Scientific and Engineering Practices in the Framework and Next Generation Science Standards Vision for Science Education

Developed by

The Council of State Science Supervisors

Presentation Designed to Provide Awareness of the Practices

Council of State Science Supervisors

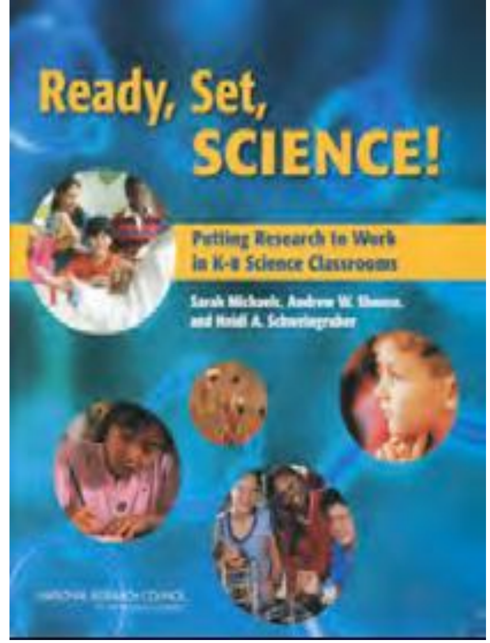
Science Education for a New Generation

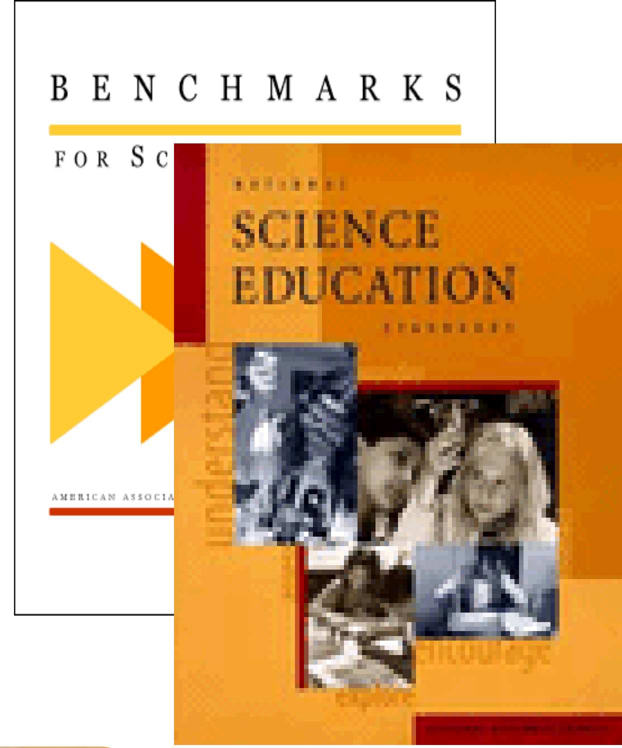
Produced by the Council of State Science Supervisors www.csss-science.org

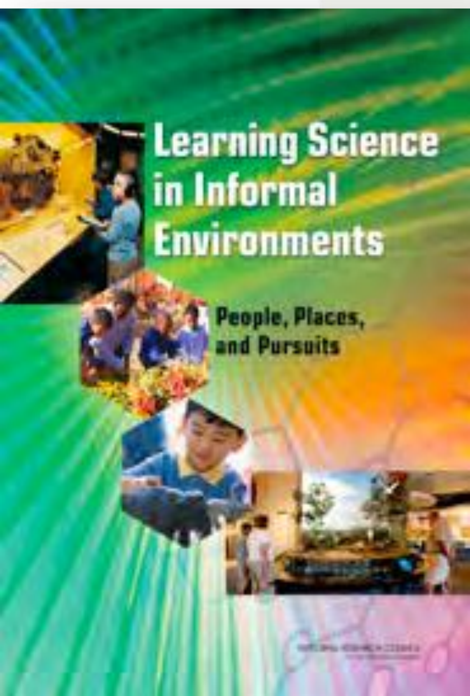
Overview

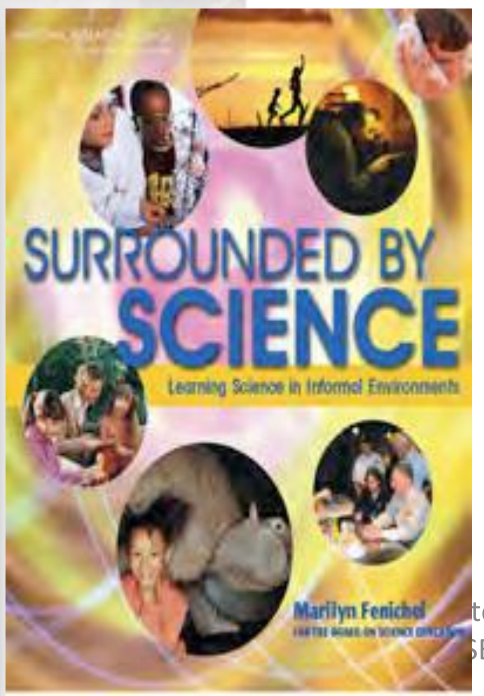
- A Framework for K-12 Science Education
- Science & Engineering Practices
- A Focus on Engineering Design
- Similarities and Differences
- Representation in NGSS
- Implications and Discussion

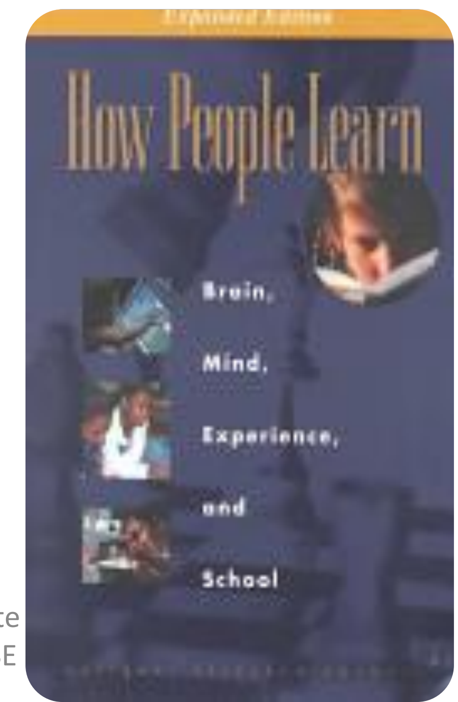
Building from research & key reports…



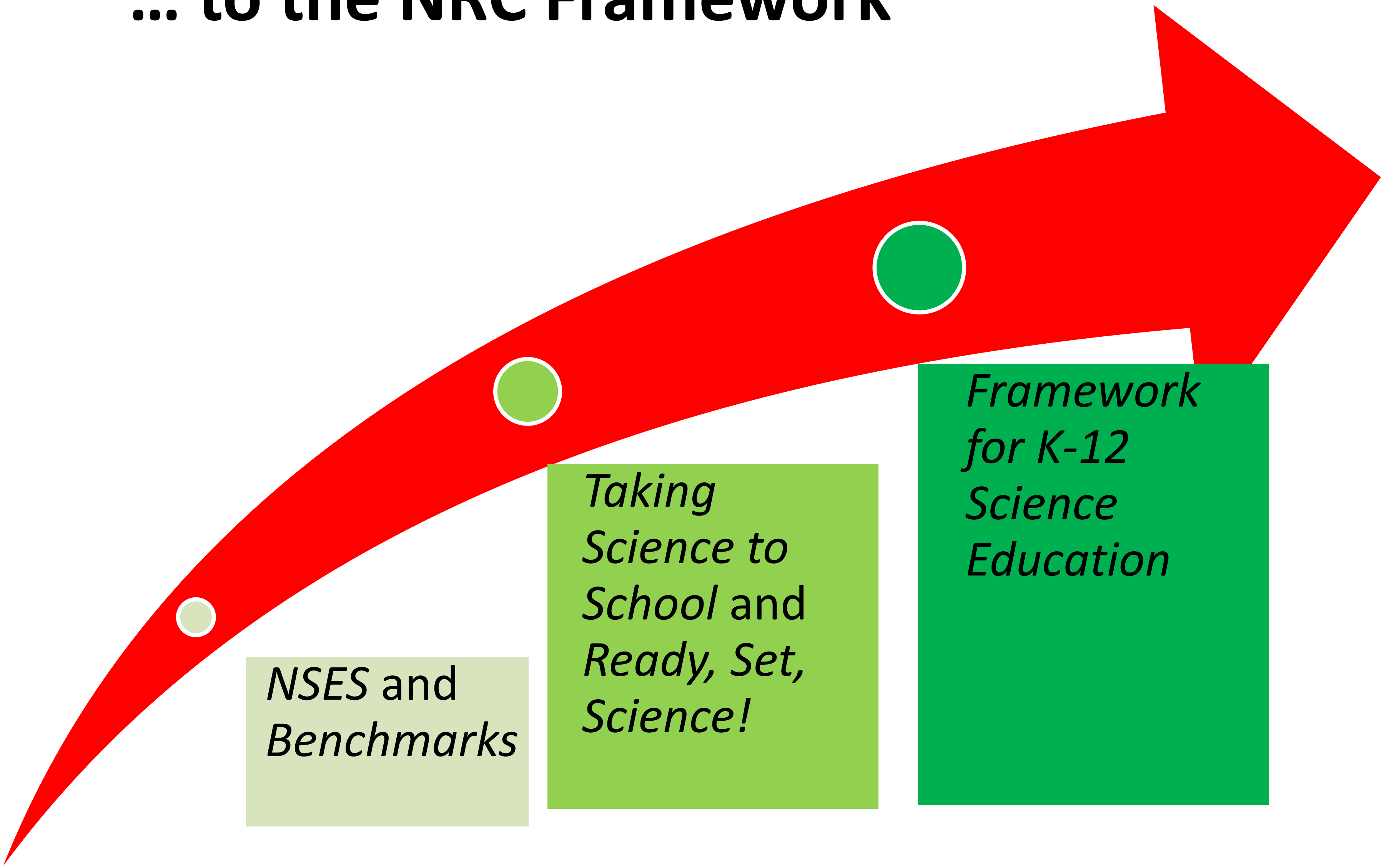






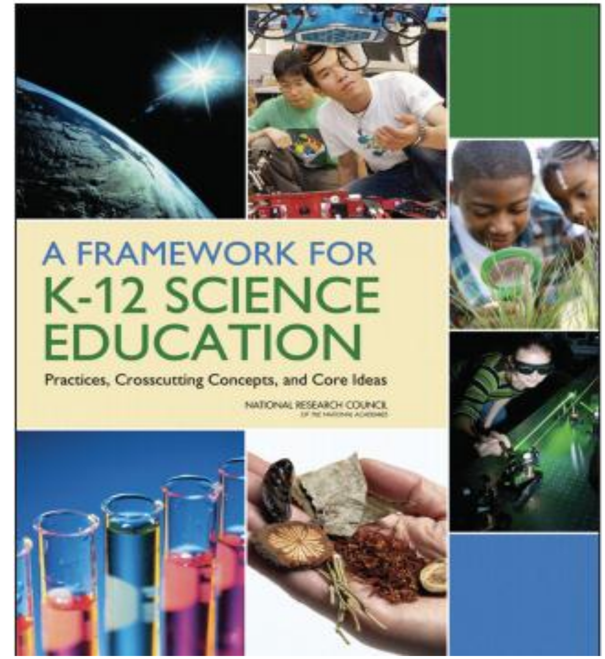


… to the NRC Framework



The NRC Framework

– A Vision of Science Education
– 3 Dimensions
  • Science & Engineering Practices
  • Core Ideas
  • Crosscutting Concepts



A Vision for K-12 Education in the Natural Sciences and Engineering

Students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of each fields' disciplinary core ideas.

Engaging in Science and Engineering Through Practices

Think-Pair-Share

- Describe some of the "typical" science projects your school engages in.
- What kind of inquiry or engineering design skills are needed to complete those science projects?
- Many science activities in which students are currently engaged are as much engineering as science.

Why Practices and Why Not Inquiry? "Doing and Learning Together"

Scientific inquiry is one form of scientific practice.

So, the perspective presented in the Framework is not one of replacing inquiry; rather, it is one of expanding and enriching the teaching and learning of science.

Science and Engineering Practices

1. Asking Questions (Science) and Defining Problems (Engineering)
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 (Science) and Designing Solutions (Engineering)
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

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Science and Engineering Practices

- Science & Engineering Practices distinguish science from other ways of knowing.
- When students actively engage in Science & Engineering Practices, they deepen their understanding of core science ideas.
- This vision of the core ideas, concepts, and practices provides the utility students need to engage in making sense of the natural and designed world.

Why Practices?

The idea of science as a set of practices has emerged from the work of historians, philosophers, psychologists, and sociologists over the past 60 years. This perspective is an improvement over previous approaches in several ways.

First – It minimizes the tendency to reduce scientific practices to a single set of procedures, such as identifying and controlling variables, classifying entities, and identifying sources of error.
This tendency overemphasizes experimental investigation at the expense of other practices, such as, posing questions, arguing from evidence, modeling, critique, and communication.

Second – A focus on practices (in the plural) avoids the mistaken impression that there is one distinctive approach common to all science—a single "scientific method"—or that uncertainty is a universal attribute of science.

Third – Attempts to develop the idea that science should be taught through a process of inquiry have been hampered by the lack of a commonly accepted definition of its constituent elements.

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Why Practices?

- Emphasizes outcomes from instruction
- References both scientific inquiry *and* engineering design

Engineering Practices

- Engineering practices are a natural extension of science practices.
- Science instruction often includes opportunities for engineering practices.
- Engineering is not a new component of science standards. Some states currently have elements of engineering in their science standards.
- The Framework provides meaningful connections of science and engineering in the Practices.

Let's Explore Engineering with Paper – Activity

- 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 the engineering practices that are useful in constructing the tower.
- Consider the science knowledge needed or relevant to construct the tower.

Core Idea ETS1 Engineering Design

How do engineers solve problems?

- The design process—engineers' basic approach to problem solving—involves many different practices.
- They include problem definition, model development and use, investigation, analysis and interpretation of data, application of mathematics and computational thinking, and determination of solutions.
- These engineering practices incorporate specialized knowledge about criteria and constraints, modeling and analysis, and optimization and trade-offs.

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- **Core Idea ETS1: Engineering Design**
  - ETS1.A: Defining and Delimiting an Engineering Problem
  - ETS1.B: Developing Possible Solutions
  - ETS1.C: Optimizing the Design Solution

Reflect on the Paper Tower Activity in Light of ETS1.A: Defining and Delimiting an Engineering Problem

What is a design for? What are the criteria and constraints of a successful solution?

The engineering design process begins with:

- Identification of a problem to solve.
- Specification of clear goals, or criteria, for final product or system.
  - Criteria, which typically reflect the needs of the expected end-user.

Engineering must contend with a variety of limitations or constraints

- Constraints, which frame the salient conditions under which the problem must be solved, may be physical, economic, legal, political, social, ethical, aesthetic, or related to time and place.
- In terms of quantitative measurements, constraints may include limits on cost, size, weight, or performance.
- Constraints place restrictions on a design, not all of them are permanent or absolute.

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Reflect on the Paper Tower Activity in Light of ETS1.B: Developing Possible Solutions

What is the process for developing potential design solutions?

The creative process of developing a new design to solve a problem is a central element of engineering.

- Open-ended generation of ideas.
- Specification of solutions that meet criteria and constraints.
- Communicated through various representations, including models .
- Data from models and experiments can be analyzed to make decisions about a design.

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Reflect on the Paper Tower Activity in Light of ETS1.C: Optimizing the Design Solution

How can the various proposed design solutions be compared and improved?

Multiple solutions to an engineering design problem are always possible; determining what constitutes “best” requires judgments.

- Optimization requires making trade-offs among competing criteria.
- Judgments are based on the situation and the perceived needs of the end-user of the product or system.
- Different designs, each optimized for different conditions, are often needed.

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Reflect on the Paper Tower Activity in Light of ETS1: Engineering Design

Core Idea ETS1: Engineering Design

- ETS1.A: Defining and Delimiting an Engineering Problem
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

Similarities and Differences

- Engineering and science are similar in that both involve creative processes, and neither use just one method.
  - Just as scientific investigation has been defined in different ways, engineering design has been described in various ways.
  - However, there is widespread agreement on the broad outlines of the engineering design process.
- Like scientific investigations, engineering design is both iterative and systematic.
  - It is iterative in that each new version of the design is tested and then modified, based on what has been learned up to that point.
  - It is systematic in that a number of characteristic steps must be undertaken.

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- Differences mainly in *purpose* and *product*

Similarities and Differences

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

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

Evidence to Support Explanations

- Science is distinguished from other ways of knowing by the reliance on evidence as the central tenet.
- Constructing science teaching and learning to value and use science as a process for students to obtain knowledge based on empirical evidence.
- Using the Engineering Design process as a tool for problem solving as described in the Disciplinary Core Ideas relies on evidence to assess solutions.

Building Interest in Science

- The line between applied science and engineering is fuzzy.
- The Framework seeks ways for science and engineering to be used to investigate real-world problems and explore opportunities to apply scientific knowledge to engineering design problems.
- The Framework is designed to build a strong base of core competencies to be applied by students to develop a better grounding in scientific knowledge and practices—and create greater interest in furthering science learning.
- Applying the science ideas in the context of engineering is one way to build interest in science.

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Goals for Science Education

The Framework's vision takes into account two major goals for K-12 science education:

(1) Educating all students in science and engineering.
(2) Providing the foundational knowledge for those who will become the scientists, engineers, technologists, and technicians of the future.

The Framework principally concerns itself with the first task—what all students should know in preparation for their individual lives and for their roles as citizens in this technology-rich and scientifically complex world.

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MS.PS-E Energy

Performance Expectations

MS.PS-E.1 Energy

Analyzing and interpreting data to explain that the kinetic energy of an object is proportional to the mass of a moving object and grows with the square of its speed. [Assessment Boundary: Qualitative, not quantitative]

Foundation Boxes

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data ▪ Use standard techniques for displaying, analyzing, and interpreting data including appropriate statistical techniques.	**PS3.A: Definitions of Energy** ▪ Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	**Scale, Proportion, and Quantity** ▪ 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.

Connection Boxes

Connections to other DCIs in this grade-level: **MS.ESS-SS, MS.LS-MEOE**

Articulation to DCIs across grade-levels: **4.E, HS.PS-E, HS.PS-FE, HS.PS-ECT**

Common Core State Standards Connections:

ELA –

W.6.1 Write arguments to support claims with clear reasons and relevant evidence

W.7.1 Write arguments to support claims with clear reasons and relevant evidence

W.8.1 Write arguments to support claims with clear reasons and relevant evidence

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.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

6.RP Understand ratio concepts and use ratio reasoning to solve problems.

6.EE Represent and analyze quantitative relationships between dependent and independent variables.

7.RP Analyze proportional relationship 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.

8.EE Understand the connections between proportional relationships, lines, and linear equations.

8.F Use functions to model relationships between quantities.

DRAFT

Implications and Discussion

- For professional development
- For curricular and instructional resources
- For assessment

Useful Websites

- Framework
  http://www.nap.edu/catalog.php?record_id=13165
- NSTA article by Cary Sneider
  http://www.nsta.org/about/standardsupdate/resources/201201_Framework-Sneider.pdf
- NGSS website

  http://www.nextgenscience.org/