Science and Technology/Engineering in NPS: Today and Tomorrow

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Current Science and Tech/Engineering Program in Newton

Elementary School

- Progression through K-5 of Physical, Life, Earth and Space Science and Engineering

Middle School

- Physical Science in Gr. 6, Life Science in Gr. 7 and Earth and Space Science in Grade 8.
- Engineering in the Fine and Applied Arts rotation

High School

- Core Sequence: Intro Physics, Chemistry, Biology
- Electives including AP/Advanced courses
- Engineering (electives and infused)

Science and Technology/Engineering(STE) MCAS

Grade 5 and Grade 8	High School
• Integrated (Physical, Earth and Space, Life Sciences, and Technology/Engineering) • Assesses 3 or more years of content	• Passing score on one STE MCAS is required for graduation • Most NPS students take the Grade 9 Introductory Physics MCAS

MCAS STE will continue for the foreseeable future.

Teaching and Learning Science: The Twentieth Century

Scientific Method (before 1959):

memorization of the five steps in the scientific method

Post-Sputnik (1960s):

observing, clarifying, measuring, inferring, and predicting

Education Reform (1990s):

- Benchmarks for Science Literacy (AAAS 1993)
- National Science Education Standards (NRC 1996)
- role of inquiry in school science programs

Massachusetts Frameworks for Science and Technology/Engineering

1996:

- Influenced by AAAS and NRC reports
- Included inquiry within the standards.

2001 revision:

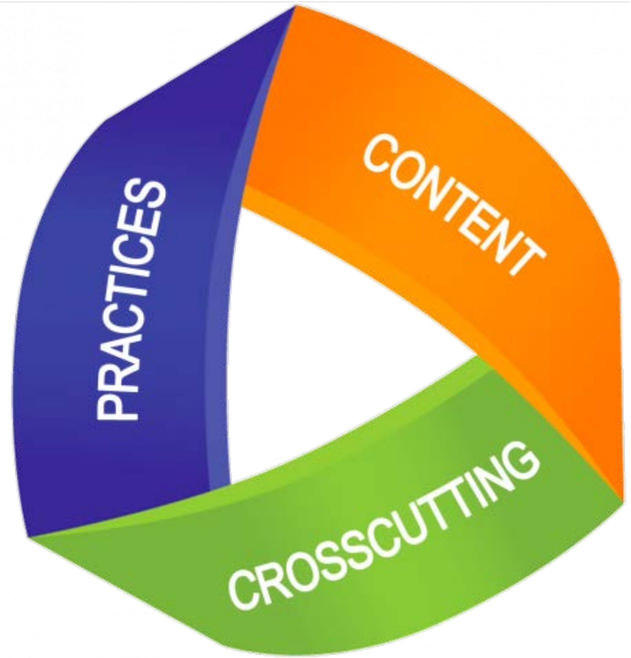
- Inquiry was removed from the standards and no longer assessed.

2006 revision:

- Clarified Introductory High School courses

National Research Council (NRC) Framework for K-12 Science Education

- Content - Disciplinary Core Ideas
- Crosscutting Concepts
- Science and Engineering Practices



Next Generation Science Standards (NGSS)

For states, by states

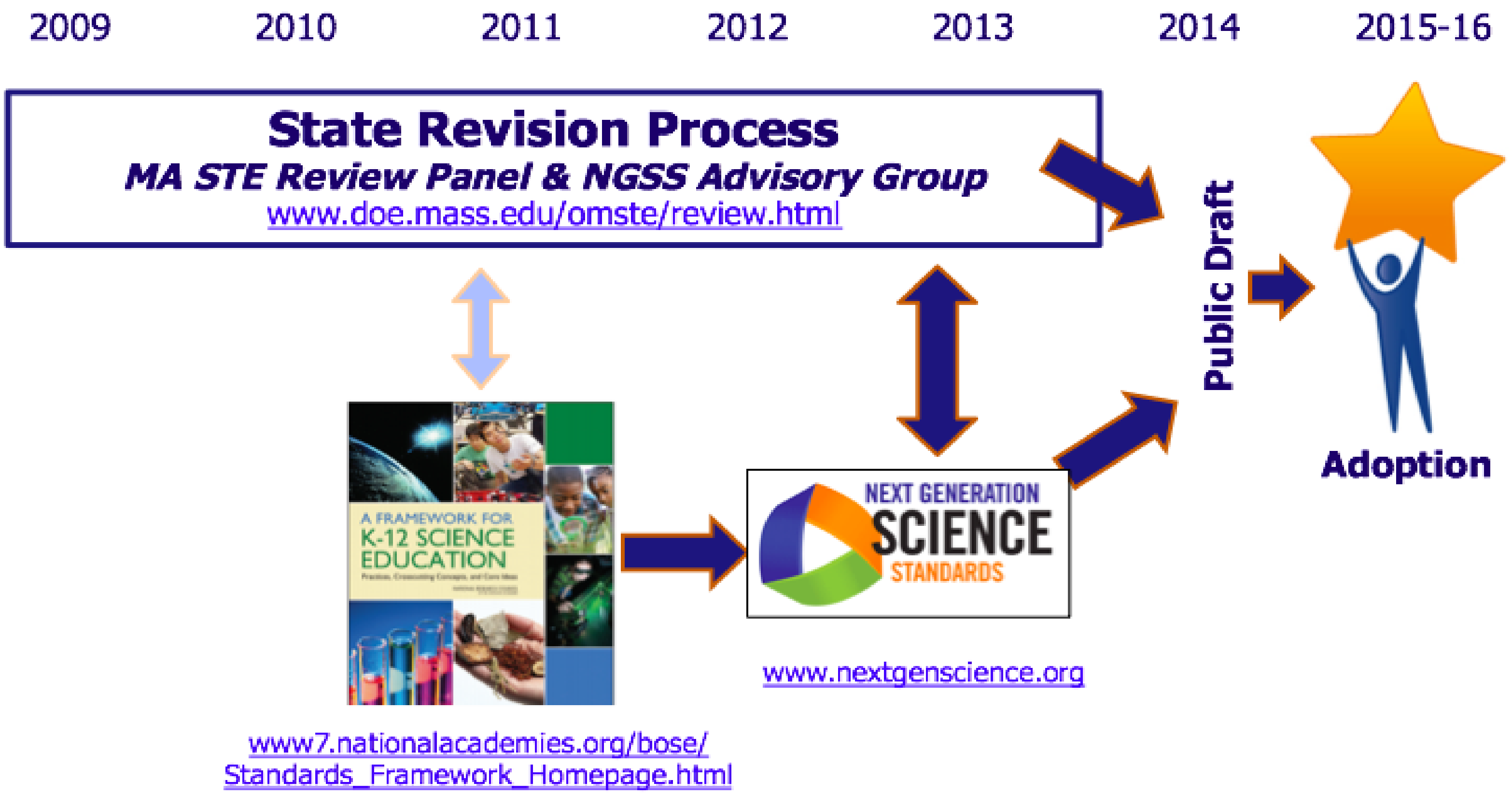
Rich in practice and content

Parallel to Common Core in Organization and Intent

Arranged coherently across disciplines and grades

Includes performance expectations

From NGSS to Massachusetts Curriculum Frameworks



What do these standards really look like?

What is a Performance Expectation?

- Integrates practices with core ideas(content)
- What a student will be expected to do
- Is NOT a curriculum or map of instruction

"Coupling practice with content gives the context for performance, whereas practices alone are activities and content alone is memorization. The scientific and engineering practices are represented across the standards."

High School Example:
Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

What is a Practice Progression?

- NRC Framework defines “What a 12th grader should be able to do.” for each practice.
- NGSS constructed progressions for each grade-band.

Sample: Engaging in Argument from Evidence

PreK-2: Comparing ideas and representations about the natural and designed worlds.

Articulated through the grades with increasing sophistication and rigor

High School: Using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world.

What is a Core Idea (Content) Progression?

- Developed using research-based learning progressions.
- Grade-band endpoints from the NRC Framework.

Sample: Chemical Reactions

PreK-2: Heating and cooling substances cause changes that are sometimes reversible and sometimes not.

Articulated through the grades with increasing sophistication and rigor

High School: Knowledge of conservation of atoms with chemical properties and electrical charges can be used to describe and predict chemical reactions.

Putting It All Together

Pre-K

- Raise questions about the differences between liquids and solids and develop awareness that a liquid can become a solid and vice versa

K

- Design and conduct an experiment to test the idea that different kinds of materials can be a solid or liquid depending on temperature

2

- Construct an argument with evidence that some changes to materials caused by heating or cooling can be reversed and some cannot

5

- <u>Measure and graph</u> the weights of substances before and after a reaction or phase change to provide evidence that regardless of the type of change that occurs when heating, cooling or combining substances, the total weight of matter is conserved

8

- <u>Use a model</u> to explain that substances are rearranged during a chemical reaction to form new molecules with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved.

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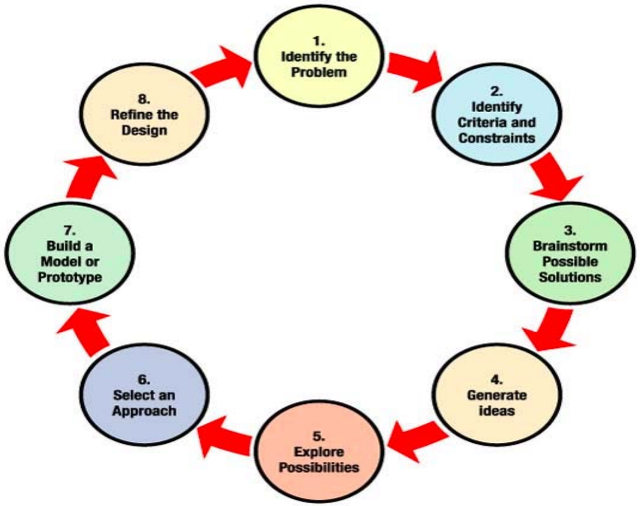
- <u>Use mathematical representations and provide experimental evidence to support the claim</u> that atoms, and therefore mass, are conserved during a chemical reaction. Use the mole concept and proportional relationships to predict the quantities (masses or moles) of specific reactants or products

Sample Performance Expectation: "Doing" Engineering

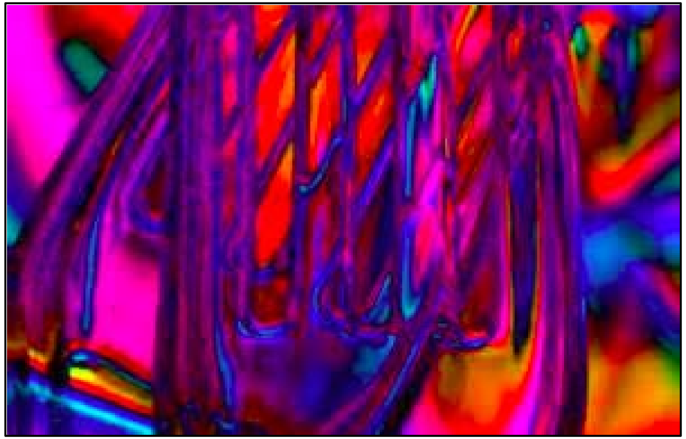
Old: (Grades 6-8)
Identify and explain the steps of the engineering design process.



New: (Grade 3)
Generate several possible solutions to a design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.*

Sample Performance Expectation: Increased Rigor

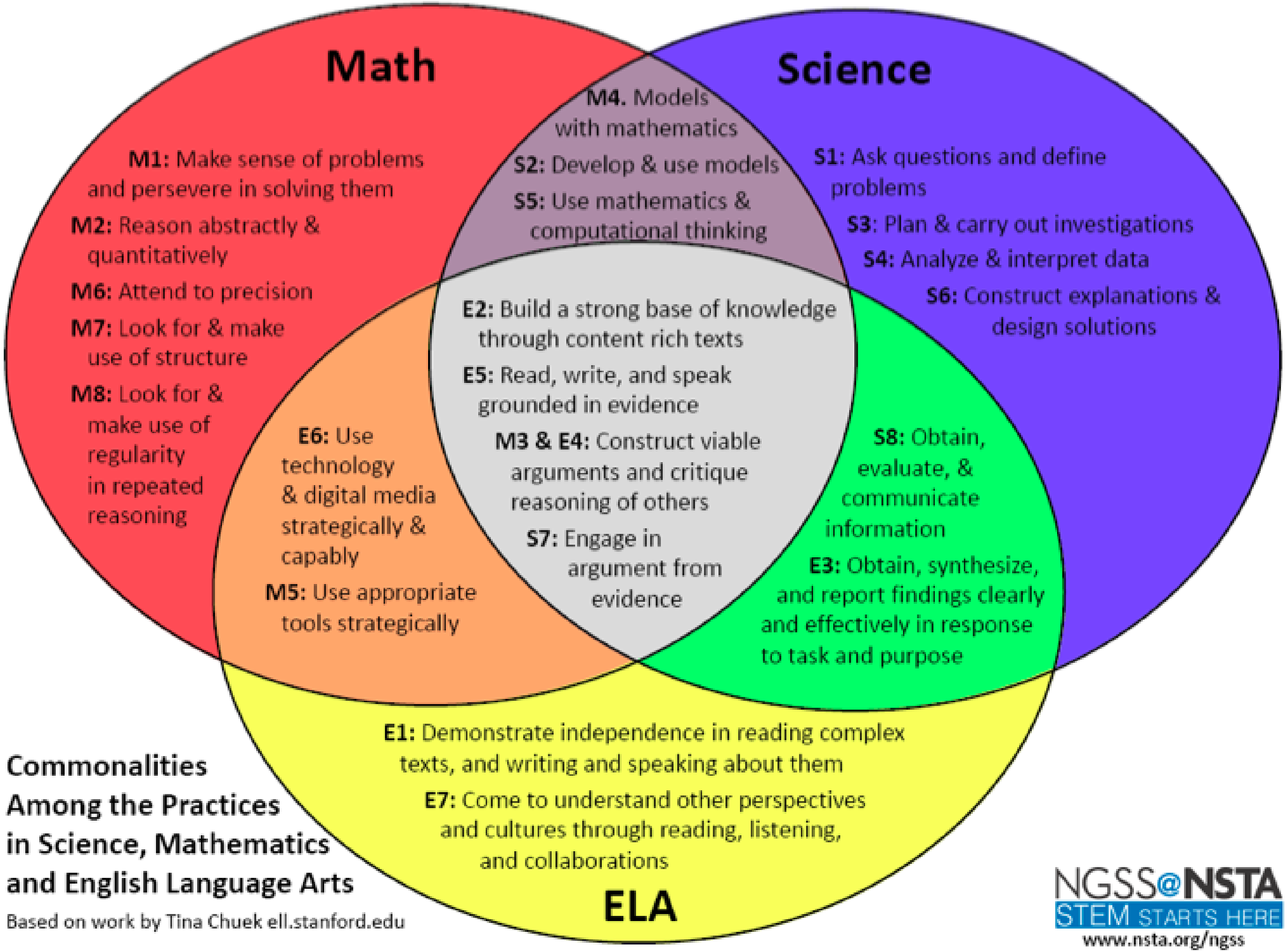
Old (High School)
Describe qualitatively the basic principles of reflection and refraction of waves.



New (High School)
Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for explaining reflection, refraction, resonance, interference, diffraction and the photoelectric effect, one model is more useful than the other.

Implications for Teaching

Shifts in revised standards	***Shift in curriculum & instruction***
Organized around core explanatory ideas	Curriculum shifts from focusing on facts to explaining phenomena.
Central role for science and engineering practices	Every student at every grade engages with all 8 practices to build and use knowledge.
Coherence	Instruction builds on connected content within and across years.
Articulation based on Learning Progressions	Students construct increasingly sophisticated understandings over time.



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

Based on work by Tina Chuek ell.stanford.edu

Overlapping Habits of Mind

ELA: Build a strong base of knowledge through content rich texts.

ELA: Read, write, and speak grounded in evidence.

Math & ELA: Construct viable arguments and critique the reasoning of others.

Science: Engage in argument from evidence.

What is exciting?

- Integration of practices and content
- Opportunity to revise and refine
- Focus on synthesis and application
- Expansion of engineering
- Overlapping practices spur cross-disciplinary collaboration resulting in coherency for students.

What is challenging?

- Increased content in Elementary School
- Integration of physical, life, and earth and space science and technology/engineering in Middle School
- Increased rigor and sophistication at High School
- Remediation and intervention at all grades
- Instructional supplies, technologies, and textbooks
- Substantial professional development needs

Next Steps

- Continued focus on the Practices.
- Collaboration with other disciplines.
- Content professional development.
- Review current curriculum, identify necessary shifts, and prioritize changes.