Hawaii State Board of Education

Student Achievement Committee
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Presentation/discussion on Next Generation Science Standards

Handout

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Three Dimensions of the *Next Generation Science Standards* (NGSS)

Scientific and Engineering Practices

Asking Questions and Defining Problems

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world.

Both scientists and engineers also ask questions to clarify the ideas of others.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.

Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.

Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.

Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.

Constructing Explanations and Designing Solutions

The products of science are explanations and the products of engineering are solutions.

The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories.

The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached.

In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits.

Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to identify strengths and weaknesses of claims.

Using Mathematics and Computational Thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships.

Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. Statistical methods are frequently used to identify significant patterns and establish correlational relationships.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to acquire information that is used to evaluate the merit and validity of claims, methods, and designs.

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Developed by based on content from the *Framework for K-12 Science Education* and supporting documen he *May 2012 Public Draft of the NGSS*

Disciplinary Core Ideas in Physical Science	Disciplinary Core Ideas in Life Science	Disciplinary Core Ideas in Earth and Space Science	Disciplinary Core Ideas in Engineering, Technology, and the Application of Science
PS1: Matter and Its Interactions PS1.A: Structure and Properties of Matter PS1.B: Chemical Reactions PS1.C: Nuclear Processes **PS2: Motion and Stability: Forces and Interactions** PS2.A: Forces and Motion PS2.B: Types of Interactions PS2.C: Stability and Instability in Physical Systems **PS3: Energy** PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS3.C: Relationship Between Energy and Forces PS3.D: Energy in Chemical Processes and Everyday Life **PS4: Waves and Their Applications in Technologies for Information Transfer** PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	**LS1: From Molecules to Organisms: Structures and Processes** LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS1.C: Organization for Matter and Energy Flow in Organisms LS1.D: Information Processing **LS2: Ecosystems: Interactions, Energy, and Dynamics** LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS2.D: Social Interactions and Group Behavior **LS3: Heredity: Inheritance and Variation of Traits** LS3.A: Inheritance of Traits LS3.B: Variation of Traits **LS4: Biological Evolution: Unity and Diversity** LS4.A: Evidence of Common Ancestry and Diversity LS4.B: Natural Selection LS4.C: Adaptation LS4.D: Biodiversity and Humans	**ESS1: Earth's Place in the Universe** ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System ESS1.C: The History of Planet Earth **ESS2: Earth's Systems** ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions ESS2.C: The Roles of Water in Earth's Surface Processes ESS2.D: Weather and Climate ESS2.E: Biogeology **ESS3: Earth and Human Activity** ESS3.A: Natural Resources ESS3.B: Natural Hazards ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change	**ETS1: Engineering Design** ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution **ETS2: Links Among Engineering, Technology, Science, and Society** ETS2.A: Interdependence of Science, Engineering, and Technology ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Crosscutting Concepts

Patterns
Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and Effect: Mechanism and Explanation
Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, Proportion, and Quantity
In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and System Models
Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and Matter: Flows, Cycles, and Conservation
Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and Function
The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and Change
For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Developed by NSTA based on content from the *Framework for K-12 Science Education* and supporting documents for the *May 2012 Public Draft of the NGSS*

A look at the *Next Generation Science Standards*

By Ted Willard

The final version of the *Next Generation Science Standards* (NGSS) is expected later this spring. Once it is released, educators across the country will need to carefully study the standards as plans are made for adoption and implementation. The following text and diagram below provides an overview on the architecture of the standards.

Overall architecture

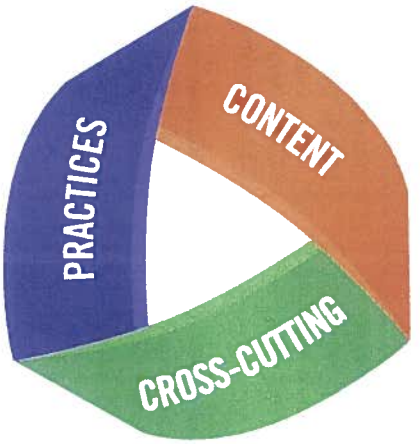
NGSS differs from prior science standards in that they integrate three dimensions (science and engineering practices, disciplinary core ideas, and crosscutting concepts) into a single performance expectation and have intentional connections between performance expectations. The system architecture of NGSS highlights the performance expectations as well as each of the three integral dimensions and connections to other grade bands and subjects. The architecture involves a table with three main sections.

What is assessed (performance expectations)

A performance expectation describes what students should be able to do at the end of instruction and incorporates a practice, a disciplinary core idea, and a crosscutting concept from the foundation box. Performance expectations are intended to guide the development of assessments. Groupings of performance expectations do not imply a preferred ordering for instruction—nor should all performance expectations under one topic necessarily be taught in one course. This section also contains *Assessment Boundary Statements* and *Clarification Statements* that are meant to render additional support and clarity to the performance expectations.

Foundation box

The foundation box contains the learning goals that students should achieve. It is critical that science educators consider the foundation box an essential component when reading the NGSS and developing curricula. There are three main parts of the foundation box: science and engineering practices, disciplinary core ideas, and crosscutting concepts, all of which are derived from *A Framework for K–12 Science Education*.



During instruction, teachers will need to have students use multiple practices to help students understand the core ideas. Most topical groupings of performance expectations emphasize only a few practices or crosscutting concepts; however, all are emphasized within a grade band. The foundation box also contains learning goals for *Connections to Engineering, Technology, and Applications of Science* and *Connections to the Nature of Science*.

Connection box

The connection box identifies other topics in NGSS and in the Common Core State Standards (CCSS) that are relevant to the performance expectations in this topic. The *Connections to other DCIs in this grade level* contains the names of topics in other science disciplines that have corresponding disciplinary core ideas at the same grade level. The *Articulation of Disciplinary Core Ideas (DCIs) across grade levels* contains the names of other science topics that either provide a foundation for student understanding of the core ideas in this standard (usually standards at prior grade levels) or build on the foundation provided by the core ideas in this standard (usually standards at subsequent grade levels). The *Connections to the Common Core State Standards* contains the coding and names of CCSS in Mathematics and in English Language Arts & Literacy that align to the performance expectations.

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Inside the NGSS Box

What is Assessed

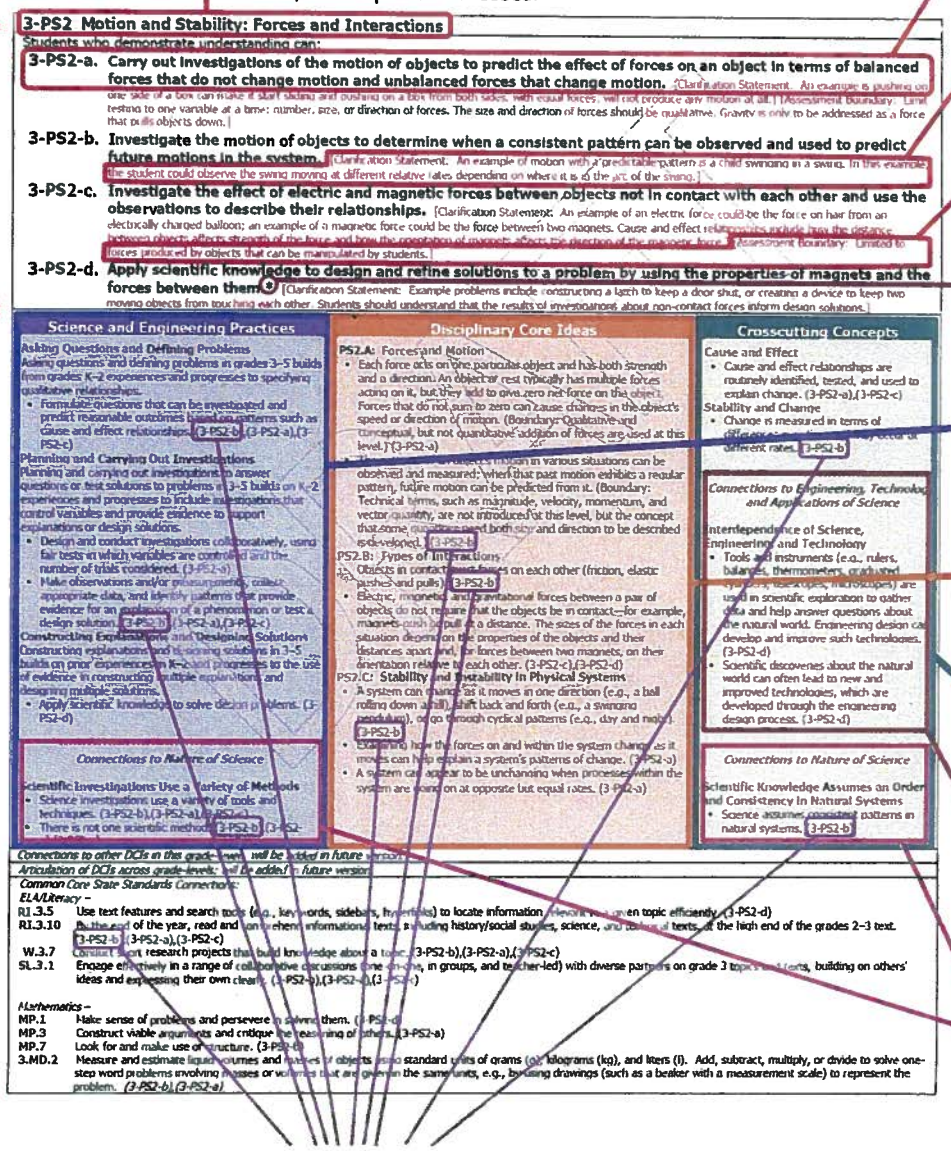
A collection of several performance expectations describing what students should be able to do to master this standard.

Foundation Box

The practices, core disciplinary ideas, and crosscutting concepts from *A Framework for K–12 Science Education* that were used to form the performance expectations.

Connection Box

Other standards in the *Next Generation Science Standards* or in the *Common Core State Standards* that are related to this standard.



Title and Code

The titles of standard pages are not necessarily unique and may be reused at several different grade levels. The code, however, is a unique identifier for each set based on the grade level, content area, and topic it addresses.

Performance Expectations

A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned.

Clarification Statement

A statement that supplies examples or additional clarification to the performance expectation.

Assessment Boundary

A statement that provides guidance about the scope of the performance expectation at a particular grade level.

Engineering Connection (*)

An asterisk indicates an engineering connection in the practice, core idea, or crosscutting concept that supports the performance expectation.

Scientific and Engineering Practices

Activities that scientists and engineers engage in to either understand the world or solve a problem.

Disciplinary Core Ideas

Concepts in science and engineering that have broad importance within and across disciplines as well as relevance to people's lives.

Crosscutting Concepts

Ideas, such as *Patterns* and *Cause and Effect*, which are not specific to any one discipline but cut across them all.

Connections to Engineering, Technology, and Applications of Science

These connections are drawn from the disciplinary core ideas for engineering, technology, and applications of science in the *Framework*.

Connections to Nature of Science

Connections are listed in either the practices or the crosscutting connections section of the foundation box.

Codes for Performance Expectations

Codes designate the relevant performance expectation for an item in the foundation box and connection box. In the connections to common core, italics indicate a potential connection rather than a required prerequisite connection.

Based on the January 2013 Draft of NGSS

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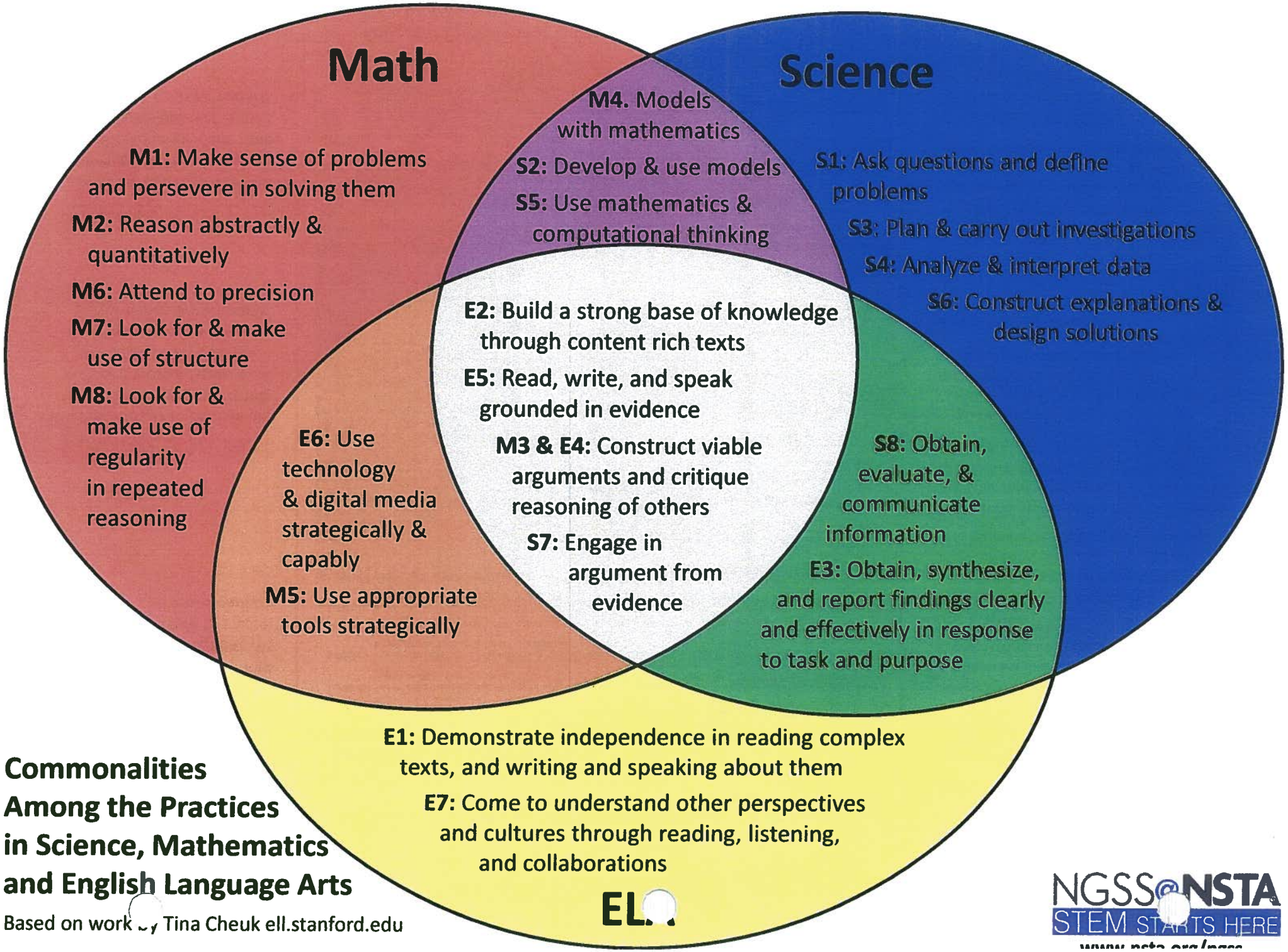

Commonalities Among the Practices in Science, Mathematics and English Language Arts

Based on work by Tina Cheuk ell.stanford.edu

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Practices in Mathematics, Science, and English Language Arts*

Math	Science	English Language Arts
M1. Make sense of problems and persevere in solving them.	**S1.** Asking questions (for science) and defining problems (for engineering).	**E1.** They demonstrate independence.
M2. Reason abstractly and quantitatively.	**S2.** Developing and using models.	**E2.** They build strong content knowledge.
M3. Construct viable arguments and critique the reasoning of others.	**S3.** Planning and carrying out investigations.	**E3.** They respond to the varying demands of audience, task, purpose, and discipline.
M4. Model with mathematics.	**S4.** Analyzing and interpreting data.	**E4.** They comprehend as well as critique.
M5. Use appropriate tools strategically.	**S5.** Using mathematics, information and computer technology, and computational thinking.	**E5.** They value evidence.
M6. Attend to precision.	**S6.** Constructing explanations (for science) and designing solutions (for engineering).	**E6.** They use technology and digital media strategically and capably.
M7. Look for and make use of structure.	**S7.** Engaging in argument from evidence.	**E7.** They come to understanding other perspectives and cultures.
M8. Look for and express regularity in repeated reasoning.	**S8.** Obtaining, evaluating, and communicating information.	

* The Common Core English Language Arts uses the term "student capacities" rather than the term "practices" used in Common Core Mathematics and the Next Generation Science Standards.

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