Implementing the NGSS

NEXT GENERATION SCIENCE STANDARDS
For States, By States

NGSS Support

Current and Upcoming NGSS Projects

- Science EQuIP – Spring 2014
- Standards Comparison Document – Summer 2014
- High School Evidence Statements – Fall 2014
- SciMath – Fall 2014
- Accelerated Model Course Maps – Spring 2015
- IB Model Course Maps – Spring 2015
- Model Content Frameworks – Spring 2015
- K-8 Evidence Statements – Spring 2015
- Publishers Criteria – Summer 2015

Key Innovations in the NGSS

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Innovations in the NGSS

1. Three-Dimensional Learning
2. Students Engaging in Phenomena and Designed Solutions
3. Engineering and Nature of Science is integrated into science
4. All three dimensions build coherent learning progressions
5. Science is connected to math and literacy

Three-Dimensional Learning

A. Grade-appropriate elements of the science and engineering practice(s), disciplinary core idea(s), and crosscutting concept(s), work together to support students in three-dimensional learning to make sense of phenomena and/or to design solutions to problems.
   i. Provides opportunities to develop and use specific elements of the practice(s) to make sense of phenomena and/or to design solutions to problems.
   ii. Provides opportunities to develop and use specific elements of the disciplinary core idea(s) to make sense of phenomena and/or to design solutions to problems.
   iii. Provides opportunities to develop and use specific elements of the crosscutting concept(s) to make sense of phenomena and/or to design solutions to problems.
   iv. The three dimensions work together to support students to make sense of phenomena and/or to design solutions to problems.

Practices, what do they mean?

Scientific Models

- Component: Models includes specific variables or factors within the system under study.

- Relationship: Models need to represent the relationship among components in order to provide an account of why the phenomenon occurs.

- Connection: Models needs to be connected to causal phenomena or scientific theory that students are expected to explain or predict.

Constructing Explanations

- Explanation of phenomena

- Evidence : scientific data that supports the student's claim. This data can come from an investigation that students complete or from another source, such as observations, reading material, archived data, or other sources of information. The data needs to be both *appropriate* and *sufficient* to support the claim.

- Reasoning : a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles. The reasoning ties in the scientific background knowledge or scientific theory that justifies making the claim and choosing the appropriate evidence.

Engaging in Argument from Evidence

- Supported claims : Any ideas or designs that students are supporting.
- Identifying scientific evidence: identification of multiple lines of scientific evidence that is relevant to a particular scientific question or engineering design problem.
- Evaluation and critique : Identification of strength of the evidence used to support an argument or a particular design solution.
- Reasoning and Synthesis: Synthesizing the evidence logically and connecting to phenomena.

Bundling

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Black Boxes

- Black boxes are areas of instruction that the student is expected to just memorize a piece of the “puzzle” and hope they make a connection later

Teaching Photosynthesis

Some questions to consider

- Should photosynthesis be the focus of instruction
- Is photosynthesis a core idea?
- Does learning about photosynthesis give students a piece to a larger picture?

What makes things grow?

- MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- 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.
- MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

A closer look

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. *[Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]*

Constructing Explanations and Designing Solutions

Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-5),(MS-LS1-6)

LS1.C: Organization for Matter and Energy Flow in Organisms

Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)

Energy and Matter

Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)

A closer look

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. *[Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.]*

Developing and Using Models
Develop and use a model to describe phenomena.

ESS2.A: Earth's Materials and Systems
All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1)

Stability and Change
Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)

An even closer look

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HS-PS-1

HS-PS1-1

Students who demonstrate understanding can:

HS-PS1-1. **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.**

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to predict the relationships between systems or between components of a system.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS-1 Evidence of Student Performance

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students identify the following components of the given model:	
		i.	Elements and their arrangement in the periodic table;
		ii.	A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;
		iii.	Electrons in the outermost energy level of atoms (i.e., valence electrons); and
		iv.	The number of protons in each element.
2	Relationships		
	a	Students identify the following relationships between components in the given model:	
		i.	The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
		ii.	Elements in the periodic table are arranged by the numbers of protons in atoms.
3	Connections		
	a	Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.	
	b	Students predict the following patterns of properties:	
		i.	The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
		ii.	The number and charges in stable ions that form from atoms in a group of the periodic table;
		iii.	The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and
		iv.	The relative sizes of atoms both across a row and down a group in the periodic table.

Simple bundle

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS-1 and HS-PS-2

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students identify the following components of the given model:	
		i.	Elements and their arrangement in the periodic table;
		ii.	A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;
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		iv.	The relative sizes of atoms both across a row and down a group in the periodic table.

Observable features of the student performance by the end of the course:			
1	Explanation of phenomena		
	a	Students construct an explanation of the outcome of the given reaction, including:	
		i.	The idea that the total number of atoms of each element in the reactant and products is the same;
		ii.	The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity;
		iii.	The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on their position in the periodic table; and
		iv.	A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons).
2	Evidence		
	a	Students use evidence to construct the explanation, including:	
		i.	Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons;
		ii.	Identification that the number and types of atoms are the same both before and after a reaction;
		iii.	Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products;
		iv.	The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table; and
		v.	The outermost (valence) electron configuration and the relative electronegativity of the atoms that make up both the reactants and the products of the reaction based on their position in the periodic table.
3	Reasoning		
	a	Students integrate the evidence to explain how the patterns of outermost electrons and the electronegativity of elements can be used to predict the number and types of bonds each element forms.	
	b	In the explanation, students provide the causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.	
4	Revision		
	a	Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.	

HS-PS-1 and HS-PS-2

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1	Components of the model		
	a	Students identify the following components of the given model:	
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		iv.	The number of protons in each element.
2	Relationships		
	a	Students identify the following relationships between components in the given model:	
		i.	The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
		ii.	Elements in the periodic table are arranged by the numbers of protons in atoms.
3	Connections		
	a	Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.	
	b	Students predict the following patterns of properties:	
		i.	The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
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		iv.	A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons).
2	Evidence		
	a	Students use evidence to construct the explanation, including:	
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	a	Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.	

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