A Primer on the Next Generation Science Standards and Considerations for Next Steps
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Presentation Agenda

Next Generation Science Standards

• What Are They?
• Why Are They Needed?
• How Were They Developed and What was Delaware’s Role?
• Are they Aligned to Support and Enhance CCSS and College and Career readiness efforts?
• What are Delaware’s Next Steps?
Introduction video to Next Generation Science Standards
Building on the Past, Preparing for the Future, Leading to the NGSS

Phase I

1/2010 - 7/2011

Phase II

7/2011 – March 2013
State Involvement: (Lead States and Writing Team Members)
Delaware’s Role in the NGSS Development

• **July 2011**: K-12 Science Education Framework released – Delaware was involved in the writing of this tool

• **November 2011**: Delaware became a LEAD State in the NGSS development

• **December 2011-December 2012**: DE Science Educators provide feedback on 1st and 2nd drafts of NGSS

• **Since November 2011**: DE involved in multiple professional learning and national planning meetings
The Next Generation Science Standards (NGSS)

- Every NGSS standard has three dimensions:
  - Disciplinary core ideas
  - Scientific and Engineering Practices
  - Cross cutting concepts.
- Science concepts build coherently across grade K=12
- Scientific and Engineering Practices and Cross Cutting Concepts are designed to be taught in context throughout the year.
- The NGSS focus on a smaller set of Disciplinary Core Ideas
- Science and Engineering are integrated into science education by raising engineering design to the same level as scientific inquiry.
- The NGSS is focused on preparing students for college and career.
Three Dimensions of the NGSS

The **practices** are the processes of building and using the **core ideas** to make sense of the natural and designed world, and the **cross cutting concepts** hold the discipline together.
NGSS Content: Three Dimensions Intertwined

- NGSS will require contextual application of the three dimensions by students.
Dimension 1: Science and Engineering Practices

• Asking questions and defining problems
• Developing and using models
• Planning and carrying out investigations
• Analyzing and interpreting data
• Using mathematics, information and computer technology, and computational thinking
• Constructing explanations and designing solutions
• Engaging in argument from evidence
• Obtaining, evaluating, and communicating information

NRC Framework pp.41-82
Dimension 2: Cross Cutting Concepts

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change

NRC Framework pp. 83-102
Dimension 3: Disciplinary Core Ideas

- Physical Science, Life Science, Earth and Space Science and Engineering, Technology and Application of Science

- A core idea for K-12 science instruction is a scientific idea that:
  1. Has broad importance across multiple science or engineering disciplines or is a key organizing concept of a single discipline
  2. Provides a key tool for understanding or investigating more complex ideas and solving problems
  3. Relates to the interests and life experiences of students or can be connected to societal or personal concerns that require scientific or technical knowledge
  4. Is teachable and learnable over multiple grades at increasing levels of depth and sophistication

NRC Framework pp. 83-102
### MS-PS-IF Interactions of Forces

**Students who demonstrate understanding can:**

a. **Plan and carry out investigations to illustrate the factors that affect the strength of electric and magnetic forces.** [Clarification Statement: Investigations can include observing the electric force produced between two charged objects at different distances; and measuring the magnetic force produced by an electromagnet with a varying number of wire turns, number or size of dry cells, or size of iron core.] [Assessment Boundary: Qualitative, not quantitative; no assessment of Coulomb's law.]

b. **Use a model or various representations to describe the relationship among gravitational force, the mass of the interacting objects, and the distance between them.** [Clarification Statement: Examples of models and representations can include labeled diagrams of the relationship between Earth and man-made satellites, the International Space Station, and an airplane taking off.] [Assessment Boundary: Qualitative, not quantitative.]

c. **Plan and carry out investigations to demonstrate that some forces act at a distance through fields.** [Assessment Boundary: Fields included are limited to gravitational, electric, and magnetic. Determination of fields are qualitative not quantitative (e.g., forces between two human-scale objects are too small to measure without sensitive instrumentation).]

d. **Develop a simple model using given data that represents the relationship of gravitational interactions and the motion of objects in space.** [Clarification Statement: Examples of simple models can include charts displaying mass, distance from the sun, and orbital periods of objects within the solar system.](a)(d)

(e) **Develop or modify models to demonstrate that systems can withstand small changes, relying on feedback mechanisms to maintain stability.** [Assessment Boundary: Use models to determine a relationship conceptually, not quantitatively.]

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### Science and Engineering Practices

**Developing and Using Models**

- Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to explain, explore, and predict more abstract phenomena and design systems.
  - Use and/or construct models to predict, explain, and explore phenomena in natural or designed systems, including those representing inputs and outputs.
  - Pose models to describe mechanisms at unobservable scales.
  - Model beyond their limitations to increase detail or clarity, or to explore what will happen if a component is changed.
  - Use and construct models of simple systems with uncertain and less predictable factors.

**Planning and Carrying Out Investigations**

- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.
- Collect data and generate evidence to answer scientific questions or test design solutions under a range of conditions.

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### Disciplinary Core Ideas

**PS2.B: Types of Interactions**
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic field strengths and on the distances between the interacting objects.
  - Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
  - Long-range gravitational interactions govern the evolution and maintenance of large-scale systems in space, such as galaxies or the solar system, and determine the motion of objects within those structures.
  - Forces that are at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effects on a test object (a ball, a charged object, or a magnet, respectively).

**PS2.C: Stability and Instability in Physical Systems**
- A stable system is one in which any small change results in forces that return the system to its prior state (e.g., a weight hanging from a string).
  - Many systems, both natural and engineered, rely on feedback mechanisms to maintain stability, but they can function only within a limited range of conditions. With no energy inputs, a system starting out in an unstable state will continue to change until it reaches a stable configuration (e.g., sand in an hourglass).

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### Crosscutting Concepts

**Cause and Effect**
- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

**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. The observed function of natural and designed systems may change with scale.
  - Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. Scientific relationships can be represented through the use of algebraic expressions and equations.

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### Common Core State Standards Connections

**ELA**
- **RST.6.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- **WHST.7:** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

**Mathematics**
- **MP 1:** Make sense of problems and persevere in solving them.
- **MP 2:** Reason abstractly and quantitatively.
- **MP 3:** Model with mathematics.
- **MP 6:** Attend to precision.
- **5.OA:** Analyze patterns and relationships.
- **6.EE:** Analyze and understand quantitative relationships between dependent and independent variables.
- **7.RP:** Analyze proportional relationships and use them to solve real-world and mathematical problems.
- **7.EE:** Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
Extra Content in the NGSS*

Appendices are being developed on several topics including:

- College and Career Readiness
- All Standards, All Students
- Science and Engineering Practices in the NGSS
- Nature of Science
- Engineering Design, Technology, and the Applications of Science in the NGSS
- Model Course Mapping in Middle and High School

*http://www.nextgenscience.org/next-generation-science-standards
Conceptual Shifts in the NGSS

1. K-12 science education should reflect the interconnected nature of science as it is practiced and experienced in the real world.
2. The Next Generation Science Standards are student performance expectations – NOT curriculum.
3. The science concepts build coherently from K-12.
4. The NGSS focus on deeper understanding of content as well as application of content.
5. Science and engineering are integrated in the NGSS from K–12.
6. The NGSS are designed to prepare students for college, career, and citizenship.
7. The NGSS and Common Core State Standards (English Language Arts and Mathematics) are aligned.

*See additional handout posted in agenda item for more detail*
MS.PS-IF Interactions of Forces

Students who demonstrate understanding can:

a. Plan and carry out investigations to illustrate the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Investigations can include observing the electric force produced between two charged objects at different distances; and measuring the magnetic force produced by an electromagnet with a varying number of wire turns, number or size of dry cells, or size of iron core.] [Assessment Boundary: Qualitative, not quantitative; no assessment of Coulomb's law.]

b. Use a model or various representations to describe the relationship among gravitational force, the mass of the interacting objects, and the distance between them. [Clarification Statement: Examples of models and representations can include labeled diagrams of the relationship between Earth and man-made satellites, the International Space Station, and an airplane taking off.] [Assessment Boundary: Qualitative, not quantitative.]

c. Plan and carry out investigations to demonstrate that some forces act at a distance through fields. [Assessment Boundary: Fields include magnetic and gravitational.] [Assessment Boundary: Not quantitative, for example, forces between two human-scale objects are too small to measure without sensitive instrumentation.]

d. Develop a simple model using given data that represents the relationship of gravitational interactions and the motion of objects in space. [Clarification Statement: Examples of simple models can include charts displaying mass, distance from the sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Use models to determine a relationship conceptually. Qualitative, not quantitative.]

e. Develop or modify models to demonstrate that systems can withstand small changes, relying on feedback mechanisms to maintain stability. [Assessment Boundary: Use models to determine a relationship conceptually, not quantitatively.]

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

Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to explain, design, and predict more abstract phenomena and design systems.
- Use and/or construct models to predict, explain, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs.
- Pose models to describe mechanisms at observable scales. (b), (d)
- Modify models—based on their limitations—to increase detail or clarity, or to explore what happens when different variables are changed.
- Use and construct models of simple systems with uncertain and less predictable factors.

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions in problems in 6–8 builds on K–5 and progresses to include investigations that consider multiple variables and provide evidence to support explanations or design solutions.
- Collect and generate evidence to answer scientific questions or test design solutions under a range of conditions.

Disciplinary Core Ideas

PS2.B: Types of Interactions
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
- Long-range gravitational interactions govern the evolution and maintenance of large-scale systems in space, such as galaxies or the solar system, and determine the patterns of motion within those structures.
- Forces that act at a distance (gravitational, electromagnetic, and electric) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively).

PS2.C: Stability and Instability in Physical Systems
- A stable system is one in which any small change results in forces that return the system to its prior state (e.g., a weight hanging from a string).
- Many systems, both natural and engineered, rely on feedback mechanisms to maintain stability, but they can function only within a limited range of conditions. With no energy inputs, a system starting out in an unstable state will continue to change until it reaches a stable configuration (e.g., sand in an hourglass).

Connections to other DCIs in this grade level: MS.ESS-SS, MS.ESS-EDP, MS.ESS-ESP, MS.ESS-WC

Crosscutting Concepts

Cause and Effect
Relationships can be classified as causal or correlation, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

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. The observed function of natural and designed systems may change with scale.

RST.6.3 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.7 Analyze patterns and relationships.
Comparison of Some Grade 4 Life Science Example Standards

<table>
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<tbody>
<tr>
<td>• Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.</td>
<td><strong>Performance Expectations</strong></td>
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<tr>
<td>• Plants and animals closely resemble their parents.</td>
<td>• Investigate the life cycles of plants and animals to compare similarities and differences among organisms.</td>
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<tr>
<td>• Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal.</td>
<td>• Use evidence to compare characteristics inherited from parents, characteristics caused by the environment, and those resulting from both.</td>
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<td>• Obtain and communicate information about different versions of the same traits in different kinds of organisms.</td>
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<td>• Use evidence to describe patterns of variation in a trait across individuals of the same kind of organism.</td>
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NGSS College and Career Ready

NGSS is working with the 26 lead states to develop a specific definition of College and Career ready in reference to the NGSS standards.

Delaware’s Definition:
Each Delaware student will graduate ready for college and career. Students will be prepared to successfully plan and pursue an education and career path aligned to their personal goals, with the ability to adapt and innovate as demands change. Students will graduate with strong academic knowledge, the behaviors and skills with which to apply their knowledge, and the ability to collaborate and communicate effectively. Each student will exhibit the behaviors of an independent learner, and have respect for a diverse society and a commitment to responsible citizenship.
Common Core Adoption Map
February 2013:
46 states, D.C., Four Territories, and the Department of Defense Education Agency

Adopted
Adopted ELA Only
Have not adopted CCSS
CCSS State Led Initiatives:

Professional Learning Opportunities:
- Kentucky legislature allocated monies to develop systemic professional learning through its Kentucky Leadership Network.
- Delaware hosted training for 700 educators through its “Common Ground for Common Core” initiative.
- The Florida College System Teacher Educator Programs voluntarily committed to a system-wide implementation of the Common Core State Standards.

Communication and Outreach
- Georgia Department of Education partnered with Georgia Public Broadcasting.
- Many states created teacher channels and instructional video modules. Ex: Arkansas and Vermont
CCSS and NGSS Resources

- NASBE’s CCSS Toolkit for Implementation: http://playbook.hopestreetgroup.org/commoncore
- NASBE Resource Guide
- NGSS content/process: http://www.nextgenscience.org

Francis Eberle – francise@nasbe.org
Other Initiatives in Science Education with Similar Emphasis

- NAEP Frameworks for Science, and Technology and Engineering (NAGBE)
- New Advanced Placement Coursework and Assessments (College Board)
- PISA 2015 (OECD)
- Vision and Change in Undergraduate Biology (NSF)
- A New Biology for the 21st Century (NAS)
- Scientific Foundations for Future Physicians (AAMC and HHMI)
“For every increment of performance I demand from you, I have an equal responsibility to provide you with the capacity to meet that expectation.”

--Richard Elmore
Delaware’s Next Steps

Next Generation Science Standards

Common Core Standards
Delaware Plan

• Development of State NGSS Planning team
  • Secretary Murphy will convene a team of Stakeholders to evaluate the standards and provide recommendation for potential adoption (April 2013)
  • State-wide outreach planned to provide awareness, request public comment, and answer FAQ’s about the standards prior to their recommendation for adoption. (April – August 2013)
  • Additional SBE Presentation planned for June 2013.
  • Potential Adoption action in August 2013
Current Local Planning Efforts with National Support

- Building Capacity for State Science Education (Council of State Science Supervisors)
  - Meetings of state science educator teams to prepare for NGSS from September 2011 through June 2013
- Adoption Institutes (Achieve)
  - Meetings of Lead State teams from February 2013 through November 2013
- Information and Instructional Tools (NSTA)
  - Web portal, online courses, listserv, webinars, resources
Policy Alignment – State Statue and Regulatory Issues

- Standards
- Preparation, Licensing and certification
- Educator Evaluation and Effectiveness
- Professional Development
- Assessment Systems
- Graduation Requirements
- Higher Education