Plenary Session On
Next Generation Science Standards

S. James Gates, Jr.

University System of Maryland Regents Professor, John S. Toll Professor of Physics and Center for String and Particle Theory Director
28 July 2013

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301-405-6025 http://www.umdphysics.umd.edu/people/faculty/135-gates.html
Q: Why must we focus on science and STEM more generally in the realm of education?

A: The population of the U.S. is about 300 million and is expected to continue to grow. So unless the amount of wealth continues to grow commensurately, on average the citizens of this nation will become poorer. Since WWII, economists have come to the conclusion that the major component to the growth of U.S. wealth comes from STEM related activities.
NGSS: A Key To Unlocking The American Dream

Provenance: The National Research Council’s “A Framework for K-12 Science Education”

Doctrine: The high quality learning of science, more importantly the skill set developed from this, can no longer be regarded as a realm only for the elite and must serve the goal of permitting the broadest possible access to the American Dream for this Nation’s citizens (SJG).

Process: Intensely Collaborative Multi-State & State-Driven

Product: The Next Generation Science Standards
Provenance

A Framework for K-12 Science Education
Practices, Crosscutting Concepts, and Core Ideas
National Research Council
of the National Academies

Next Generation Science Standards
A Framework for K-12 Science Standards:
Practices, Crosscutting Concepts, and Core Ideas

COMMITTEE ON A CONCEPTUAL FRAMEWORK FOR NEW SCIENCE EDUCATION STANDARDS

HELEN R. QUINN (Chair), SLAC National Accelerator Laboratory, Stanford University; WYATT W.
ANDERSON, Department of Genetics, University of Georgia, Athens; TANYA ATWATER, Department
of Earth Science, University of California, Santa Barbara; PHILIP BELL, Learning Sciences, University of
Washington, Seattle; THOMAS B. CORCORAN, Teachers College, Columbia University; RODOLFO
DIRZO, Department of Biology, Stanford University; PHILLIP A. GRIFFITHS, Institute for Advanced Study,
Princeton, New Jersey; DUDLEY R. HERSCHBACH, Department of Chemistry and Chemical Biology,
Harvard University; LINDA P.B. KATEHI, Office of the Chancellor, University of California, Davis; JOHN
C. MATHER, NASA Goddard Space Flight Center, Greenbelt, Maryland; BRETT D. MOULDING, Utah
Partnership for Effective Science Teaching and Learning, North Ogden; JONATHAN OSBORNE, School
of Education, Stanford University; JAMES W. PELLEGRINO, School of Education and Social Policy, Uni-
versity of Illinois, Chicago; STEPHEN L. PRUITT, Office of the State Superintendent of Schools, Georgia
Department of Education (until June, 2010); BRIAN REISER, School of Education and Social Policy, North-
western University; REBECCA R. RICHARDS-KORTUM, Department of Bioengineering, Rice University;
WALTER G. SECADA, School of Education, University of Miami; DEBORAH C. SMITH, Department of
Curriculum and Instruction, Pennsylvania State University.
HOW THE FRAMEWORK WAS DEVELOPED

NRC convened a committee of 18 experts in education and scientists from many disciplines to develop the framework drawing on their own expertise, current research, and guidance from small teams of specialists.

A draft of the framework was released in the summer of 2010 to gather comments from scientists, teachers, and the public. The National Science Teachers Association, the American Association for the Advancement of Science, and other groups aided this effort by collecting feedback from their members.

The committee revised the draft in response to all the comments received.

As a final step to ensure high quality, the framework went through the NRC’s intensive peer-review process. More than 20 experts in the sciences, engineering, and teaching and learning provided detailed comments.

The committee revised the framework again in response to the experts’ comments.
DIMENSION 1: SCIENTIFIC AND ENGINEERING PRACTICES

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
DIMENSION 2: CROSSCUTTING CONCEPTS THAT HAVE COMMON APPLICATION ACROSS FIELDS

1. Patterns
2. Cause and effect: mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: flows, cycles, and conservation
6. Structure and function
7. Stability and change
DIMENSION 3: 
CORE IDEAS IN FOUR DISCIPLINARY AREAS

Physical Sciences
PS 1: Matter and its interactions
PS 2: Motion and stability: Forces and interactions
PS 3: Energy
PS 4: Waves and their applications in technologies for information transfer

Life Sciences
LS 1: From molecules to organisms: Structures and processes
LS 2: Ecosystems: Interactions, energy, and dynamics
LS 3: Heredity: Inheritance and variation of traits
LS 4: Biological Evolution: Unity and diversity

Earth and Space Sciences
ESS 1: Earth’s place in the universe
ESS 2: Earth’s systems
ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science
ETS 1: Engineering design
ETS 2: Links among engineering, technology, science, and society
Principles of the Framework

- Children are born investigators
- Understanding builds over time
- Science and Engineering require both knowledge and practice
- Connecting to students’ interests and experiences is essential
- Focusing on core ideas and practices
- Promoting equity
Investment in an Educated Workforce -
The Secret to The American Dream
Claudia Goldin & Lawrence Katz

Early U.S. emphasis on education

Best educated workforce (1850)

The high school movement (1910)

Lost momentum (1970s–present)
Billions of 2005 Dollars

US

UK

“Common School Movement”

Best Educated Workforce

1820 1830 1840 1850 1860 1870
The National Defense Education Act of 1958
The GI Bill (1944)
"High School Movement" (1910)

Billions of 2005 Dollars

1800 1850 1900 1950 2000 2050

US
UK
Doctrine

SOMETHING FOR EVERYONE: America’s Great Vehicular Melting Pot

By Hardy Drackett
STEM Skills are Needed in a Growing Number of Occupations

Figure E-1 Total U.S. Workforce

Some postsecondary education

Need additional 4-year and 2-year degrees and credentials

Need additional 4-year degrees in the next decade

People with non-STEM jobs that do not require STEM skills.

People with non-STEM jobs that require STEM skills.

People with STEM degrees, credentials, or skills and STEM-capable jobs.

People with STEM degrees and STEM jobs.
Healthcare, community services and arts, and STEM are the three fastest growing occupational clusters. Healthcare support, however, will have very low wage growth.

TABLE 6: Occupations 2010–2020—fastest growing

<table>
<thead>
<tr>
<th>Occupation</th>
<th>2010 Total jobs ('000)</th>
<th>Rank</th>
<th>2020 Total jobs ('000)</th>
<th>Rank</th>
<th>Changes in employment 2010–2020</th>
<th>Rank</th>
<th>Fastest growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare professional &amp; technical</td>
<td>6,480</td>
<td>6</td>
<td>8,490</td>
<td>6</td>
<td>2,010</td>
<td>31</td>
<td>5</td>
</tr>
<tr>
<td>Healthcare support</td>
<td>3,660</td>
<td>9</td>
<td>4,610</td>
<td>9</td>
<td>950</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>Community services &amp; arts</td>
<td>6,290</td>
<td>7</td>
<td>7,920</td>
<td>7</td>
<td>1,630</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>STEM</td>
<td>6,050</td>
<td>8</td>
<td>7,600</td>
<td>8</td>
<td>1,550</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>Education</td>
<td>8,160</td>
<td>5</td>
<td>10,120</td>
<td>5</td>
<td>1,960</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Managerial &amp; professional office</td>
<td>19,980</td>
<td>4</td>
<td>24,740</td>
<td>4</td>
<td>4,760</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Social science</td>
<td>700</td>
<td>10</td>
<td>830</td>
<td>10</td>
<td>130</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Food &amp; personal services</td>
<td>23,220</td>
<td>3</td>
<td>27,380</td>
<td>3</td>
<td>4,160</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Sales &amp; office support</td>
<td>37,660</td>
<td>1</td>
<td>42,130</td>
<td>1</td>
<td>4,470</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Blue collar</td>
<td>28,400</td>
<td>2</td>
<td>30,750</td>
<td>2</td>
<td>2,350</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Total jobs and rate of growth (% change)</td>
<td>140,600</td>
<td></td>
<td>164,590</td>
<td></td>
<td></td>
<td></td>
<td>23,990 17</td>
</tr>
</tbody>
</table>

Projections of Jobs and Education Requirements Through 2020
June 2013

Recovery
By 2020, 65 percent of all jobs will require postsecondary education and training, up from 28 percent in 1973.

FIGURE 4: Postsecondary education and training

YEAR AND NUMBER OF WORKING PEOPLE

<table>
<thead>
<tr>
<th>Year</th>
<th>1973</th>
<th>1992</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>91 MILLION</td>
<td>129 MILLION</td>
<td>143 MILLION</td>
<td>164 MILLION</td>
</tr>
</tbody>
</table>

Note: Numbers may not sum to 100 percent due to rounding.
Why is NGSS important?

Why do we need a ‘Tin-Lizzy’ version of science standards now?
<table>
<thead>
<tr>
<th>People QuickFacts</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population, 2012 estimate</td>
<td>313,914,040</td>
</tr>
<tr>
<td>Population, 2010 (April 1) estimates case</td>
<td>308,747,508</td>
</tr>
<tr>
<td>Population, percent change, April 1, 2010 to July 1, 2012</td>
<td>1.7%</td>
</tr>
<tr>
<td>Population, 2010</td>
<td>308,745,538</td>
</tr>
<tr>
<td>Persons under 5 years, percent, 2012</td>
<td>6.4%</td>
</tr>
<tr>
<td>Persons under 18 years, percent, 2012</td>
<td>23.5%</td>
</tr>
<tr>
<td>Persons 65 years and over, percent, 2012</td>
<td>13.7%</td>
</tr>
<tr>
<td>Female persons, percent, 2012</td>
<td>50.8%</td>
</tr>
<tr>
<td>White alone, percent, 2012 (a)</td>
<td>77.9%</td>
</tr>
<tr>
<td>Black or African American alone, percent, 2012 (a)</td>
<td>13.1%</td>
</tr>
<tr>
<td>American Indian and Alaska Native alone, percent, 2012 (a)</td>
<td>1.2%</td>
</tr>
<tr>
<td>Asian alone, percent, 2012 (a)</td>
<td>5.1%</td>
</tr>
<tr>
<td>Native Hawaiian and Other Pacific Islander alone, percent, 2012 (a)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Two or More Races, percent, 2012</td>
<td>2.4%</td>
</tr>
<tr>
<td>Hispanic or Latino, percent, 2012 (b)</td>
<td>16.9%</td>
</tr>
<tr>
<td>White alone, not Hispanic or Latino, percent, 2012</td>
<td>63.0%</td>
</tr>
</tbody>
</table>
Women have surpassed men in college attendance (2012).

<table>
<thead>
<tr>
<th>Number of U.S. Colleges and Universities</th>
<th>Number</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public 4-year institutions</td>
<td>629</td>
<td>6,837,605</td>
</tr>
<tr>
<td>Private 4-year institutions</td>
<td>1,845</td>
<td>4,161,815</td>
</tr>
<tr>
<td>Public 2-year institutions</td>
<td>1,070</td>
<td>4,161,815</td>
</tr>
<tr>
<td>Private 2-year institutions</td>
<td>596</td>
<td>303,826</td>
</tr>
<tr>
<td>Total</td>
<td>4,140</td>
<td>17,467,475</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Degrees Awarded Annually:</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associate</td>
<td>696,660</td>
</tr>
<tr>
<td>Bachelor's</td>
<td>1,439,264</td>
</tr>
<tr>
<td>Master's</td>
<td>574,618</td>
</tr>
<tr>
<td>Doctorate</td>
<td>52,631</td>
</tr>
<tr>
<td>Professional</td>
<td>87,289</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enrollment Demographics:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>57.4%</td>
</tr>
<tr>
<td>Full-time</td>
<td>61.7%</td>
</tr>
<tr>
<td>Minority</td>
<td>30.9%</td>
</tr>
<tr>
<td>Foreign</td>
<td>3.3%</td>
</tr>
</tbody>
</table>
1845: Beginning A Struggle

The first school desegregation case occurred on the island of Nantucket. A young black female student educated in the black elementary school scored highest on admission exam at the local high school but was denied entrance. Absalom Boston, a black whaling captain and her father, supported the effort to integrate the school. After a legal suit the school is integrated.
FIGURE I
U.S. Population by Race/Ethnicity:
1995 and 2050

1995

73.6% White
12% Black
10.2% Hispanic
3.5% Asian American
0.7% American Indian

2050

52.5% White
14.4% Black
22.5% Hispanic
9.7% Asian American
0.9% American Indian

Minorities on the rise

Minorities are projected to make up more than half of the U.S. population by 2050, with Hispanics leading the growth.

Source: US Census

Bay Area News Group
The implications are pretty clear.

If we want to have an citizen-based workforce that is equipped with the STEM-capable skills to advance the Nation’s economic interest, we cannot continue to teach science as if it is for only an elite few.
Process:
Lead Partner States

- Open invitation to all states to apply to be Lead Partner States.

- 20 states were selected based on a set of specific criteria to lead the development of standards, render policy advice, and participate in implementation planning.
Lead Partner States (through State Superintendent and State Board of Education Chair signature) agreed to:

- seriously consider adopting the *Next Generation Science Standards* as presented
- participate in Multi-State Action Committee meetings of the Chief State School Officers to discuss adoption and implementation
- commit SEA staff time to actively participate in the standards development process and planning for implementation
- make public that the state is part of the NGSS effort and make transparent the state’s process for receiving feedback
- identify a state lead and form broad-based committee
Lead Partner States’ Commitment

Lead Partner States exhibited evidence of

- Commitment to Quality Science Education
- State’s Unique Contributions
- Alliances and Infrastructure for Successful Adoption and Implementation
- State Leadership Team
Key Features of Lead Partner States

- As a whole group, Lead Partner States have the following characteristics
  - Broad Geographic Representation
  - Account for 48% of the nation’s public school students
  - A bipartisan collection of states based on current governor
  - Are in one of the assessment consortia
  - Slightly more than half have grade-by-grade standards through grade eight
  - Most require three years of science for high school graduation
Writing Team

- Will write the standards based on the NRC’s *A Framework for K-12 Science Education*
- 40 members with expertise in teaching at all grade levels, working with students with disabilities, English language acquisition, state level standards/assessment, workforce development, engineering, technology, and life, earth and physical science
- Includes prominent scientists and academics that have working knowledge of science standards
- Selected based on recommendations from various groups including NSTA and the Council of State Science Supervisors
- Led by the education community
Lead State Partners
NGSS Writing Team Members
Lead State Partners and NGSS Writing Team

[Map of the United States showing states in different colors representing different roles in NGSS Writing Team: Writing Team Only, Lead State Partner Only, and Lead State Partner and Writing Team.]
Product:

http://www.nextgenscience.org/
Three Dimensions Intertwined

- The NGSS are written as Performance Expectations
- NGSS will require contextual application of the three dimensions by students.
- Focus is on how and why as well as what
The Two Ways To Teach Arithmetic (and Science)

Content
(1.)
Teach students how memorize $1 + 1 = 2$, $1 + 2 = 3$, etc., etc., etc. (i.e. the Yul Brunner methodology).

Process
(2.)
Teach students the process that goes behind these memorized results so that they are able to add any two numbers, even ones they have never encountered about before.
### LS2.B By end of grade 8 – Confidential – Populated Next Generation Science Standards Template

**Essential Question – How do matter and energy move through an ecosystem?**

<table>
<thead>
<tr>
<th>Standards</th>
</tr>
</thead>
</table>
| Students demonstrate an understanding of the transfer of matter and energy into and out of the physical environment by:
| 1. Investigating local and non-local ecosystems, identifying producers, consumers, and decomposers. |
| 2. Constructing and communicating a model (diagram, food web) for how matter and energy are transferred between organisms (producers, consumers, decomposers) within an ecosystem and to the surroundings through energy flow. |
| 3. Using the atomic molecular theory to construct an explanation of how food molecules are broken down and rearranged as they pass through different organisms in a food web. |
| 4. Tracing the movement of atoms (e.g., carbon or oxygen atom) into and out of the physical environment in an ecosystem, and explaining and communicating how a specific atom in the body of one organism might later be found in another organism. For example, connecting an atom in a prehistoric animal to what it is in a modern animal. |
| 5. Investigating the energy content of foods, and describing the role of oxygen in releasing energy from food molecules for use in plants and animals. |
| 6. Predicting the effect on an ecosystem of changing one of the components by using a model or simulation. |
| 7. Constructing an explanation (model) for how energy can be transformed and stored in a system of molecules (sugar and oxygen). |

### Core Disciplinary Ideas

**LS2.B**

1. Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and algae) and organisms that engage in photosynthesis, consumers, and decomposers as these groups interact—primarily, for food—within an ecosystem.
2. Transfers of matter into and out of the physical environment occur at every level, for example when a) molecules from food eaten with oxygen captured from the environment are transferred back to the environment and ultimately to (a) waste products, such as feces; or b) waste products, such as carbon dioxide. c) Decomposers recycle nutrients from dead plants or animals back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organism in an ecosystem are recycled repeatedly from living and nonliving parts of the ecosystem.

**From LS2.B.1**

1. Animals obtain food from eating plants or eating other animals.
2. Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth or to release energy.
3. In most animals and plants oxygen reacts with carbon-containing molecules (sugar) to provide energy and produce water and carbon dioxide.
4. In aerobic respiration, carbon dioxide and water are released by the body of an organism.

### Crosscutting Concepts

- System and system models:
  - **System** (e.g., ecosystems) can be described in terms of its components and their interactions (e.g., matter transfer between producers and consumers).
  - **Energy and matter**: Flow, cycles, and conservation:
    - Energy can take different forms as it flows through a natural system, but the total amount of energy does not change.
  - **Cause and effect**: Cause and effect relationships may be used to predict phenomena in natural systems.

### Prerequisites

- Developing and using models:
  - Use various representations (e.g., diagrams and computer simulations) to predict, explain, and test ideas about phenomena in a natural system (e.g., transfer of matter in an ecosystem).
  - Apply scientific principles and concepts to develop, review, and debate various representations and models.
- Constructing explanations and designing solutions:
  - Generate and revise causal science explanations from data (e.g., observations and sources of reliable information) and refine these explanations to current science knowledge (e.g., about how matter and energy are transferred between producers, consumers, and decomposers within an ecosystem).
  - Construct a shared mental explanation of phenomena (e.g., explain using atomic molecular theory why matter is conserved across ecosystems) using evidence and logic to resolve differences between students.
- Planning and Carrying Out Investigations:
  - Collect data to investigate and generate reliable science evidence to answer questions, such as defining which organisms are in an ecosystem.
  - Plan and carry out investigations in a safe and ethical manner.
SCIENTIFIC AND ENGINEERING PRACTICES
Developing and Using Models
Why are there seasons?
Why did the structure collapse?
How is electric power generated?
What do plants need to survive?
Planning and Carrying Out Investigations
Analyzing and Interpreting Data
Using Mathematics and Computational Thinking
Constructing Explanations (Science) and . . .
... Designing Solutions (Engineering)
Obtaining, Evaluating, and Communicating Information
Systems and System Models: Scale, Proportion and Quantity

Patterns

Stability and Change
Energy and Matter: Flows, Cycles and Conservation

Cause and Effect

Structure and Function
PHYSICAL SCIENCES

- PS 1: Matter
- PS 2: Motion and stability
- PS 3: Energy
- PS 4: Waves
LIFE SCIENCES

- LS 1: Structures and Processes
- LS 2: Ecosystems
- LS 3: Heredity
- LS 4: Biological evolution
EARTH AND SPACE SCIENCES

- **ESS 1:** Earth and the Universe
- **ESS 2:** Earth Systems
- **ESS 3:** Earth and Human Activity

**Global Temperatures**

- Annual Average
- Five Year Average

<table>
<thead>
<tr>
<th>Year</th>
<th>Temperature Anomaly (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880</td>
<td>-0.4</td>
</tr>
<tr>
<td>1890</td>
<td>-0.3</td>
</tr>
<tr>
<td>1900</td>
<td>-0.2</td>
</tr>
<tr>
<td>1910</td>
<td>-0.1</td>
</tr>
<tr>
<td>1920</td>
<td>0.0</td>
</tr>
<tr>
<td>1930</td>
<td>0.1</td>
</tr>
<tr>
<td>1940</td>
<td>0.2</td>
</tr>
<tr>
<td>1950</td>
<td>0.3</td>
</tr>
<tr>
<td>1960</td>
<td>0.4</td>
</tr>
<tr>
<td>1970</td>
<td>0.5</td>
</tr>
<tr>
<td>1980</td>
<td>0.6</td>
</tr>
<tr>
<td>1990</td>
<td>0.7</td>
</tr>
<tr>
<td>2000</td>
<td>0.8</td>
</tr>
</tbody>
</table>
ENGINEERING, TECHNOLOGY AND APPLICATIONS OF SCIENCES

- **ETS 1**: Engineering Design
- **ETS 2**: Links Among Engineering, Technology, Science and Society
The Common Core
State Standards Connection
CONNECTIONS TO CCSS LITERACY

- Determine Central Ideas (RST 2)
- Evidence (RST 1 & WHST 9)
- Analysis (RST 5)
- Evaluate Hypotheses (RST 8)
- Synthesize Information (RST 9)
- Writing Arguments (WHST 1)
- Use of Technology (WHST 6)
- Speaking and Listening (SL 1-6)
Comparing ‘Old Gen’-SS to NGSS

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.</td>
<td></td>
<td>Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.</td>
</tr>
<tr>
<td></td>
<td>If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q: Aren’t the NGSS less rigorous?
Q: Aren’t the NGSS less rigorous?

A: It depends in part on whether you think memorization is equivalent to rigor?
### Comparing ‘Old Gen’-SS to NGSS

<table>
<thead>
<tr>
<th>Middle Level</th>
<th>National Science Education Standards (1996)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.</td>
</tr>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Middle Level</th>
<th>Next Generation Science Standards (2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.</td>
</tr>
</tbody>
</table>
## Comparing ‘Old Gen’-SS to NGSS

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<td></td>
<td>An object that is not being subjected to a force will continue to move at a constant speed and in a straight line. If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.</td>
<td></td>
<td>Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. <strong>Core Ideas:</strong> The motion of an object is determined by the sum of the forces acting on it. If the total force is not zero, its motion will change. The greater the mass of an object the greater the force needed to achieve the same change in motion. For any given object a larger force causes a larger change in motion. All positions of objects and their direction of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.</td>
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Comparing ‘Old Gen’-SS to NGSS

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<td>Plan an investigation to provide evidence</td>
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<td>Crosscutting Concept: Stability and</td>
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<td>that the change in an object’s motion</td>
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<td>change – Explanation of stability and</td>
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<td>depends on the sum of the forces on the</td>
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<td>change in natural or designed systems</td>
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<td>object and the mass of the object.</td>
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<td>can be constructed by examining the</td>
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<td>changes overtime and forces at different</td>
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<td>scales.</td>
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**Scientific and Engineering Practices:** Plan an investigation individually or collaboratively, and in the design, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data points are needed to support a claim.
Thank You.
I WANT YOU STEM STAKEHOLDERS
Acknowledgement

I would like to recognize many for support of my participation in the Maryland State engagement with the NGSS process. Some of these are Superintendent L. Lowery, M. Thurlow, and J. Jenkins at Maryland State Department of Education and my colleagues who serve on the State Board of Education. As well I have drawn material from many colleagues, other sources, and the NGSS website to construct this presentation.