Vision for Science Education

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Scientific Practices

Developed by

The Council of State Science Supervisors

Presentation Designed to Provide Awareness of the Practices

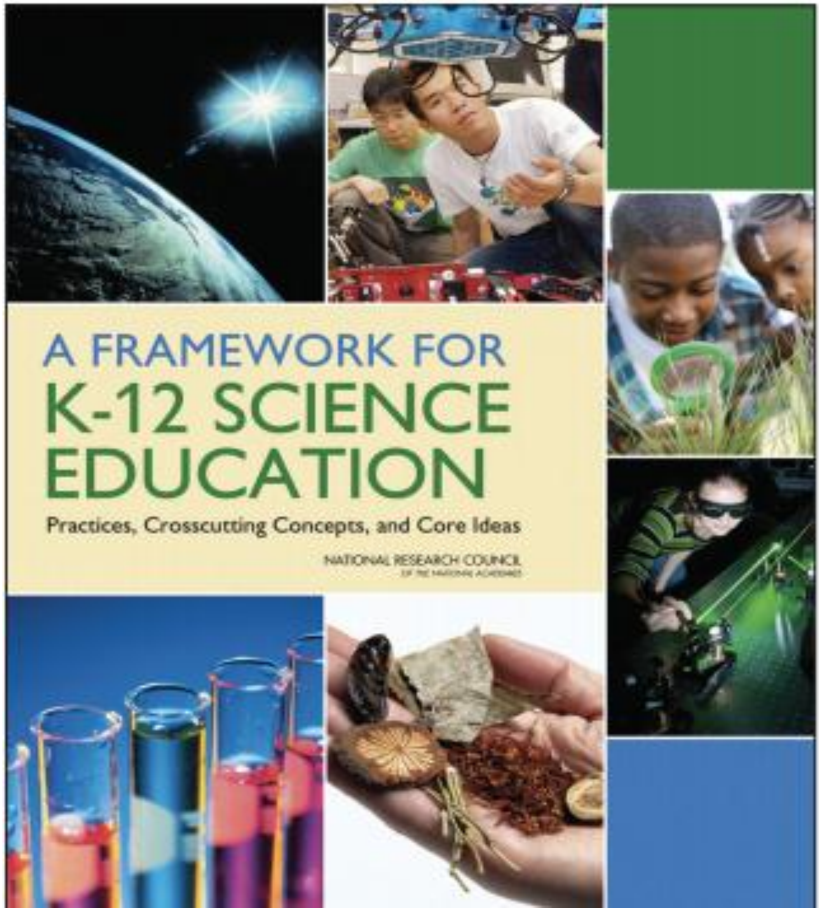
Science Education for a New Generation

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

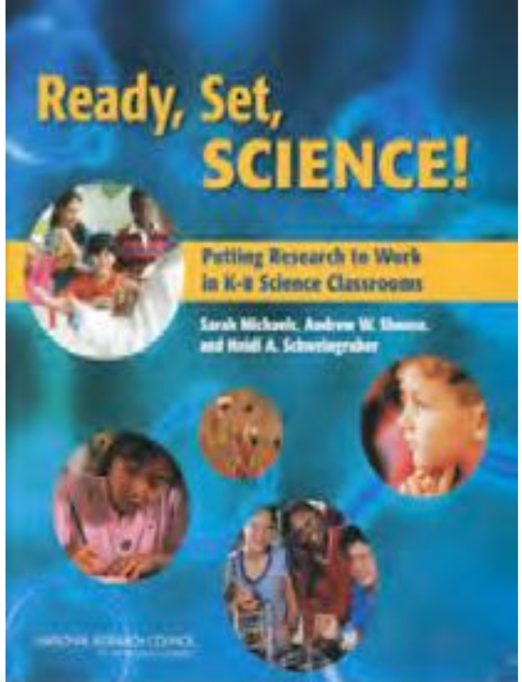
Overview of Session

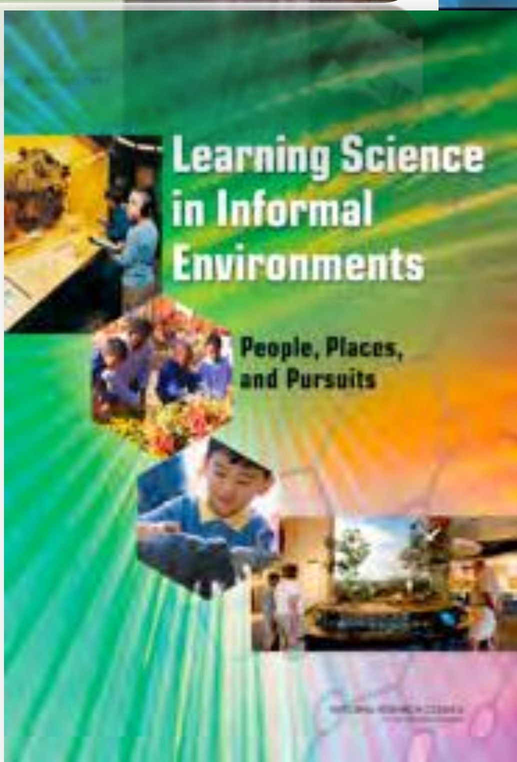
– A Vision for Science Education
– Three Dimensions of Science
– Science Practices
– What Happened to Inquiry?
– Science Practices in the Classroom
– Discussion

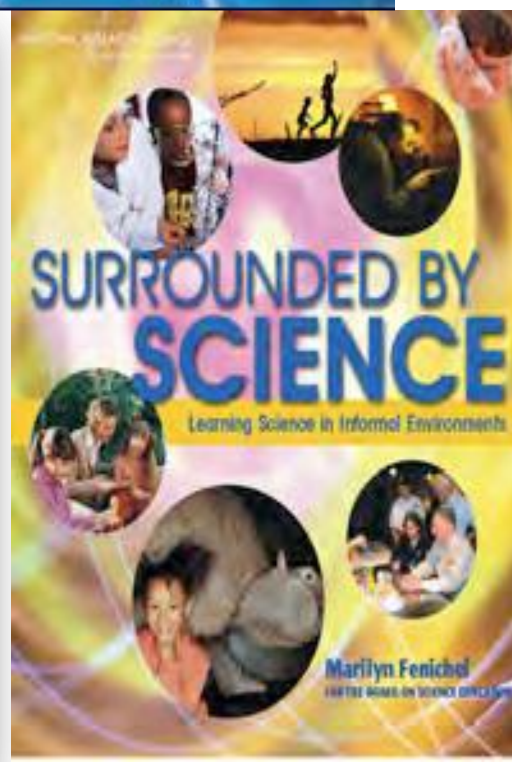
Vision for Science Teaching and Learning

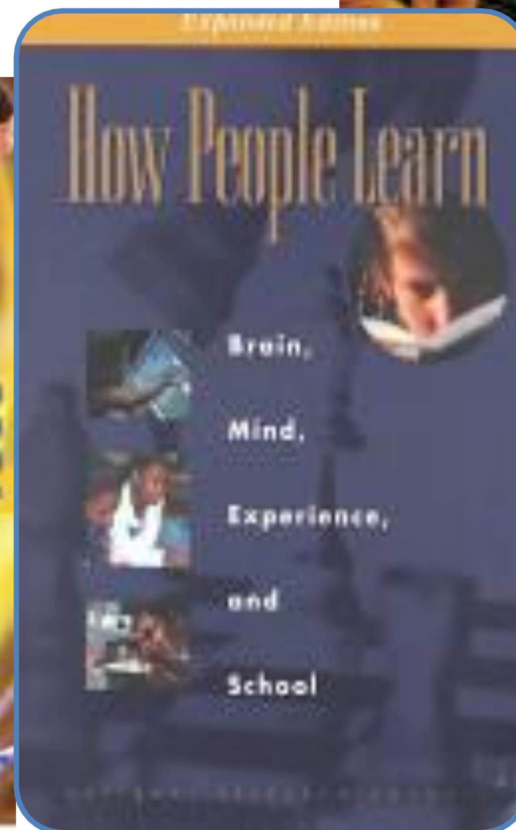


Builds on the Research on Learning the Ideas of Science

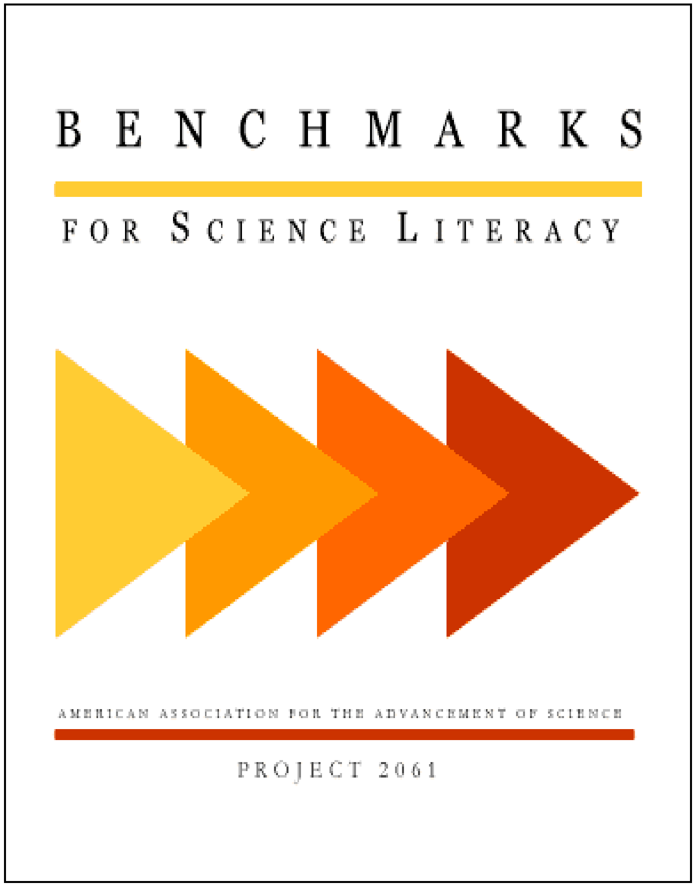


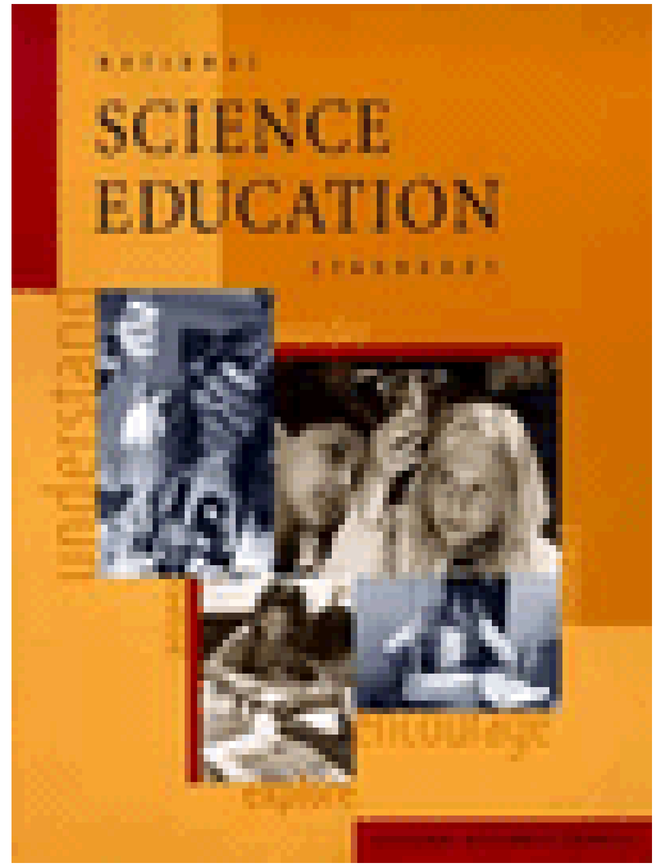






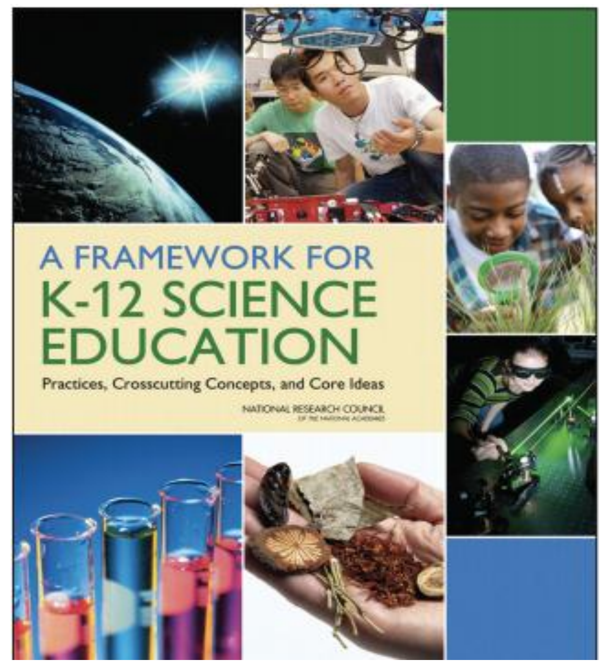
Reports that Shape Where We Find Ourselves Today





The Framework

– Vision for Science Education
– Goals for Science Education
– Three Dimensions for Standards



Goals for Science Education

Turn to the educator next to you and respond to the questions below.

One minute for each question:

1. What are a few expectations in your current state science standards specific to Science Practices? Where are they placed in these standards?
2. How are these expectations related to how science and scientists work?

Framework Page 43 How Scientists Work

Goals for Science Education

From its inception, one of the principal goals of science education has been to cultivate students’ scientific habits of mind, develop their capability to engage in scientific inquiry, and teach students how to reason in a scientific context .

There has always been a tension between the emphasis that should be placed on developing knowledge of the content of science and the emphasis placed on scientific practices.

A narrow focus on content alone has the unfortunate consequence of leaving students with naive conceptions of the nature of scientific inquiry and the impression that science is simply a body of isolated facts.

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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The Framework is Designed to Help Realize a Vision of Science Education

- All students' experiences over multiple years foster progressively deeper understanding of science.
- Students actively engage in scientific and engineering practices in order to deepen their understanding of crosscutting concepts and disciplinary core ideas.
- In order to achieve the vision embodied in the Framework and to best support students' learning, all three dimensions need to be integrated into the system of standards, curriculum, instruction, and assessment.

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Structure/Dimensions of the Framework

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

“The three dimensions of the Framework, which constitute the major conclusions of this report, are presented in separate chapters. However, in order to facilitate students’ learning, the dimensions must be woven together in standards, curricula, instruction, and assessments.

When they explore particular disciplinary ideas from Dimension 3, students will do so by engaging in practices articulated in Dimension 1 and should be helped to make connections to the crosscutting concepts in Dimension 2.”

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Understanding How Science Works

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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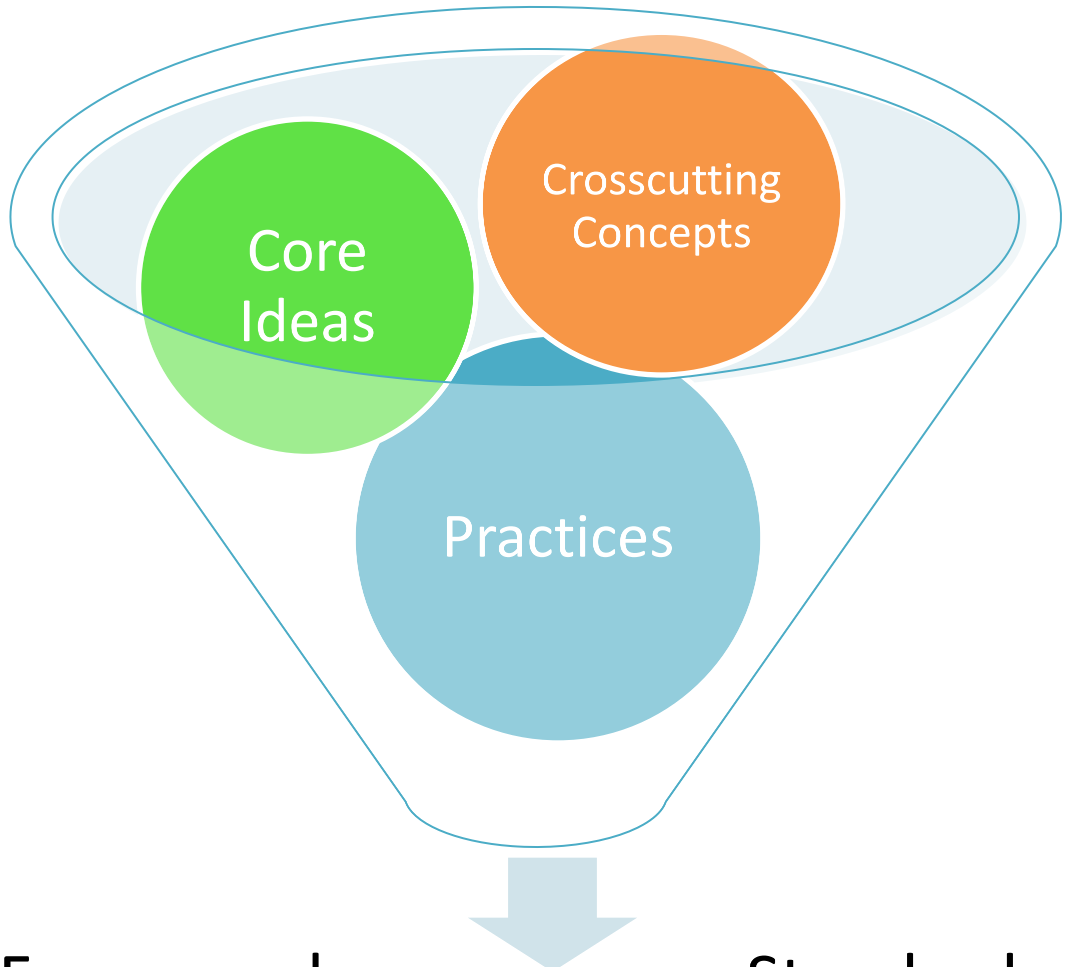

Framework → Standards

Student Performance Expectations

Scientific Practices

Developing students' "scientific habits of mind" is typically the principal goal of science education. Attention to this goal can lead to students valuing and using science as a way of knowing based on evidence. To make science learning meaningful, a balance is necessary between science content, science concepts (e.g., patterns, structure/function) and the use of the scientific practices.

This session will explore the balance as described in the NRC Science Framework and the implications for science education standards, classroom instruction, and assessment of student learning.

The session will use organizing documents to help clarify the role of science practices and discuss the appropriate use in state standards, classroom instruction, and ways to inform instruction by assessing students' abilities to use the practices.

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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Engaging in
Arguments
from Evidence
Constructing
Explanations
Investigations
Asking questions
Analyzing Data

Science and Engineering Practices

- Science and Engineering Practices are the processes, nature, and habits of mind for science and/or engineering.
- Science Practices distinguish science from other ways of knowing.
- When students actively engage in science practices, they deepen their understanding of core science ideas.
- This vision of the core ideas, concepts, and practices provides the tools for students to engage in making sense of the natural and designed world.

Science and Engineering Practices

Activity: Explanations Using Evidence

Activity – Explanations from Evidence

Investigate the behavior of the water in a closed syringe when the plunger is extracted a few centimeters with the inlet stopped.

1. Each group – Investigate the phenomena to develop an explanation supported by evidence.

2. Individually – Write an explanation of the observed phenomena, supported by observed evidence, in your journal.

Materials – Large syringes, caps, plastic beakers, water, and copy of practices one page sheet.

Evidence to Support Explanations

- What distinguishes science from other ways of knowing is the reliance on evidence as central to science.
- Value and use science as a process of obtaining knowledge based on empirical evidence.

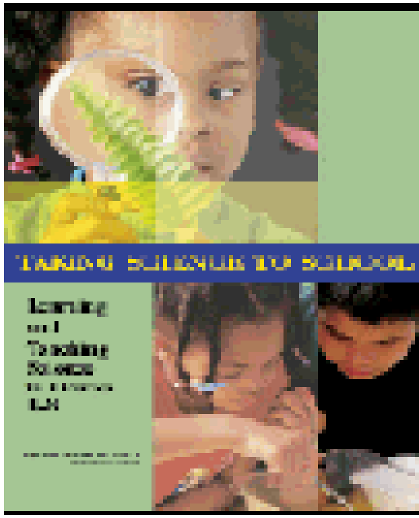
Science Argumentation

- Providing empirical evidence to support assertions.
- Listening to others’ arguments and analyzing the evidence.
- Evaluating arguments based on evidence and reasoning.

Making Thinking Visible

Making Thinking Visible

- Making thinking visible through writing and classroom discourse is an important way to provide models for students' expectations of engaging in science and engineering practices.
- The practices make the science classroom more science-like.
- It is essential that the questions posed by teachers engage students and provide opportunities to inform instruction.



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How will the Practices Appear in Standards?

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.

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]		

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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.

CCSS Language Arts

"Students who meet the Standards readily undertake the close, attentive reading that is at the heart of understanding and enjoying complex works of literature. They habitually perform the critical reading necessary to pick carefully through the staggering amount of information available today in print and digitally. They actively seek the wide, deep, and thoughtful engagement with high-quality literary and informational texts that builds knowledge, enlarges experience, and broadens worldviews. **They reflexively demonstrate the cogent reasoning and use of evidence that is essential** to both private deliberation and responsible citizenship in a democratic republic. In short, students who meet the Standards develop the skills in reading, writing, speaking, and listening that are the foundation for any creative and purposeful expression in language."

CCSS Mathematics

"Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in **constructing arguments…They justify their conclusions, communicate them to others, and respond to the arguments of others…**Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is."

Using Evidence

- Value and use science as a process of obtaining knowledge based on observable evidence.
- Supporting science argumentation with evidence is a key practice of science.
- Using models and core ideas to make sense of novel phenomena is an essential aspect of science.
- Developing science explanations based on evidence.

Distinguishing meaningful science instruction from meaningless activities may be as simple as engaging students in science practices.

Closure and Final Questions

- So, what is your vision for science education?
- Reflect back on your experiences in science teaching and learning as well as the Framework and tell us your ideas about science and science teaching and learning.