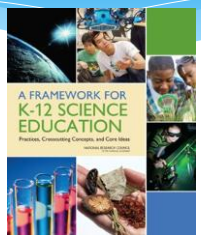
Assessing the Three Dimensions of the Next Generation Science Standards

HIGH SCHOOL SCIENCE
Career & College Readiness Conferences
Summer 2014

To what extent have you interacted with this document?

A. I've read it thoroughly.
B. I've skimmed it for general information.
C. It's on my bookshelf.
D. Huh?



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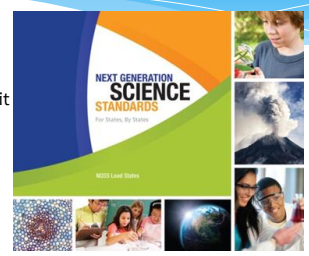
How about this one?

A. I've read it thoroughly.
B. I've skimmed it for general information.
C. It's on my bookshelf.
D. No clue



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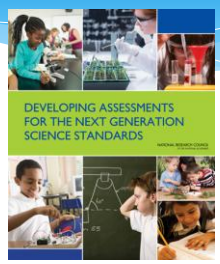
Or this one?

A. I've read it thoroughly.
B. I've skimmed it for general information.
C. It's on my bookshelf.
D. It's the first time I've seen it.



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Outcomes

- Review the process of developing NGSS
- Discuss the implications of teaching and assessing in the three Dimensions of NGSS
- Explore teaching and assessing through Science and Engineering Practices
- Identify opportunities for formative assessment during instruction
- Examine student activities for assessment tasks
- Discuss the potential structure of an assessment system for science

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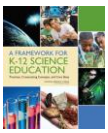
Developing Assessments for the Next Generation Science Standards

Committee on the Assessment of K-12 Science Proficiency



Board on Testing and Assessment
and
Board on Science Education
National Academy of Sciences

Topics Addressed

- The challenges of assessing three-dimensional science learning
- Principles for developing assessment tasks
- Developing classroom assessments
- Developing monitoring assessments
- Developing assessment systems
- Implementing the system

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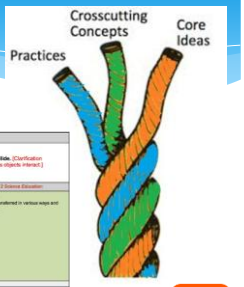
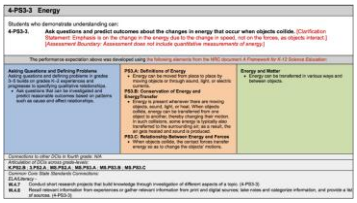
Three-Dimensional Science Learning





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NGSS Assessment Messages

- **New types of assessment are needed**
- **NGSS assessment should start with the needs of classroom teaching and learning**
- **State monitoring assessments must move beyond traditional forms**
- **States must create coherent systems of assessment that can support both classroom learning and policy monitoring functions**

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What should assessment look like?

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Focus on Formative Assessment

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Assessment Designed to Guide 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.

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The Assessment Challenge

- The NGSS describe specific goals for science learning in the form of *performance expectations*, statements
  - about what students should know and be able to do at each grade level or grade band,
  - that emphasize the importance of the connections among scientific concepts, and
  - that incorporate all three dimensions.

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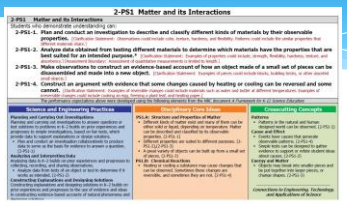
Assessment Challenge



2-PS1 Matter and its Interactions

Students who demonstrate understanding can:

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* [Clarification Statement: Examples of properties could include strength, flexibility, hardness, texture, and absorbency. Examples of materials could include metal, wood, and cloth.]

2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. [Clarification Statement: Examples of pieces could include blocks, building bricks, or other assembled small objects.]

2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing water, and burning paper.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-PS1-1) Analyzing and Interpreting Data • Analyze data in 2-PS1 to compare results collected by different groups. (2-PS1-2) Constructing Explanations and Designing Solutions • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (2-PS1-3)	PS1.A: Structure and Properties of Matter • Different properties are suited to different purposes. (2-PS1-2) • Objects can be built up from a small set of pieces. (2-PS1-3) PS1.B: Chemical Reactions • Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)	Patterns • Patterns in the natural and human designed world can be observed. (2-PS1-1) Cause and Effect • Cause and effect relationships are routinely identified. (2-PS1-4) • Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-4) Energy and Matter • Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3)

Connections to Engineering, Technology and Applications of Science

It will not be feasible to assess all of the performance expectations for a given grade band during a single assessment occasion.

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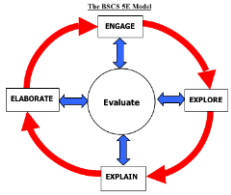
Multiple assessments

Students will need multiple—and varied—assessment opportunities to demonstrate their competence on the performance expectations for a given grade level



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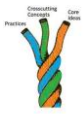
3-D Tasks

To adequately cover the three dimensions, specific components may focus on individual **practices**, **core ideas**, **or crosscutting concepts**. Assessment tasks will need to contain multiple components, i.e., a set of interrelated questions.



- *Individual and/or group investigation*
- *Observations in tables and/or graphs*
- *Constructed responses*
- *Selected responses*
- *Electronic drag and drop, ordering, etc.*

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Utilize the Practices

- Student activities that reflect such learning include the Practices of:
  - Developing and refining models
  - Generating, discussing and analyzing data
  - Engaging in both spoken and written explanations and argumentation

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Challenges and Opportunities

- Instruction that is aligned with the Framework will naturally provide many opportunities for teachers to observe and record evidence of student learning.
- Incorporate teacher and student reflection into the process

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Opportunity

- Use a set or cluster of interrelated questions to generate evidence of NGSS knowledge
  - Specific questions may focus on Practices, Disciplinary Core Ideas and/or Crosscutting Concepts
  - The parts need to support students' three-dimensional science learning as described in a specific Performance Expectation

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Antarctica's Pine Island Glacier: A "Climate Canary"?

Using atmospheric and oceanic processes and the poles to teach the climate system

Students analyze geoscience data to:

- Describe variations in the flow of energy in a system
- Collect evidence that a glacier is melting
- Determine the role of glaciers and the global ocean in the climate system

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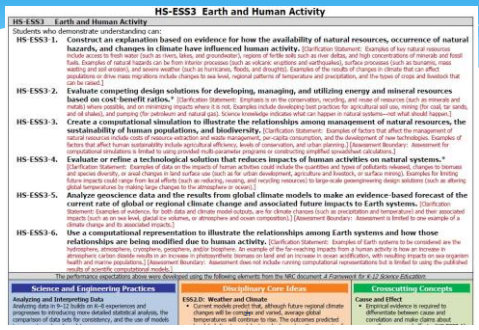
Three Dimensional Assessment



HS-ESS3 Earth and Human Activity

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. **Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

HS-ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models	ESS2.D: Weather and Climate • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted	Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about

Performance Expectation

Students who demonstrate understanding can:

HS-ESS3-5
Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

[Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

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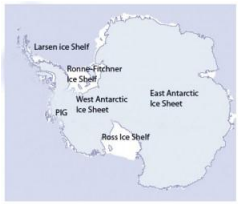
ID the Assessment Opportunities in the 5E Learning Cycle

* Engage (Step 1)
* Explore (Steps 2-3)
* Explain (Step 4)
* Elaborate (Step 5)
* Evaluate



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Assessment Opportunities?

5E	Practices	DCIs	Crosscutting
Engage			
Explore			
Explain			
Elaborate			
Evaluate			

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Assessment System

- Performance assessment tasks developed within the classroom
- Portfolio of classroom work samples with tasks specified by district and/or state
- Units (curriculum materials and assessments) developed outside of the classroom (district and/or state)
- Item banks of NGSS-aligned tasks, developed outside of the classroom, from which schools and teachers select

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Assessment System Challenges

- A single, external large-scale assessment cannot cover the full breadth and depth of NGSS
- Performance Expectations with suitable assessment tasks take time to administer and several will be required to adequately sample NGSS PE's
- Some practices are difficult to assess, e.g., carry out an investigation, using conventional formats of external, on-demand assessments

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NGSS Main Messages

- New types of assessment are needed
- State monitoring assessments must move beyond traditional forms
- NGSS assessment should start with the needs of classroom teaching and learning
- States must create coherent systems of assessment that can support both classroom learning and policy monitoring functions

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Outcomes

- Reviewed the process of developing NGSS
- Discussed the implications of teaching and assessing in the three Dimensions of NGSS
- Explored teaching and assessing through Science and Engineering Practices
- Identified opportunities for formative assessment during instruction
- Discussed the structure of an assessment system for science

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Resources

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012)
http://www.nap.edu/catalog.php?record_id=13165#

Developing Assessments for the Next Generation Science Standards
http://www.nap.edu/download.php?record_id=18409

NSTA
http://ngss.nsta.org/access-standards/

NAEP Released Items
http://nces.ed.gov/nationsreportcard/itmrlsx/default.aspx

TIMSS Released Items
http://nces.ed.gov/timss/educators.asp

PISA Released Items
http://nces.ed.gov/surveys/pisa/educators.asp

Exit Slip

- Write two statements that describe the implications for assessing student understanding in YOUR classroom.
  1) Ah-hah! statement
  2) Action(s) statement

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