DEMYSTIFYING THE NEW TN ACADEMIC STANDARDS FOR SCIENCE

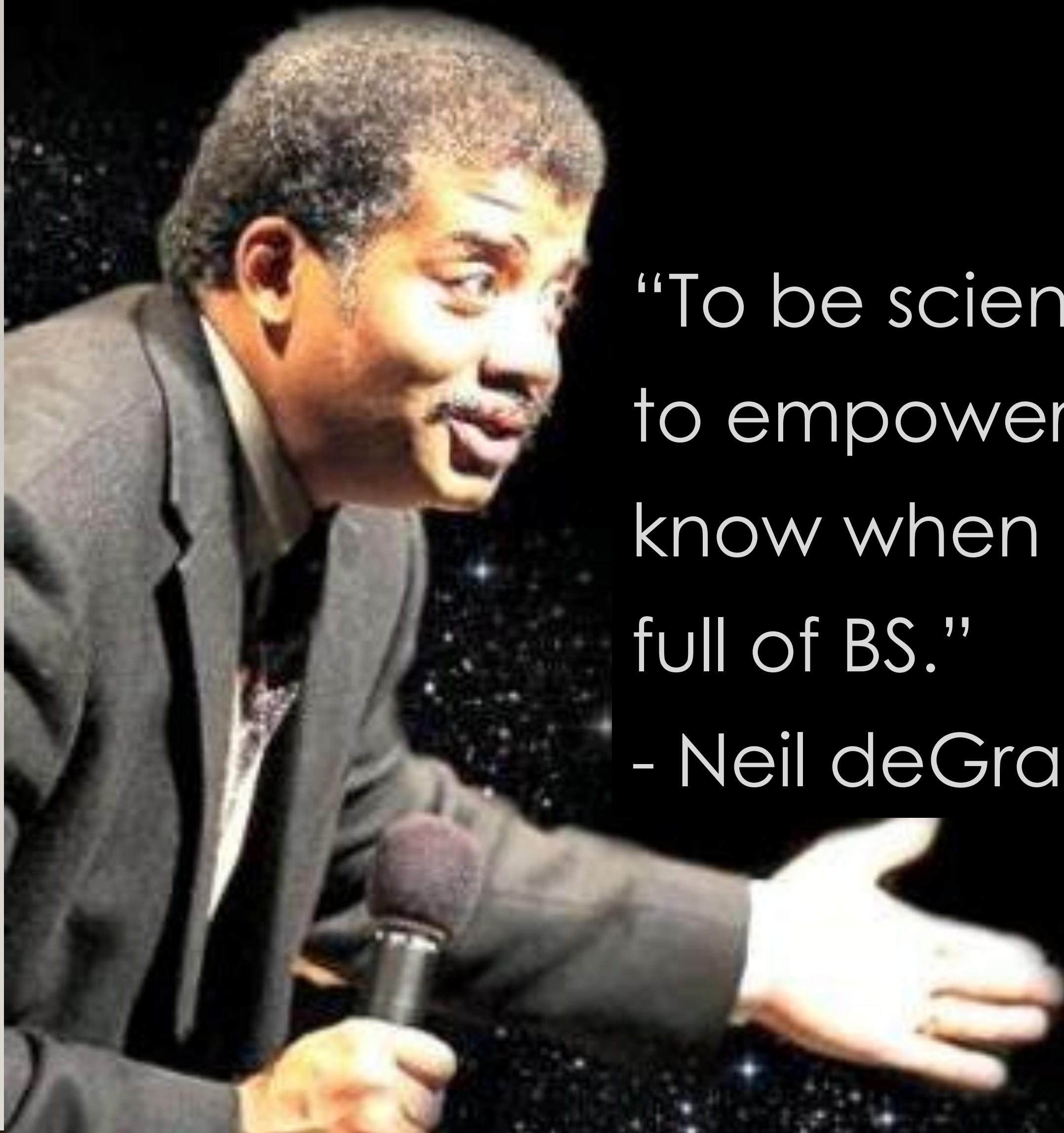
Presentation adapted from California Academy of Sciences

GROUNDING CIRCLES

- How this works:
  - Form groups of 4-6 members. Groups arrange themselves into circles.
  - There will be three questions displayed on the next slide.
  - Each member of the group will have an opportunity to respond to the three questions to the rest of the group.
  - The last member in the circle will be tasked to briefly summarize a snippet of each member's response (Notes may be jotted and support may be given from the group if that helps!).

GROUNDING QUESTIONS

- 1) What grade level do I teach and how long have I been teaching?
- 2) What do I hope to take away from this week?
- 3) What skills and abilities would I see in a scientifically literate citizen?



"To be scientifically literate is to empower yourself to know when someone else is full of BS."

- Neil deGrasse Tyson

OVERVIEW

- *Why are the standards changing?*
- *What do they look like?*
- *How did this happen?*

OVERVIEW

- ***Why are the standards changing?***
- *What do they look like?*
- *How did this happen?*

TRUE OR FALSE…

- Scientific ideas are absolute and unchanging.
- The process of science is purely analytic and does not involve creativity.
- Science is complete.
- Science is a solitary pursuit.
- Science is boring.

UC Museum of Paleontology, *Misconceptions About Science.* Retrieved from http://undsci.berkeley.edu/teaching/misconceptions.php

MORE MISCONCEPTIONS ABOUT SCIENCE

- Because scientific ideas are tentative and subject to change, they can't be trusted.
- Scientific ideas are judged democratically based on popularity.
- Scientists are judged on the basis of how many correct hypotheses they propose (i.e., good scientists are the ones who are "right" most often).
- Science is a collection of facts.

UC Museum of Paleontology, *Misconceptions About Science.* Retrieved from http://undsci.berkeley.edu/teaching/misconceptions.php

FACTS, FACTS, FACTS

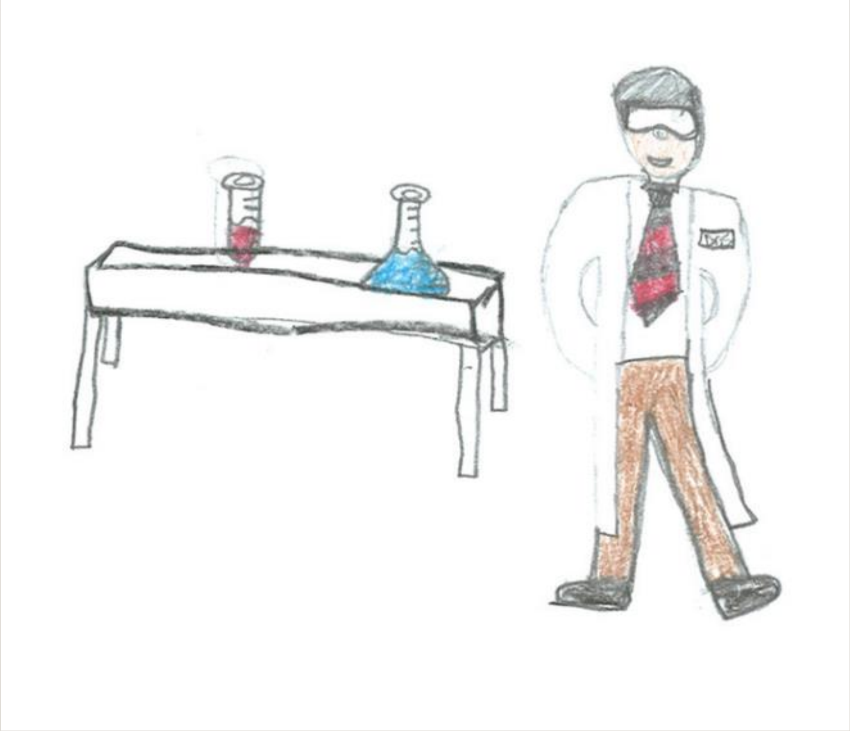
Problems with teaching science this way...

- Students don't build the skills needed for real science

FACTS, FACTS, FACTS

Problems with teaching science this way…

- Students don't relate to science or scientists



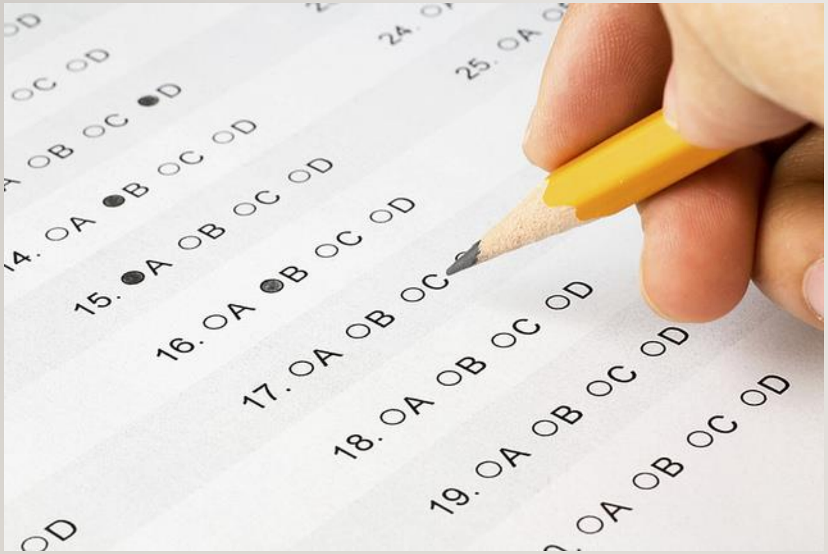
FACTS, FACTS, FACTS

Problems with teaching science this way...

- Students don’t understand where science comes from

WHY IS SCIENCE TAUGHT THIS WAY?

- Testing
- Standards



Students know biodiversity is the sum total
affected by alterations of habitats.

Students know how to analyze changes in a
climate, human activity, introduction of no
tion size.

Students know how fluctuations in populati
mined by the relative rates of birth, immig

Students know how water, carbon, and nitr
and organic matter in the ecosystem and h
thesis and respiration.

Students know a vital part of an ecosystem i
decomposers.

Students know at each link in a food web so
structures but much energy is dissipated i
dissipation may be represented in an energ

Students know how to distinguish between
organism to its environment and the gradu
isms through genetic change.

Image: Alberto G, CC BY 2.0

California Department of Education, 2000. *Science Content Standards for California Public Schools.*

CARD SORT

Work in teams of 3-4 people

- **GUIDING QUESTION**
- What are the key elements of the Framework for K-12 Science Education and the new TN Science Standards?

NEW TN STATE SCIENCE STANDARDS

Science and Engineering Practices (doing science)

Disciplinary Core Ideas (facts)

Crosscutting Concepts (connecting science)

*

*

OVERVIEW

- *Why are the standards changing?*
- ***What do they look like?***
- *How did this happen?*

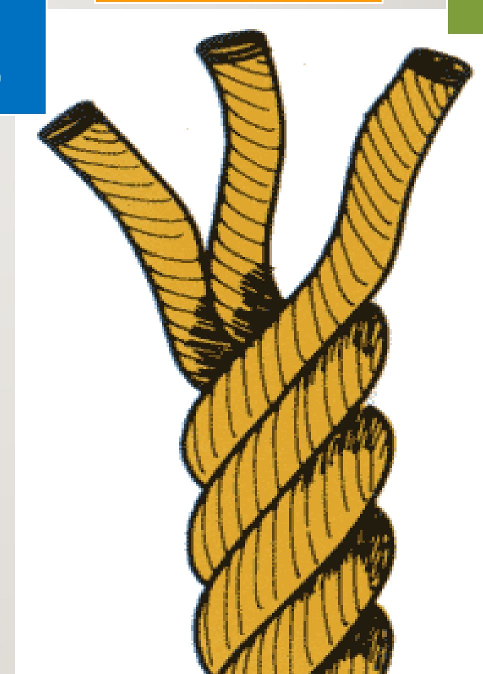
THE 3 DIMENSIONS OF THE K12 SCIENCE FRAMEWORK

This symbol actually means something!

Science & Engineering Practices (doing science)

Disciplinary Core Ideas (facts)

Crosscutting Concepts (connecting science)



Student Performance Expectation (PE)

Adapted from NSTA

UNDERSTANDING THE STANDARDS IS A PIECE OF CAKE

Performance Expectation

Baking Tools & Techniques

Science & Engineering Practices

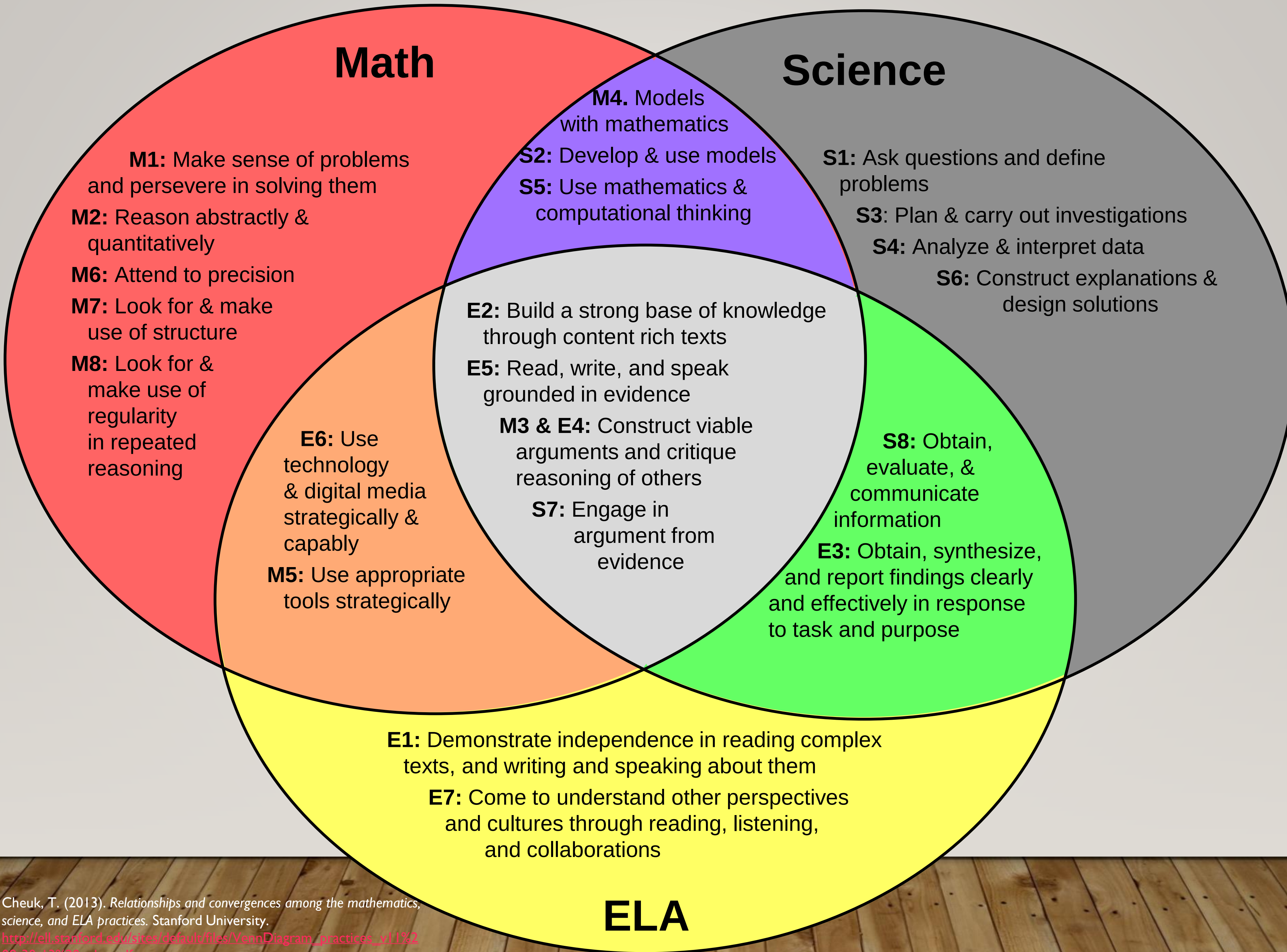
Cake

Disciplinary Core Ideas

Frosting

Crosscutting Concepts

Adapted from NSTA

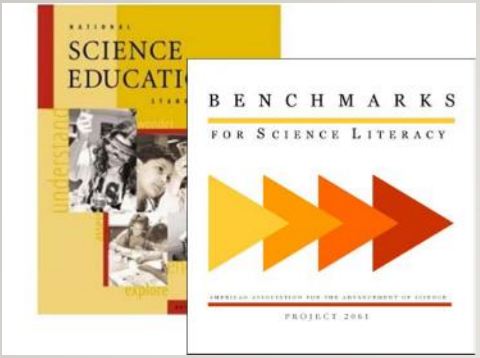


Cheuk, T. (2013). *Relationships and convergences among the mathematics, science, and ELA practices.* Stanford University. http://ell.stanford.edu/sites/default/files/VennDiagram_practices_v11%208-30-13%20color.pdf

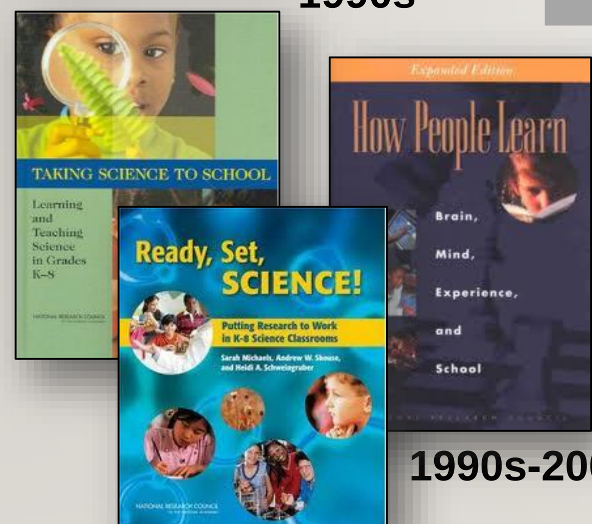
OVERVIEW

- *Why are the standards changing?*
- *What do they look like?*
- ***How did this happen?***

WHERE DID THE STANDARDS COME FROM?



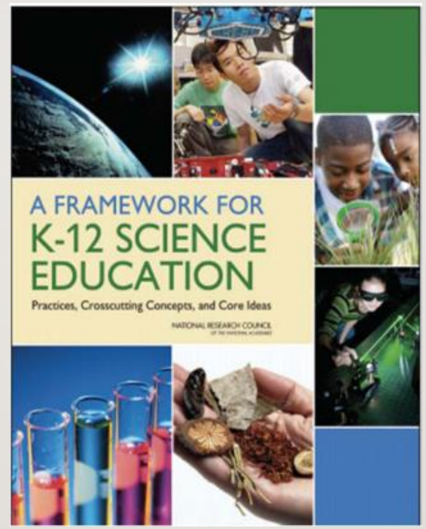
1990s



1990s-2009

Previous national science education efforts

Step 1



2010-2011
National Research Council (NRC) develops Conceptual Framework

Step 2

NEXT GENERATION SCIENCE STANDARDS

April 2013
Released for states' adoption

TN Academic Standards for Science 2018-2019

Adapted from NSTA web seminar: Karen Ostlund and Stephen Pruitt, *Introduction to the NGSS Second Public Draft*, January 2013

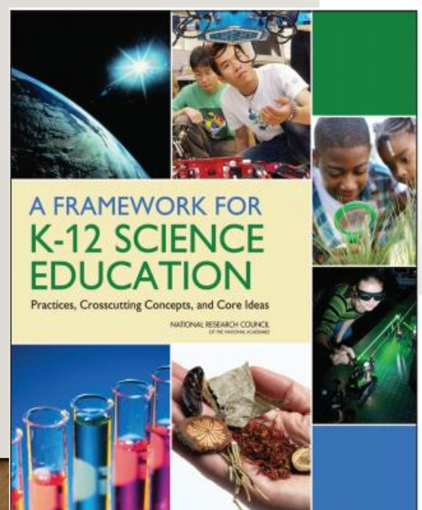
OVERVIEW

- *Why are the standards changing?*
- *What do they look like?*
- *How did this happen?*

- ***Now Let's look at the Framework***
  - ***Source: Intro to a Framework for K-12 Science Education by Amy Sandgren***
  - https://www.sites.google.com/site/ngsstrainingresources/introduction-to-the-next-generation-science-standards

PRINCIPLES OF THE FRAMEWORK

Let's Take a Closer Look at the Framework:



Tab and review sections of the Framework

A Framework for K-12 Science Education

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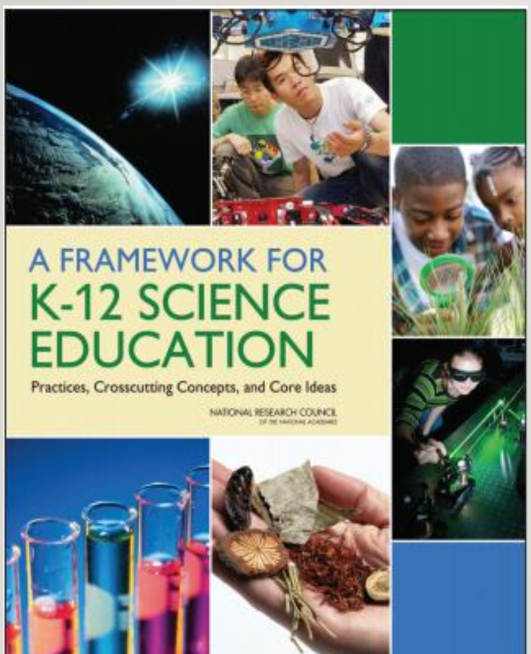
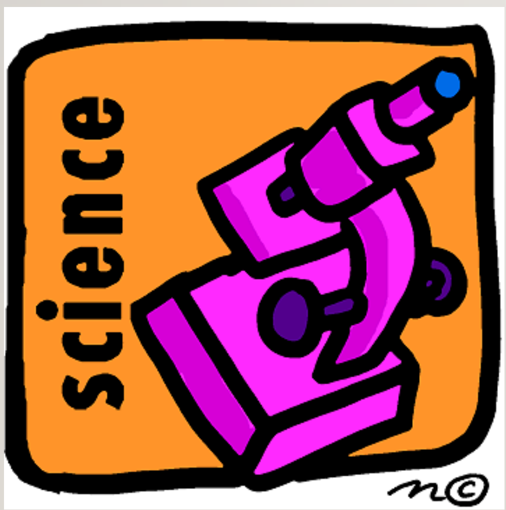


CONTENTS

A Framework for K-12 Science Education

Overview of the Framework
p. 3



BOX S-1

THE THREE DIMENSIONS OF THE FRAMEWORK

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

2 Crosscutting Concepts

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

3 Disciplinary Core Ideas

Physical Sciences

PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

Life Sciences

LS1: From molecules to organisms: Structures and processes
LS2: Ecosystems: Interactions, energy, and dynamics
LS3: Heredity: Inheritance and variation of traits
LS4: Biological evolution: Unity and diversity

Earth and Space Sciences

ESS1: Earth's place in the universe
ESS2: Earth's systems
ESS3: Earth and human activity

Engineering, Technology, and Applications of Science

ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society

A Framework for K-12 Science Education

Vision p. 8-9

K–12 Science Education Should Reflect the Real World Interconnections in Science.

"The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields."

The conceptual framework presented in this report of the Committee on a Conceptual Framework for New K-12 Science Education Standards articulates the committee's vision of the scope and nature of the education in science, engineering, and technology needed for the 21st century. It is intended as a guide to the next step, which is the process of developing standards for all students. Thus it describes the major practices, crosscutting concepts, and disciplinary core ideas that all students should be familiar with by the end of high school, and it provides an outline of how these practices, concepts, and ideas should be developed across the grade levels. Engineering and technology are featured alongside the physical sciences, life sciences, and earth and space sciences for two critical reasons: to reflect the importance of understanding the human-built world and to recognize the value of better integrating the teaching and learning of science, engineering, and technology.

By framework we mean a broad description of the content and sequence of learning expected of all students by the completion of high school—but not at the level of detail of grade-by-grade standards or, at the high school level, course descriptions and standards. Instead, as this document lays out, the framework is intended as a guide to standards developers as well as for curriculum designers, assessment developers, state and district science administrators, professionals responsible for science teacher education, and science educators working in informal settings.

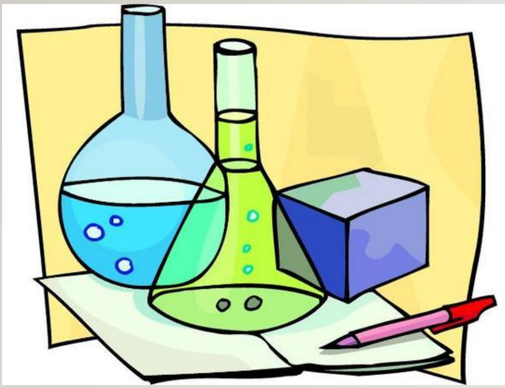
There are two primary reasons why a new framework is needed at this time. One is that it has been 15 or more years since the last comparable effort at the national scale, and new understandings both in science and in teaching and learning science have developed over that time. The second is the opportunity provided by a movement of multiple states to adopt common standards in mathematics and in language arts, which has prompted interest in comparable documents for science. This framework is the first part of a two-stage process to produce a next-generation set of science standards for voluntary adoption by states. The second step—the development of a set of standards based on this framework—is a state-led effort coordinated by Achieve, Inc., involving multiple opportunities for input from the states' science educators, including teachers, and the public.

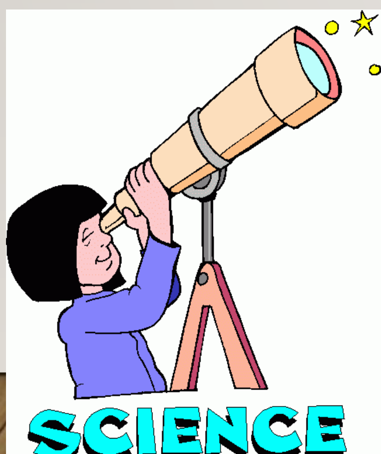
VISION FOR K-12 EDUCATION IN THE SCIENCES AND ENGINEERING

The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen

A Framework for K-12 Science Education

Two Goals p. 10





The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields.

of the broad diversity of the American population—to follow these paths than is the case today.

The committee's vision takes into account two major goals for K-12 science education: (1) educating all students in science and engineering and (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. Course options, including Advanced Placement (AP) or honors courses, should be provided that allow for greater breadth or depth in the science topics that students pursue, not only in the usual disciplines taught as natural sciences in the K-12 context but also in allied subjects, such as psychology, computer science, and economics. It is the committee's conviction that such an education, done well, will excite many more young people about science-related subjects and generate a desire to pursue science- or engineering-based careers.

Achieving the Vision

The framework is motivated in part by a growing national consensus around the need for greater coherence—that is, a sense of unity—in K-12 science education. Too often, standards are long lists of detailed and disconnected facts, reinforcing the criticism that science curricula in the United States tend to be "a mile wide and an inch deep" [1]. Not only is such an approach alienating to young people, but it can also leave them with just fragments of knowledge and little sense of the creative achievements of science, its inherent logic and consistency, and its universality. Moreover, that approach neglects the need for students to develop an understanding of the practices of science and engineering, which is as important to understanding science as knowledge of its content.

The framework endeavors to move science education toward a more coherent vision in three ways. First, it is built on the notion of learning as a developmental

A Framework for K-12 Science Education

Research Base
p. 23-28

- 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

2

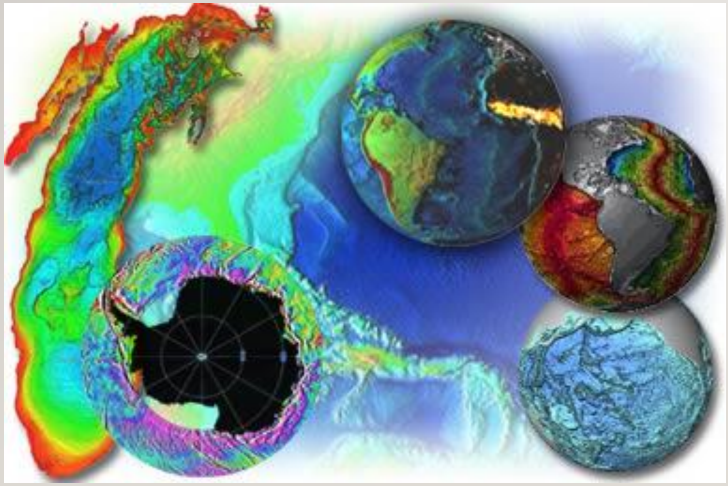
GUIDING ASSUMPTIONS AND ORGANIZATION OF THE FRAMEWORK

The conceptual framework presented in this report is based on a large and growing body of research on teaching and learning science. Much of this research base has been synthesized in other National Research Council (NRC) reports. Research on how children learn science and the implications for science instruction in grades K-8 was central to *Taking Science to School* [1], *America's Lab Report* [2] examined the role of laboratory experiences in high school science instruction, and *Learning Science in Informal Environments* [3] focused on the role of science learning experiences outside school. Complementing these publications, *Systems for State Science Assessment* [4] studied large-scale assessments of science learning, and *Engineering in K-12 Education* [5] looked into the knowledge and skills needed to introduce students to engineering in grades K-12. All of these NRC reports have been essential input to the development of the framework.

The framework also builds on two other prior works on standards: *Benchmarks for Science Literacy* published by the American Association for the Advancement of Science (AAAS) [6] and the NRC's *National Science Education Standards* (NSES) [7]. In addition, the committee examined more recent efforts, including the *Science Framework for the 2009 National Assessment of Educational Progress* [8], *Science College Board Standards for College Success* [9], the National Science Teachers Association's (NSTA's) Science Anchors project [10], and a variety of state and international science standards and curriculum specifications.

A Framework for K-12 Science Education

Development of Core Ideas p. 31



But given the cornucopia of information available today virtually at a touch—people live, after all, in an information age—an important role of science education is not to teach "all the facts" but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own. An education focused on a limited set of ideas and practices in science and engineering should enable students to evaluate and select reliable sources of scientific information and allow them to continue their development well beyond their K-12 school years as science learners, users of scientific knowledge, and perhaps also as producers of such knowledge.

With these ends in mind, the committee developed its small set of core ideas in science and engineering by applying the criteria listed below. Although not every core idea will satisfy every one of the criteria, to be regarded as core, each idea must meet at least two of them (though preferably three or all four).

Specifically, a core idea for K-12 science instruction should

1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline.
2. Provide a key tool for understanding or investigating more complex ideas and solving problems.
3. Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge.
4. Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, the idea can be made accessible to younger students but is broad enough to sustain continued investigation over years.

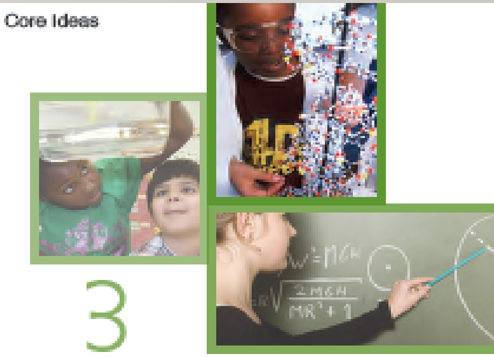
In organizing Dimension 3, we grouped disciplinary ideas into four major domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology, and applications of science. At the same time, true to Dimension 2, we acknowledge the multiple connections among domains. Indeed, more and more frequently, scientists work in interdisciplinary teams that blur traditional boundaries. As a consequence, in some instances core ideas, or elements of core ideas, appear in several disciplines (e.g., energy, human impact on the planet).

Each core idea and its components are introduced with a question designed to show some aspect of the world that this idea helps to explain. The question

A Framework for K-12 Science Education

Dimension 1
Scientific and Engineering Practices
p. 41-82

<u>Sections:</u>
- ❑ Why Practices?
- ❑ Understanding How Scientists Work
- ❑ How the Practices are Integrated into Inquiry and Design
- ❑ How Engineering and Science Differ
- ❑ The Eight Practices



3

Dimension 1
SCIENTIFIC AND ENGINEERING PRACTICES

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 them how to reason in a scientific context [1, 2]. There has always been a tension, however, 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 [3] and the impression that science is simply a body of isolated facts [4].

This chapter stresses the importance of developing students' knowledge of how science and engineering achieve their ends while also strengthening their competency with related practices. As previously noted, we use the term "practices," instead of a term such as "skills," to stress that engaging in scientific inquiry requires coordination both of knowledge and skill simultaneously.

In the chapter's three major sections, we first articulate why the learning of science and engineering practices is important for K-12 students and why these practices should reflect those of professional scientists and engineers. Second, we describe in detail eight practices we consider essential for learning science and engineering in grades K-12 (see Box 3-1). Finally, we conclude that acquiring skills in these practices supports a better understanding of how scientific knowledge is produced and how engineering solutions are developed. Such understanding will help students become more critical consumers of scientific information.

A Framework for K-12 Science Education

Dimension 2
Crosscutting Concepts
pp. 83-102

<u>Crosscutting Concepts:</u>

1. Patterns
2. Cause & Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy & Matter
6. Structure & Function
7. Stability & Change

4

Dimension 2

CROSSCUTTING CONCEPTS

Some important themes pervade science, mathematics, and technology and appear over and over again, whether we are looking at an ancient civilization, the human body, or a comet. They are ideas that transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation, and in design.

—American Association for the Advancement of Science [1].

In this chapter, we describe concepts that bridge disciplinary boundaries, having explanatory value throughout much of science and engineering. These crosscutting concepts were selected for their value across the sciences and in engineering. These concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.

Although crosscutting concepts are fundamental to an understanding of science and engineering, students have often been expected to build such knowledge without any explicit instructional support. Hence the purpose of highlighting them as Dimension 2 of the framework is to elevate their role in the development of standards, curricula, instruction, and assessments. These concepts should become common and familiar touchstones across the disciplines and grade levels. Explicit reference to the concepts, as well as their emergence in multiple disciplinary contexts, can help students develop a cumulative, coherent, and usable understanding of science and engineering.

Although we do not specify grade band endpoints for the crosscutting concepts, we do lay out a hypothetical progression for each. Like all learning

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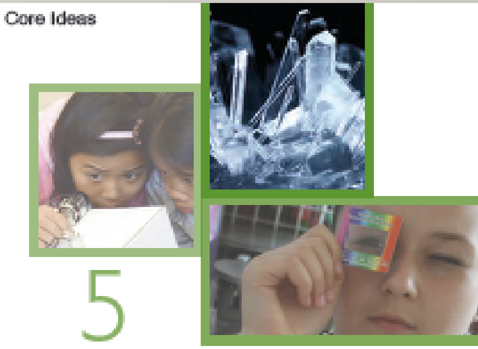
Dimension 3
Core Ideas & Components
pp. 103-214

1. **Physical Sciences** – p. 103
2. **Life Sciences** – p. 139
3. **Earth & Space Sciences** - p. 169
4. **Engineering, Technology, & Applications of Science** – p. 201



5

Dimension 3

DISCIPLINARY CORE IDEAS—PHYSICAL SCIENCES

Most systems or processes depend at some level on physical and chemical subprocesses that occur within it, whether the system in question is a star, Earth's atmosphere, a river, a bicycle, the human brain, or a living cell. Large-scale systems often have emergent properties that cannot be explained on the basis of atomic-scale processes; nevertheless, to understand the physical and chemical basis of a system, one must ultimately consider the structure of matter at the atomic and subatomic scales to discover how it influences the system's larger scale structures, properties, and functions. Similarly, understanding a process at any scale requires awareness of the interactions occurring—in terms of the forces between objects, the related energy transfers, and their consequences. In this way, the physical sciences—physics and chemistry—underlie all natural and human-created phenomena, although other kinds of information transfers, such as those facilitated by the genetic code or communicated between organisms, may also be critical to understanding their behavior. An overarching goal for learning in the physical sciences, therefore, is to help students see that there are mechanisms of cause and effect in all systems and processes that can be understood through a common set of physical and chemical principles.

The committee developed four core ideas in the physical sciences—three of which parallel those identified in previous documents, including the *National Science Education Standards* and *Benchmarks for Science Literacy* [1, 2]. The three core ideas are PS1: Matter and Its Interactions, PS2: Motion and Stability: Forces and Interactions, and PS3: Energy.

A Framework for K-12 Science Education

Realizing the Vision
pp. 217- 295

- ✓ **Integrating the Dimensions** – p. 217
- ✓ **Sample Performance Expectations** – p.220
- ✓ **Implementation (Curriculum, Instruction, P.D. and Assessment)** – p. 241
- ✓ **Equity & Diversity** – p. 277

9

INTEGRATING THE THREE DIMENSIONS

This framework is designed to help realize a vision of science education in which 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 the preceding chapters, we detailed separately the components of the three dimensions: scientific and engineering practices, 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.

TEGRATION INVOLVES

The committee recognizes that integrating the three dimensions in a coherent way is challenging and that examples of how it can be achieved are needed. We also acknowledge that there is no single approach that defines how to integrate the three dimensions into standards, curriculum, instruction, and assessment. One can in fact envision many different ways to achieve such integration, with the main components of the framework being conveyed with a high degree of fidelity, but with different choices as to when to stress a particular practice or crosscutting idea. For these reasons, in this chapter we offer only preliminary examples of the type of integration we envision, noting that the development of