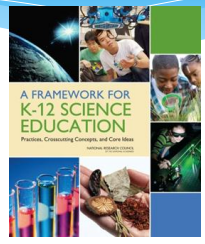
Assessing the Three Dimensions of the Next Generation Science Standards

MIDDLE 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?

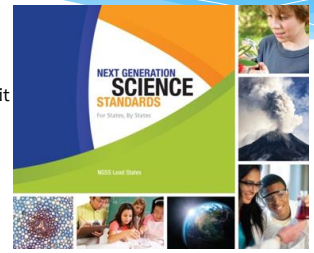


http://www.nap.edu/catalog.php?record_id=13165

2

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



3

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.

http://www.nap.edu/catalog.php?record_id=18409

4

Outcomes

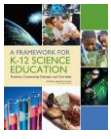
* Review the process of developing NGSS
* Discuss the implications of teaching and assessing in the three Dimensions of NGSS
* Explore teaching and assessing through Science and Engineering Practices
* Identify opportunities for formative assessment during instruction
* Examine student activities for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

NEXT GENERATION SCIENCE STANDARDS
For States, By States

5

Developing Assessments for the Next Generation Science Standards

Committee on the Assessment of K-12 Science Proficiency



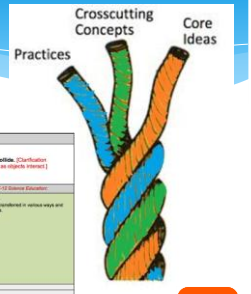
Board on Testing and Assessment
and
Board on Science Education
National Academy of Sciences

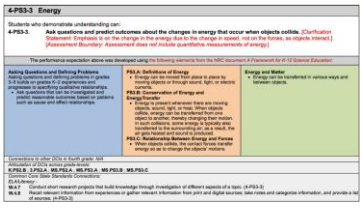
Topics Addressed in the Report

- 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

7

Three-Dimensional Science Learning





4-PS3-3 Energy

Students who demonstrate understanding can:

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

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

Asking Questions and Defining Problems
- Ask questions and predict outcomes about the changes in energy that occur when objects collide.

PS3.A: Definitions of Energy
- The faster a given object is moving, the more energy it possesses.

PS3.B: Conservation of Energy and Energy Transfer
- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air as a result, the air gets heated and sound is produced.

PS3.C: Relationship Between Energy and Forces
- When objects collide, the contact forces transfer energy so as to change the objects' motions.

Energy and Matter
- Energy can be transferred in various ways and between objects.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: K-PS2.B: 1-PS2.A; MS.PS2.A; MS.PS3.B; MS.PS3.C

Common Core State Standards Connections:

ELA/Literacy:
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-3)
W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-3)

8

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**

9

What should assessment look like?

10

Focus on Formative Assessment

11

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.**

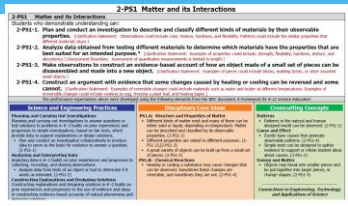
12

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.
- Each performance expectation incorporates all three dimensions, and the NGSS emphasize the importance of the connections among scientific concepts.

13

Assessment Challenge

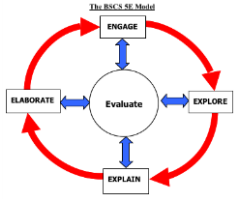


It will not be feasible to assess all of the performance expectations for a given grade band during a single assessment occasion.

14

Multiple assessments

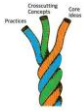
Students will need multiple—and varied—assessment opportunities to demonstrate their competence on the performance expectations for a given grade level



15

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.*

16

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

17

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

18

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

19

Drinking Straws & Air Pressure

Develop a model to explain what happens to the air molecules inside and outside a drinking straw.

- Students use a straw to investigate and explain air pressure
- Discuss ideas about what is happening to the air
- Make a claim …
- Engage in argument from evidence

20

Three Dimensional Assessment

MS-PS1 Matter and Its Interactions

MS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

MS-PS1-1. **Develop models to describe the atomic composition of simple molecules and extended structures.** [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energies, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure.]

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 HCl.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

MS-PS1-3. **Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.** [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicines, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]

MS-PS1-4. **Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.** [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

MS-PS1-5. **Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.** [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

MS-PS1-6. **Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

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
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4) • Develop a model to describe unobservable mechanisms. (MS-PS1-5) **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and	**PS1.A: Structure and Properties of Matter** • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2),(MS-PS1-3) • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) • 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	**Patterns** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2) **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4) **Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Performance Expectation

Students who demonstrate understanding can:

MS-PS1-1
Develop models to describe the atomic composition of simple molecules and extended structures.
[Clarification statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include… Assessment Boundary: Assessment does not include valence electrons and bonding energy…]

22

ID the Assessment Opportunities in the 5E Learning Cycle

* Engage
* Explore
* Explain
* Elaborate
* Evaluate

23

Explore!

* Materials: drinking straw, clear cup, water, straight pin
* Follow the procedure on the *Drinking Straws and Air Pressure Exploration*.
* Explain predictions & results to a partner
* Draw models to explain the behavior of the water in the straw during each part

24

Assessment Opportunities?

5E	Practices	DCIs	Crosscutting
Engage			
Explore			
Explain			
Elaborate			
Evaluate			

25

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

26

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

27

Review 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

28

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

29

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

31

Contacts

* Mary Thurlow, Coordinator for Science, mthurlow@msde.state.md.us
* Gary Hedges, Science Specialist, ghedges@msde.state.md.us
* JoAnn Roberts, Disciplinary Literacy Specialist, jroberts@msde.state.md.us

MARYLAND STATE DEPARTMENT OF EDUCATION
Preparing World-Class Students

32