K-12 SCIENCE AND UNDERGRADUATE BIOLOGY EDUCATION REFORM

A Conversation with

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Key Questions

1. Where is science and biology education reform headed?
2. In what ways are the NGSS and the Vision and Change Call to Action (V&C) aligned?
3. What implications do the alignments of NGSS and V&C have for professional development so we continue to build biological literacy over a students' career?

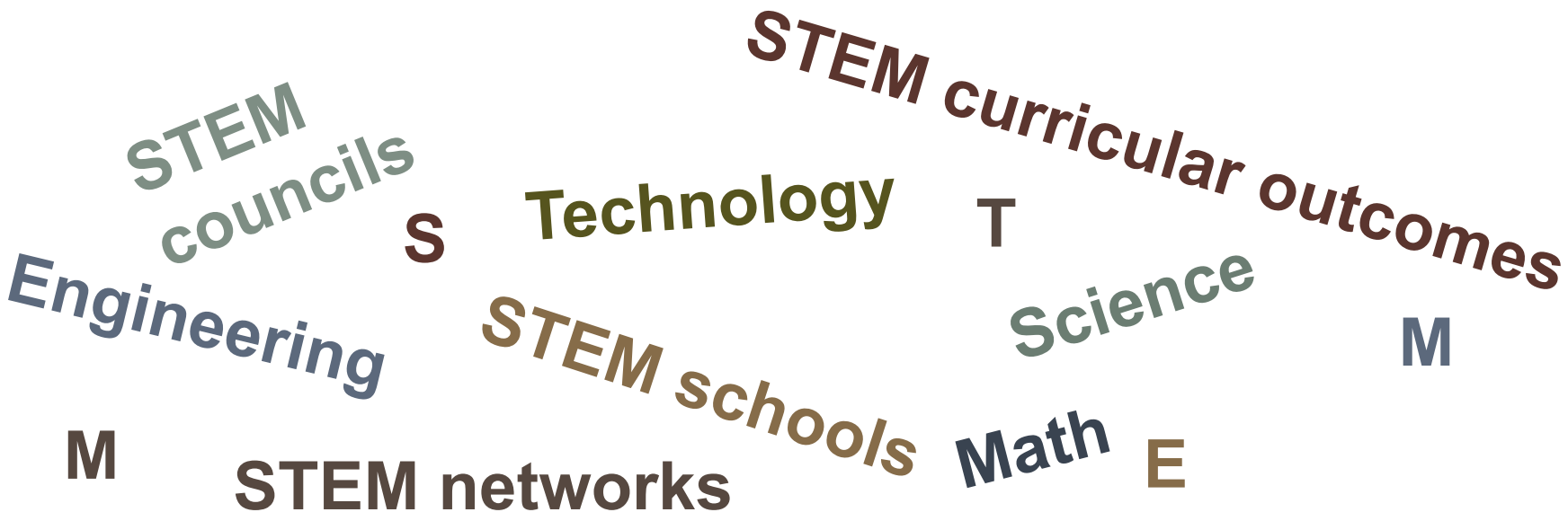
Multiple Reports → A Growing Synergy

Weaving meaningful connections across STEM learning is beginning to echo across all levels of education.

- K-12 Science Education Framework
- Common Core Mathematics Standards
- New AP curriculum
- Vision and Change in Undergraduate Biology
- A New Biology for the 21st Century
- Scientific Foundations for Future Physicians

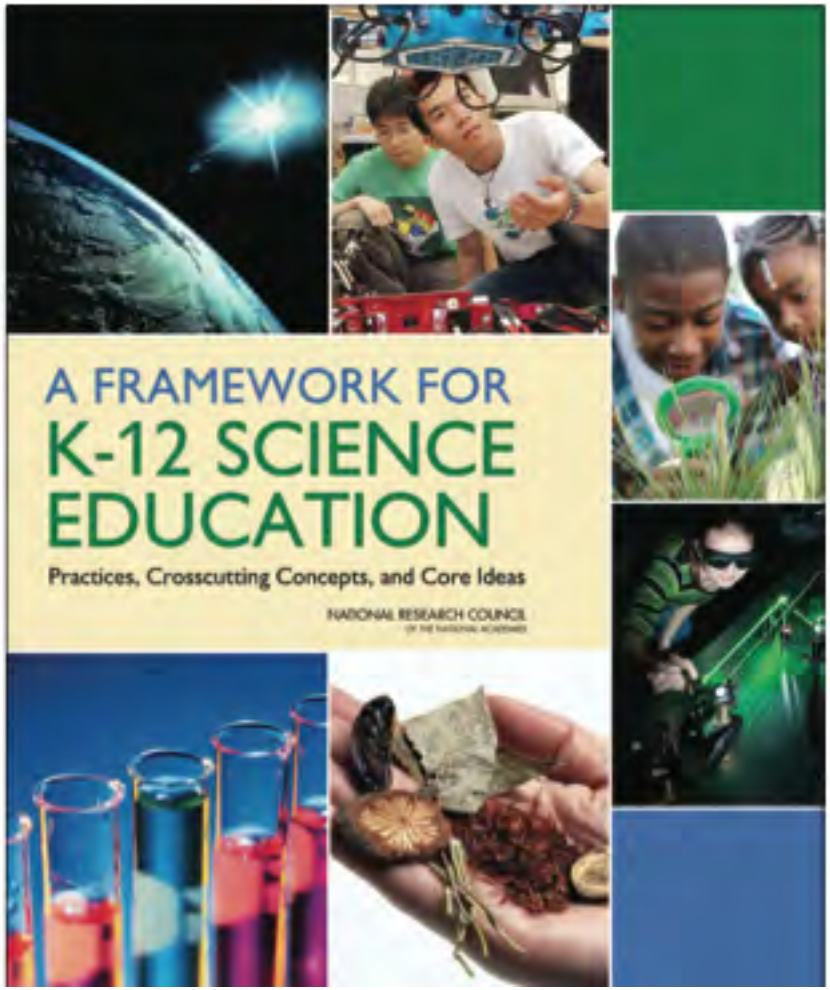
Moving Beyond the Alphabet Soup of STEM

- Despite the well-intended branding, understanding of the brand itself remains elusive
- A field of unique knowledge, practices, and expertise that can be leveraged to enhance learning in all STEM domains



Moon, J. and S.R. Singer (2012) Bringing STEM into focus. Ed Week, January 30, 2012

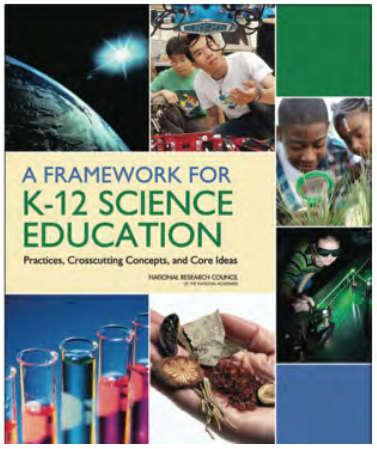
K-12 Science Education Framework offers clues to "What is STEM?"

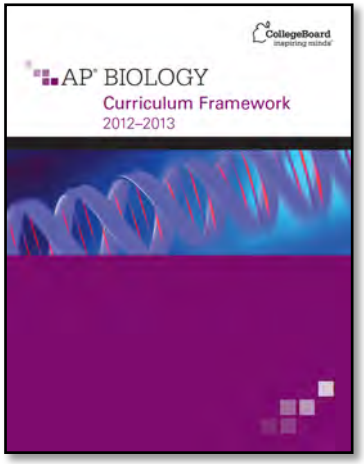


Turns attention away from a content- specific definition of STEM to a more epistemic one—the sources, strategies, or practices from which science and, by extension, STEM knowledge comes and, in turn, is shared.

Opportunities for Better K-16 Alignment

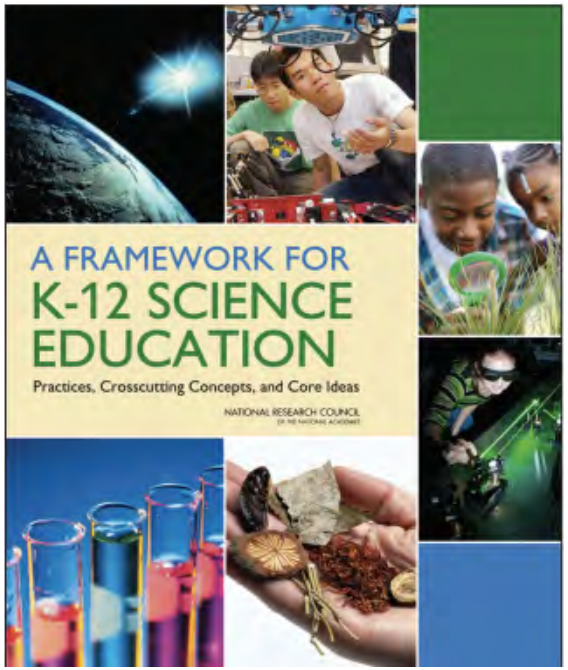
- A Framework for K-12 Science Education and the Next Generation Science Standards
- New AP Biology Curriculum
- NSF/AAAS Vision and Change in Undergraduate Biology Education (PULSECommunity.org)





A FRAMEWORK FOR SCIENCE EDUCATION

Practices, Crosscutting Concepts, and Core Ideas

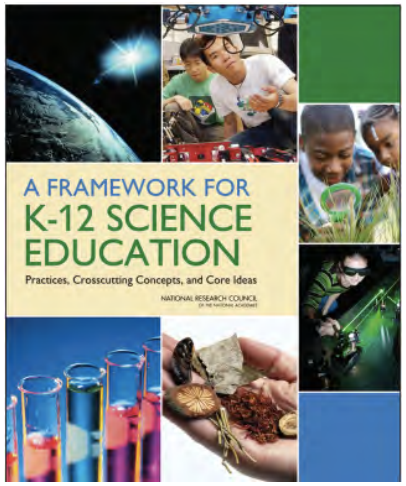


- Provides a vision for science education: Science for ALL students, coherent learning, emphasis on "how", not "what"
- Defines what students should know for their lives and roles as citizens in a scientifically complex world.
- First step in the development of the Next Generation Science Standards

SUMMARY OF THE FRAMEWORK

- Incorporates two decades of research-based approaches and findings on how students learn science most effectively
- Focused on limited number of core ideas and practices.
- Calls for full integration of content knowledge and the practices needed to engage in scientific inquiry
- Serves as the foundation for Next Generation Science Standards (NGSS)
- Is a guide for curriculum, professional development and assessment

THE PROCESS



NEXT GENERATION SCIENCE STANDARDS

- Assessments
- Curricula
- Instruction
- Teacher Development

Next Generation Science Standards (NGSS) – Standards, not Curriculum

- The NGSS are standards, or goals, that reflect what a student should know and be able to do.
- They do not dictate the manner or methods by which the standards are taught.
- Performance expectations express the way a concept and skills can be performed but still leaves curricular and instructional decisions to states, districts, school and teachers.

KEY GUIDING PRINCIPLE: Learning Develops Over Time

- Knowledge is structured around *conceptual frameworks that guide how to solve problems, make observations, organize, and structure new information*
- Learning *core ideas* requires multiple years of school
- Learning is facilitated when *new and existing knowledge* is structured around core ideas
- Developing understanding is dependent on instruction and opportunities to *experience that understanding*
- Both elements– *knowledge and practice*--are essential to engage and learn science meaningfully

NGSS – Overview

The NGSS have three main components

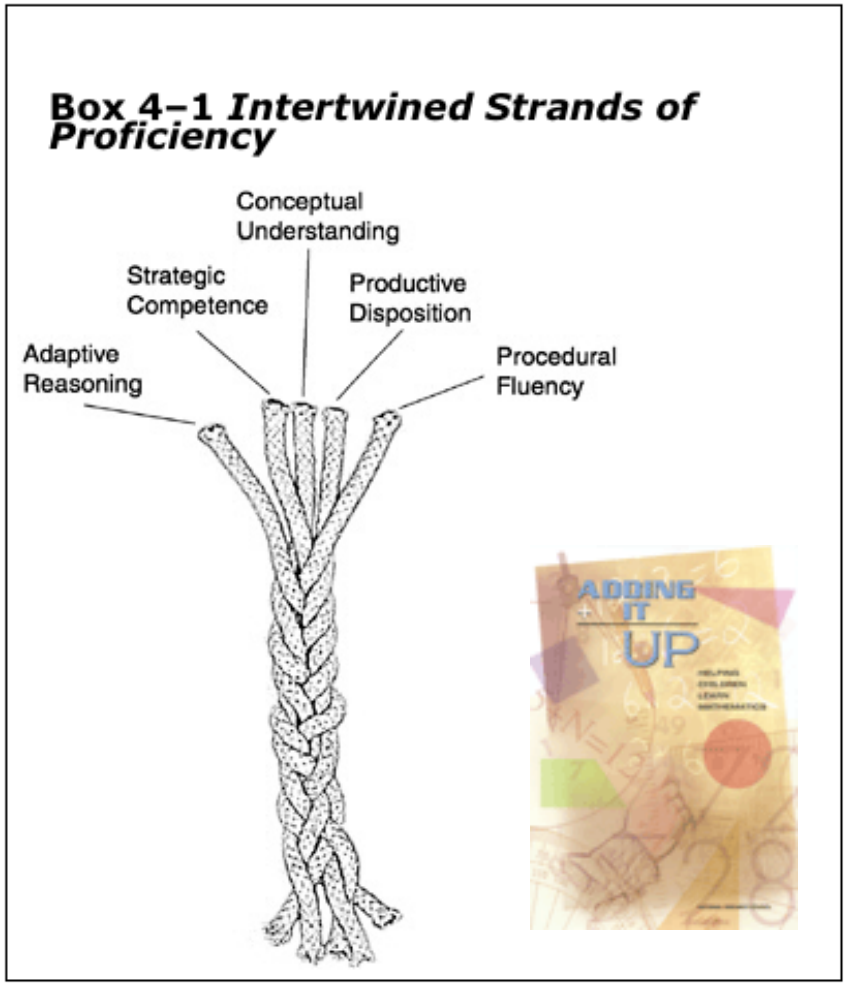
1. Disciplinary Content Ideas (DCIs)
2. Scientific and Engineering Practices
3. Crosscutting Concepts

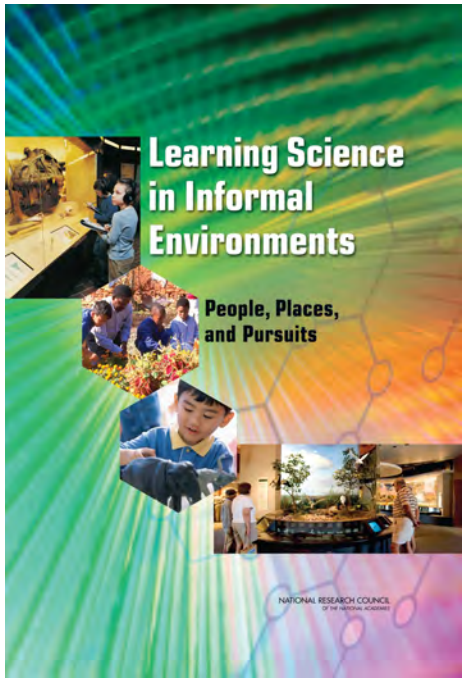
The 3 dimensions are incorporated into *every standards statement.*

- Emphasis on depth of thought over breadth of content
- Engineering is more prominent and science is updated
- Progression of learning revised throughout multiple years

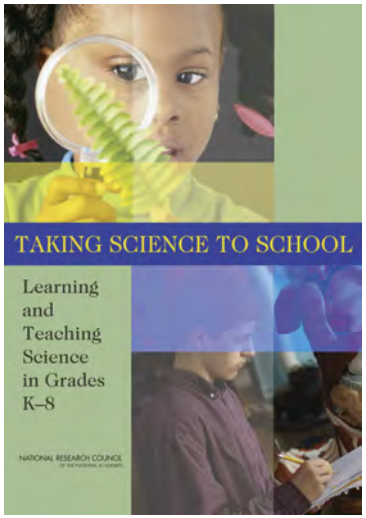
Not Separate Goals

intertwined strands during effective learning and teaching



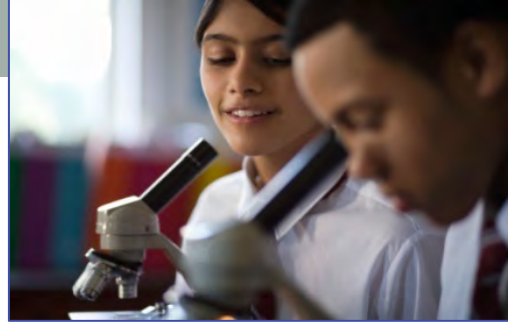


6 strands – incorporates affective domain



4 strands

DIMENSION 2
Crosscutting Concepts



- Patterns – organization and classification
- Cause and effect – mechanism and explanation
- Scale, proportion, and quantity - recognize what is relevant
- Systems and system models – define the system under study
- Energy and matter - flows, cycles and conservation
- Structure and function – determine properties of things
- Stability and change – determine rate of change or evolution

DIMENSION 3
Disciplinary Core Ideas

- DISCIPLINARY SIGNIFICANCE

  Has broad importance across multiple science or engineering disciplines, a key organizing concept of a single discipline

- EXPLANATORY POWER

  Can be used to explain a host of phenomena

- GENERATIVE

  Provides a key tool for understanding or investigating complex ideas and solving problems

- RELEVANT TO PEOPLES' LIVES

  Relates to the interests and life experiences of students, connected to societal or personal concerns

- USABLE FROM K TO 12

  Is teachable and learnable over multiple grades at increasing levels of depth and sophistication

Disciplinary Core Idea

ENGINEERING, TECHNOLOGY, & APPLICATIONS OF SCIENCE

- ETS1 ENGINEERING DESIGN
  How do engineering solve problems?
- ETS2 LINKS AMONG ENGINEERING, TECHNOLOGY, SCIENCE AND SOCIETY
  How are engineering, technology, science, and society interconnected?

A Framework for K-12 Science Education

Life Sciences

LS 1: From molecules to organisms: Structures and processes

LS 2: Ecosystems: Interactions, energy, and dynamics

LS 3: Heredity: Inheritance and variation of traits

LS 4: Biological evolution: Unity and diversity

Big Ideas in AP Biology

Big Idea 1: The process of evolution drives the diversity and unity of life.

Big Idea 2: Biological systems utilize energy and molecular building blocks to grow, reproduce, and maintain homeostasis.

Big Idea 3: Living systems retrieve, transmit, and respond to information essential to life processes.

Big Idea 4: Biological systems interact, and these interactions possess complex properties.

Source: College Board http://apcentral.collegeboard.com/apc/public/repository/draft_revised_ap_biology_curriculum.pdf

Vision and Change Core Concepts

1.0 Evolution

2.0 Structure and function

3.0 Information flow, exchange, and storage

4.0 Pathways and transformations of energy

5.0 Systems

DIMENSION 1
Scientific 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 and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Science Practices for AP Biology

1.0 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

2.0 The student can use mathematics appropriately.

3.0 The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

4.0 Student can plan and implement data collection strategies in relation to a particular scientific question.

5.0 The student can perform data analysis and evaluation of evidence.

6.0 The student can work with scientific explanations and theories.

7.0 The student can connect and relate knowledge across various scales, concepts, and representations in and across domains.

Source: College Board

Vision and Change: Core Disciplinary Practices

1.0 Ability to apply the process of science

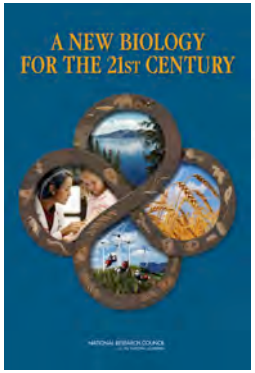
2.0 Ability to use quantitative reasoning

3.0 Ability to use modeling and simulations

4.0 Ability to tap into the interdisciplinary nature of science

5.0 Ability to communicate and collaborate with other disciplines

6.0 Ability to understand the relationship between science and society



ENVIRONMENT

FOOD

HEALTH

ENERGY

Biology-Based Solutions to Societal Problems

NEW BIOLOGY

Deeper Understanding of Biological Systems:
- *Organizing Principles*
- *Predict/Analyze/Modulate*

Scientific Integration

Physical & Chemical Sciences

Computer Science

Biology

Engineering

Science Education

Mathematics

Genomics education

http://www.nap.edu/catalog.php?record_id=12764

Shifts in Science Teaching and Learning

- Teaching and learning is organized around limited number of core ideas
- Core ideas are revisited in increasing depth across years by engaging in the science/engineering practices and the discussions by which ideas are developed and refined
- Focus on the connections between ideas
- Performance expectations should bring together core ideas, cross cutting concepts, and the scientific and engineering practices.

Be an Agent of Change

1. **Cross the boundaries**
   - IHEs and K-12 folks need to talk to each other
   - Be familiar with the constraints in each other's worlds
   - Be respectful of each other's strengths and differences

Be an Agent of Change

2. **Be ready for students who**
   - Understand cross cutting themes
   - Can use the practices of science
   - Are able to make connections
   - Are able to develop and apply scientific ideas to make sense of phenomena

Be an Agent of Change

3. **Think differently about undergraduate biology**

- Teaching needs to revisit core ideas in increasing depth and sophistication across years.
- Focus of teaching needs to be on developing ideas and building connections
- Teaching needs to involve learners in practices that develop, use, and refine the scientific ideas
- Careful construction of a storyline – helping learners build sophisticated ideas from simpler explanations, using evidence
- Connections between scientific disciplines, using powerful ideas (nature of matter, energy) across life, physical and environmental sciences