evidence** will students need to provide to demonstrate proficiency? (Evidence Model)
- What kinds of **tasks / task features** will elicit the desired evidence? (Task Model)



When we have logical and coherent answers to these three questions, we have an *assessment argument*.

Assessment Argument Components

Claim

Which learning performance are you targeting for your assessment?

Evidence

What student behaviors will provide evidence of this learning performance?

Students should be able to construct an explanation (including claims, evidence, and reasoning) in which substances are identified based upon characteristic properties

- **Claim:** Statement that substances (e.g., Liquid A and B) are the same/different
- **Evidence:** Identification of at least two properties to support claim
- **Reasoning:** Statement that the same substance must have the same set of characteristic properties or that different substances have different characteristic properties

Assessment Argument Components

Additional Knowledge, Skills and Abilities

What background knowledge and experiences do students need to respond to the task?

Are there ELA or mathematics skills that will be required?

What skills do students need to express a correct response?

- Knowledge that some properties can be used to identify substances and these properties are called characteristic properties
- Knowledge that temperature, volume, and mass cannot be used to identify substances and are not characteristic properties
- Ability to identify which data can be used as valid and appropriate evidence
- Knowledge that a scientific explanation includes a claim, evidence, and reasoning

Assessment Argument Components

Characteristic Task Features

What features are common across all assessment tasks for this performance expectation?

What are the assessment boundaries to consider?

- Assessment is limited to analysis of the density, melting point, boiling point, solubility, flammability, and odor
- The term "substance" means a pure material (not a mixture)
- Tasks provide data about characteristic properties of substances
- Tasks provide a motivating context

Assessment Argument Components

Variable Task Features

How can you vary contexts for tasks?

How can you vary the complexity of tasks?

How can you increase or reduce demands for ELA and math skills?

- Types of properties included as data/evidence
- State of matter of substances (i.e., solid, liquid, or gas state)
- Inclusion of irrelevant data (e.g., non-characteristic properties)
- Level of scaffolding to develop claim, evidence, and reasoning

Creating a Task and Rubric

Steven found four different bottles filled with unknown pure liquids. He measured the properties of each liquid. The measurements are displayed in the data table below. Steven wonders if any of the liquids are the same substance.

Liquid	Density	Color	Volume	Boiling Point
1	1.0 g/cm^3	Clear	6.1 cm^3	100 C$^\circ$
2	0.89 g/cm^3	Clear	6.1 cm^3	211 C$^\circ$
3	0.92 g/cm^3	Clear	10.2 cm^3	298 C$^\circ$
4	0.89 g/cm^3	Clear	10.2 cm^3	211 C$^\circ$

Use the data in the table to:
1) Write a claim stating whether any of the liquids are the same substance.
2) Provide at least two pieces of evidence to support your claim.
3) Provide reason(s) that justify why the evidence supports your claim.

Variable Task Features

- Types of properties included as data/ evidence – **density and boiling point**
- State of matter of substances – **all liquids**
- Inclusion of irrelevant data – **yes**
- Level of scaffolding to develop claim, evidence, and reasoning – **yes**

Creating a Task and Rubric

For full credit

- **Claim** explicitly states that Liquid 2 and 4 are the same substance.
- **Evidence** includes at least two of the following pieces of evidence: density, boiling point, or color of Liquid 2 and 4 are the same.
- **Reasoning** indicates that density, boiling point, and color are characteristic properties; same substances have the same set of characteristic properties; and Liquid 2 and 4 have the same set of characteristic properties, so they are the same substance.

The Value of ECD

- A systematic process to facilitate consensus about the design principles of tasks (in this case, knowledge-in-use assessments)
- Benefits
  - Developing a shared vision about assessments with colleagues
  - Documentation of design decisions
  - Creating more well-aligned tasks
  - Scalability

Putting Our Ideas and Solutions Out Into Practice

Quick Summary of Project Status

- Identified relevant clusters of Performance Expectations in physical science for middle school students
- Unpacked the Practices, DCIs, and Cross Cutting Concepts
- Identified multiple Learning Performances linked to the multiple Performance Expectations in physical science
- Developed Design Patterns to undergird Task Development
- Developed multiple tasks spanning grades 6-8
- Had teachers review task for relevance to their students
- Implemented tasks in a technology delivery platform
- Collected pilot data on tasks from 50 or more students in each of grades 6, 7 & 8
- Have arrangements in place to collaborate with teachers in CA, MI, and IL on assessment design, interpretation & use