NEXT GENERATION SCIENCE STANDARDS
For States, By States
Development of State Science Standards

Phase I

1/2010 - 7/2011

Phase II

7/2010 – April 2013

1990s

1990s-2009

1/2010 - 7/2011

NEXT GENERATION SCIENCE STANDARDS
For States, By States
NGSS Sponsors

- Boeing
- Carnegie Corporation of New York
- Cisco Foundation
- DuPont
- GE Foundation
- Noyce Foundation
Process for Development of Next Generation Science Standards

States and other key stakeholders are engaged in the development and review of the new college and career ready science standards

- State Led Process
- Writing Teams
- Critical Stakeholder Team
- Business engagement

NRC Study Committee members to check the fidelity of standards based on framework
New Jersey NGSS Team

- 30% Teachers
- 30% Business/Partners
- 25% Higher Ed
- 5% NJDOE
- 10% Informal Education Centers
New Jersey Critical Stakeholders

- Critical Stakeholder Organizations
- Chatham High School, School District of the Chathams
- Rutgers University
- Rutgers University, Department of Earth and Environmental Science
- Bergen County Technical School, New Jersey Center for Teaching and Learning
- New Jersey City University
- Red Bank School District
The NGSS have passed a fidelity review by the NRC.

The review panel was made up of some members from the actual Framework committee and other experts who were familiar with the Framework and NGSS.

The National Academies Press will publish the NGSS in print form. This represents the first time in its history that the NAP is publishing a report that was not developed by a committee or board of the National Academies.
Scientific and Educator Organization Support

- American Association of Physics Teachers
- American Chemical Society
- American Federation of Teachers
- American Meteorological Society
- American Physical Society
- American Society of Plant Biologists
- ASME (American Society of Mechanical Engineers)
- Association of American Universities
- Association of Presidential Awardees in Science Teaching
- Association of Public and Land Grant Universities
- Council of State Science Supervisors
- National Association of Biology Teachers
- National Association of Geoscience Teachers
- National Association of Gifted Children
- National Education Association
- National Science Education Leadership Association
- National Science Teachers Association
Scientist Support

- Bruce Alberts, Stanford University / Past President, National Academy of Sciences
- James Gates, University of Maryland / National Medal of Science / Maryland State Board of Education
- Jonathan Osborne, Stanford University, PISA Science Framework Director
- 4 Nobel Laureates including Carl Wieman, Stanford University
Business Support

- Businesses are critical partners in the successful adoption and implementation of the NGSS

- Over 60 companies have signed a letter of support for the NGSS

New Jersey Business Support

Businesses with Headquarters in New Jersey
- Bayer Corporation
- Prudential
- Merck

Businesses with Offices in New Jersey
- Battelle Memorial Institute
- Broadcom
- California Technologies
- Chevron
- Corning, Inc.
- Dell Inc.
- Microsoft Corporation
- Parsons
A 3 Dimensional Vision for Science Education
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Framework pp.41-82
<table>
<thead>
<tr>
<th>Grades K-2</th>
<th>Grades 3-5</th>
<th>Grades 6-8</th>
<th>Grades 9-12</th>
</tr>
</thead>
</table>
| Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.  
- Distinguish between a model and the actual object, process, and/or events the model represents.  
- Compare models to identify common features and differences.  
- Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).  
- Develop a simple model based on evidence to represent a proposed object or tool. | Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.  
- Identify limitations of models.  
- Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.  
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.  
- Develop and/or use models to describe and/or predict phenomena.  
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. | Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.  
- Evaluate limitations of a model for a proposed object or tool.  
- Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.  
- Use and/or develop a model of simple systems with uncertain and less predictable factors.  
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.  
- Develop and/or use a model to predict and/or describe phenomena.  
- Develop a model to describe unobservable mechanisms.  
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. | Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.  
- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.  
- Design a test of a model to ascertain its reliability.  
- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.  
- Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.  
- Develop a complex model that allows for manipulation and testing of a proposed process or system.  
- Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. |
Crosscutting Concepts
Crosscutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

Framework pp. 83-102
Disciplinary Core Ideas
Disciplinary Core Ideas

Physical Sciences

Life Sciences

Earth Space Sciences

Engineering, Technology and Applications of Science
Three Dimensions Intertwined

- Performance Expectations
- The Framework requires contextual application of the three dimensions by students.
- Focus is on how and why as well as what
Appendices have been added to support the NGSS and in response to feedback:

- Appendix A – Conceptual Shifts
- Appendix B – Responses to Public Feedback
- Appendix C – College and Career Readiness
- Appendix D – All Standards, All Students
- Appendix E – Disciplinary Core Idea Progressions in the NGSS
- Appendix F – Science and Engineering Practices in the NGSS
- Appendix G – Crosscutting Concepts in the NGSS
- Appendix H – Nature of Science
- Appendix I – Engineering Design in the NGSS
- Appendix J – Science, Technology, Society, and the Environment
- Appendix K – Model Course Mapping in Middle and High School
- Appendix L – Connections to Common Core State Standards in Mathematics
- Appendix M – Connections to Common Core State Standards in ELA
What About Engineering?
## Similarities and Differences

<table>
<thead>
<tr>
<th>Scientific Inquiry</th>
<th>Engineering Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask a question</td>
<td>Define a problem</td>
</tr>
<tr>
<td>Obtain, evaluate and communicate technical information</td>
<td>Obtain, evaluate and communicate technical information</td>
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<tr>
<td>Plan investigations</td>
<td>Plan designs and tests</td>
</tr>
<tr>
<td>Develop and use models</td>
<td>Develop and use models</td>
</tr>
<tr>
<td>Design and conduct tests of experiments or models</td>
<td>Design and conduct tests of prototypes or models</td>
</tr>
<tr>
<td>Analyze and interpret data</td>
<td>Analyze and interpret data</td>
</tr>
<tr>
<td>Use mathematics and computational thinking</td>
<td>Use mathematics and computational thinking</td>
</tr>
<tr>
<td>Construct explanations using evidence</td>
<td>Design solutions using evidence</td>
</tr>
<tr>
<td>Engage in argument using evidence</td>
<td>Engage in argument using evidence</td>
</tr>
</tbody>
</table>

Adapted from A Framework for K-12 Science Education (NRC, 2011)
Middle School

Define
Attend to precision of criteria and constraints and considerations likely to limit possible solutions

Optimize
Use systematic processes to iteratively test and refine a solution

Develop solutions
Combine parts of different solutions to create new solutions

Engineering Design and the NGSS
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
Engineering with Paper

• Using only the two sheets of paper provided, construct a platform that supports the mass of the full water bottle in a stable position as far above the table top as possible.

• While constructing the tower, consider useful engineering practices that support your design.

• Consider the useful science ideas and concepts used to help design and construct the tower.
Moving from Standards to Instruction
Instruction Builds Toward PEs

Performance Expectation
MS-PS1-4 Develop a model that predicts and describes changes in atomic motion, temperature and state of a pure substance when thermal energy is added or removed.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the motion energy of an object changes energy is transferred to or from the object.

**Developing and Using Models**

**Students decide on one model to explain why the tanker imploded.**

**Drawings included molecules and force arrows.**

**Apply understanding of internal and external pressure**

**Developing and Using Models**

**Students revise models.**

**Obtaining, evaluating, and communicating information**

**Students evaluate a video that shows a tanker dramatically imploding the day after being washed out with steam and then all the outlet valves were closed.**

**Students discuss spacing of molecules during liquid and gas phase of water.**

**MS-PS1 - in a gas, they are widely spaced except when they happen to collide.**

**Matter and Energy**

**Cause and Effect**
**MS-PS1-4** Develop a model that predicts and describes changes in atomic motion, temperature and state of a pure substance when thermal energy is added or removed.

**MS-PS3-5.** Construct, use, and present arguments to support the claim that when the motion energy of an object changes energy is transferred to or from the object.

**Constructing Explanations**

Students construct explanations about their ideas of why blimps have balloonets filled with air.

**Engaging in Argument from Evidence**

Students translate the data into evidence from the investigations to construct an argument of the tanker implosion.

**Planning and carrying out investigations**

Students refined their models by planning and carrying out an investigation using the collapsing can to evaluate different variables.

**MS-PS1** - …in a gas, they are widely spaced except when they happen to collide.

**MS-PS1** - The changes of state that occur with variations in temperature or pressure can be described and predicted.

**MS-PS3** - Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

_Students can use their conceptual model to describe changes in temperature and pressure in terms of space between and motion of gaseous molecules._
Bundling Math and Science

Construct and compare linear, quadratic, and exponential models and solve problems.

1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

For exponential models, express as a logarithm the solution to \( ab^{ct}=d \) where \( a, c, \) and \( d \) are numbers and the base \( b \) is 2, 10, or \( e \); evaluate the logarithm using technology.

2. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*
In 1966, a Miami boy smuggled three Giant African Land Snails into the country. His grandmother eventually released them into the garden, and in seven years there were approximately 18,000 of them. The snails are very destructive and had to be eradicated. They consume over 500 different types of plants, lay over 1,200 eggs per year, and have been shown to cause indigenous snails’ populations to decrease over time. According to the USDA, it took 10 years and cost $1 million to eradicate them. Now, Miami-Dade County, Florida faces the same infestation.
Giant African Land Snail

a. Assuming the snail population grows exponentially, write an expression for the population, $P$, in terms of the number, $t$, of years since their release in 1966.

b. How long does it take for the population to double?

c. Assuming the cost of eradicating the snails is proportional to the population, how much would it have cost to eradicate them if

i. The Florida Department of Agriculture (FDA) had started the eradication program a year earlier?

ii. The FDA had let the population grow unchecked for another year?
d. Using information from online sources develop a model of a possible food web for current day Miami-Dade County. The web should include at least one indigenous snail, the wolf snail and at least three indigenous plants. Be sure to include mathematical or computational representations about the current carrying capacity of the ecosystem as well as the energy dissipation as energy is transferred from organism to organism.

e. Given the population growth and the nature of the Land Snails, insert the Land Snails into the previously constructed food web. Using your previous representation, construct an argument based on the competitive relationships and the mathematical comparisons between a normally functioning ecosystem versus one with the Land Snails. The argument should also include the Land Snails effect on other organisms within the food web.
f. Apply concepts of statistics and probability to develop evidence that the Land Snail has an advantageous heritable trait and tend to increase in proportion to wolf snails.

g. In Hawaii, a new species of snail was introduced to combat the Land Snails. While it showed some progress, there was an extinction of some indigenous snails as a result of the new species. Construct a possible alternative to eradicating the Land Snails and the new species. The plan should include clear discussions regarding the criteria, trade-offs, and the plan for the mitigation of human intervention.
Evidence Statements
Structure

- Organized by Scientific and Engineering Practice
- Includes all dimensions
- Developed specifically for the Performance Expectations
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.
Explanation Template

- 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.
Argument Template

- 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/Synthesis: Synthesizing the evidence logically and connecting to phenomena
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.

Observable features of the student performance:

1. Components of the model include
   a. Elements and their arrangement in the periodic table
   b. Electrons in the outermost energy level of atoms (i.e., valence electrons)
   c. Number of protons in each element.

2. Relationship
   a. Model describes that:
      i. The patterns of outermost electrons are reflected in the arrangement of the main groups of the periodic table.
      ii. Elements in the periodic table are arranged by the numbers of protons in atoms

3. Connection
   a. The periodic table is used to predict the patterns of behavior of the elements based on the patterns of outer electrons that determine the typical reactivity of an element (metal, non-metal, noble gas)
   b. The patterns of behavior that are predicted are:
      i. The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements.
      ii. The number and charges that form in stable ions that form from atoms in a group of the periodic table
      iii. The trend in reactivity down a group, and across a row in the periodic table, based on relative attractions of electrons to the nucleus.
Adopting States

- California
- Delaware
- District of Columbia
- Illinois
- Kansas
- Kentucky
- Maryland
- Oregon
- Nevada
- Rhode Island
- Vermont
- Washington
2014 NGSS Annual Leadership Meeting

The first NGSS Annual Meeting for State Leadership Teams and Partners was held in Atlanta, Georgia in February 2014.

In total, attendees represented over 80 organizations, including state education agencies, school districts, state boards of education, higher education institutions, teacher organizations, research organizations, other third party advocates, and the business community.

The 2014 NGSS Leadership Meeting focused on developing strategies for building and sustaining systems for standards implementation, including: professional development; leadership development; curriculum and instructional materials transitions; communications, advocacy and coalition building; and assessment transitions.

Please check back for additional updates.

Presentations

- The State of State Science Education Research Handout - Stephen Pruitt & Jennifer Hoover
Presentations

- The State of State Science Education Research Handout - Stephen Pruitt & Maria Ferguson
- Overview of the NGSS Implementation Workbook - Alissa Peltzman
- Defining Your State’s Role in Implementation - Alissa Peltzman
  - Defining Your State’s Role in Implementation-Exercise

Professional Development

- Alabama Math, Science, and Technology Initiative - Steve Ricks
- A Vision of Science Education in South Dakota - Sam Shaw
- Systems of Large-Scale Professional Development - Sean Smith
- New Mexico’s Common Core State Standard’s RFP Process - Kanna Vanderbilt

Leadership Development

- Washington State’s Story of Building Capacity for Next Generation Science Standards - Ellen Ebert & Peggy Willcuts

Curriculum and Instructional Materials Transitions

- Evaluating Curriculum & Instructional Materials - Joe Krajcik
- EQuIP NGSS Rubric & Delaware’s NGSS Implementation Plan - Shelley Rouser & John Moyer

Communications, Advocacy and Coalition Building

- Engaging Business in Support of NGSS - Weedon
Product Development
Current and Upcoming NGSS Projects

- Science EQuIP – Spring 2014
- High School Evidence Statements – Summer 2014
- SciMath – Summer 2014
- Accelerated Model Course Maps – Summer 2014
- State of Science Education Research – Summer 2014
- Standards Comparison Document – Summer 2014
- Alignment Institutes – Fall 2014
- Publishers Criteria – Fall 2014
- Model Content Frameworks – Fall 2014
- Computer Science Interaction – 2014
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