EMBRACING THE FUTURE OF K-16 STEM EDUCATION

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Informal PUS to PES

- Committee on Public Understanding of Science 1985 (British Association Advancement Science & Royal Society)– A Lesson Learned! "Deficit Model" John Ziman "Present the facts"
  - Mad Cow Disease, GM Foods, Cell Phone Masts, MMR Jabs

- ***Walter Bodmer*** *Public Understanding of Science: The BA, the Royal Society and COPUS*
  - ***Notes Rec. R. Soc.*** **2010 64**, S151-S161

- Publics Engagement in Science
  - Forums – Museum of Science Boston, USA
  - Dramas – Science Museum, London, England
  - Festivals/Events – Cambridge Science Festival, MIT, Boston, New York City Science Festival
  - STS Exhibits/Events - Antenna Science Museum – London (MMR Jabs & Autism)

Understanding to Engagement

- NRC (2012) A Framework for K-12 Science Education
- NRC (2012) Monitoring Progress Toward Successful K-12 STEM Education
- NRC (2012) Education for Life & Work
- NRC (2012) Disciplinary Based Education Research

K-16 PUS TO PES

- Public Understanding of Science
  - Transmission Model
  - Lecturing as Transmission
  - Confirmation Lab Activities
  - What we Know
- Publics Engagement in Science
  - NAEP AP – Using knowledge
  - Practices Model
  - Teaching Sequences & Immersion Units – PES
  - Learning Trajectories & Progressions – PES
  - How we Know; Why we Believe

Framework 3 Dimensions

- Practices
- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

- Crosscutting Concepts
- Patterns
- Cause & Effect
- Scale, Proportion & Quantity
- Systems and Systems Models
- Energy and Matter in Systems
- Form & Function
- Stability

- Core Ideas
  - Physical Sciences
  - Life Sciences
  - Earth/Space Sciences

Monitoring STEM Indicators

- Number of, and enrollment in, different types of STEM schools and programs in each district
- *Time allocated to teach science in grades K-5*
- Science-related learning opportunities in elementary schools
- *Adoption of instructional materials in grades K-12 that embody Common Core State Standards in mathematics and A Framework for K-12 Science Education*
- *Classroom coverage of content and practices in Common Core State Standards in mathematics and A Framework for K-12 Science Education*
- *Teachers' science and mathematics content knowledge for teaching*
- Teachers' participation in STEM-specific professional development activities
- Instructional leaders' participation in professional development on creating conditions that support STEM learning
- *Inclusion of science in federal and state accountability systems*
- Inclusion of science in major federal K-12 education initiatives
- State and district staff dedicated to supporting science instruction
- State's use of assessments that measure the core concepts and practices of science and mathematics disciplines
- State and federal expenditures dedicated to improving the K-12 STEM teaching workforce
- *Federal funding for the research identified in Successful K-12 STEM Education.*

Life & Work Competencies for Deep Learning

- Cognitive competencies - reasoning and memory (e.g. critical thinking, information literacy, reasoning and argumentation, innovation).
- Intrapersonal competencies - managing one’s behavior and emotions (e.g. flexibility, initiative, appreciation for diversity, metacognition).
- Interpersonal competencies - expressing one’s ideas and interpreting and responding to others (e.g. communication skills, collaboration, responsibility, conflict resolution).

Discipline-Based Education Research

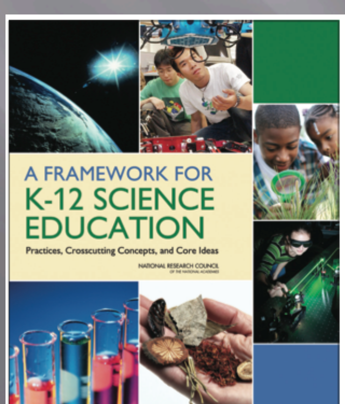
- DBER - teaching and learning priorities: worldview, knowledge, and practices.
- Three research foci:
- 1) understanding how people learn the concepts, practices, and ways of thinking of science and engineering within each discipline,
- 2) identifying and measuring instructional approaches that support student's understanding of the concepts and practices, and
- 3) identifying approaches that are more inclusive for all students.

A K-16 Problem: A Systems Approach

- NGSS & CCS K-12 learners moving into colleges and universities – reception problem.
- Faculty, graduates and students moving into NGSS & CCS K-12 systems – transmission problem

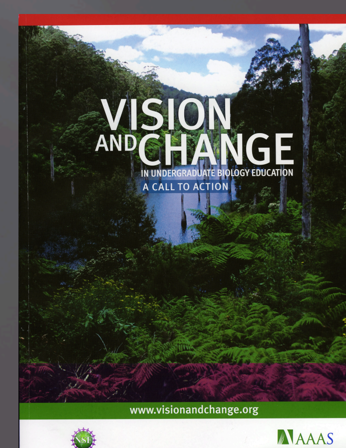
Opportunities for Better K-16 Alignment

- 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)



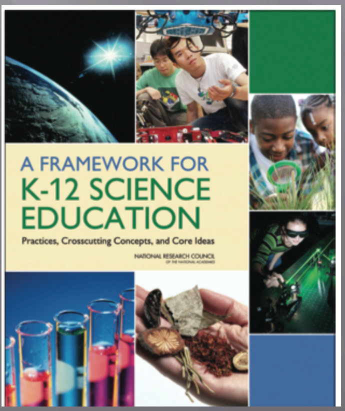
NEXT GENERATION SCIENCE STANDARDS
For States, By States

CollegeBoard inspiring minds
AP® BIOLOGY



Dimension 3: Core Ideas

- 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



NEXT GENERATION SCIENCE STANDARDS
For States, By States

Big Ideas in AP Biology

Source: College Board

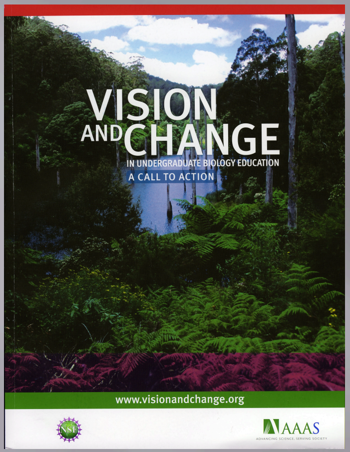
Big Idea 1: The process of evolution drives the diversity and unity of life.

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.

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



Vision and Change Core Concepts

- Evolution: the diversity of life evolved over time by processes of mutation, selection, and genetic change.
- Struture and Function: Basic units of structure define the function of all living things.
- Information Flow, Exchange, and Storage: the growth and behavior of organisms are activated through the expression of genetic information in context.
- Pathways and Transformations of Energy and Matter: Biological systems grow and change by processes based upon chemical transformation pathways and are governed by the laws of thermodynamics.
- Systems: Living systems are interconnected and interacting.

DIMENSION 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

Science practices for AP Biology (similar for *Vision and Change*)

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.

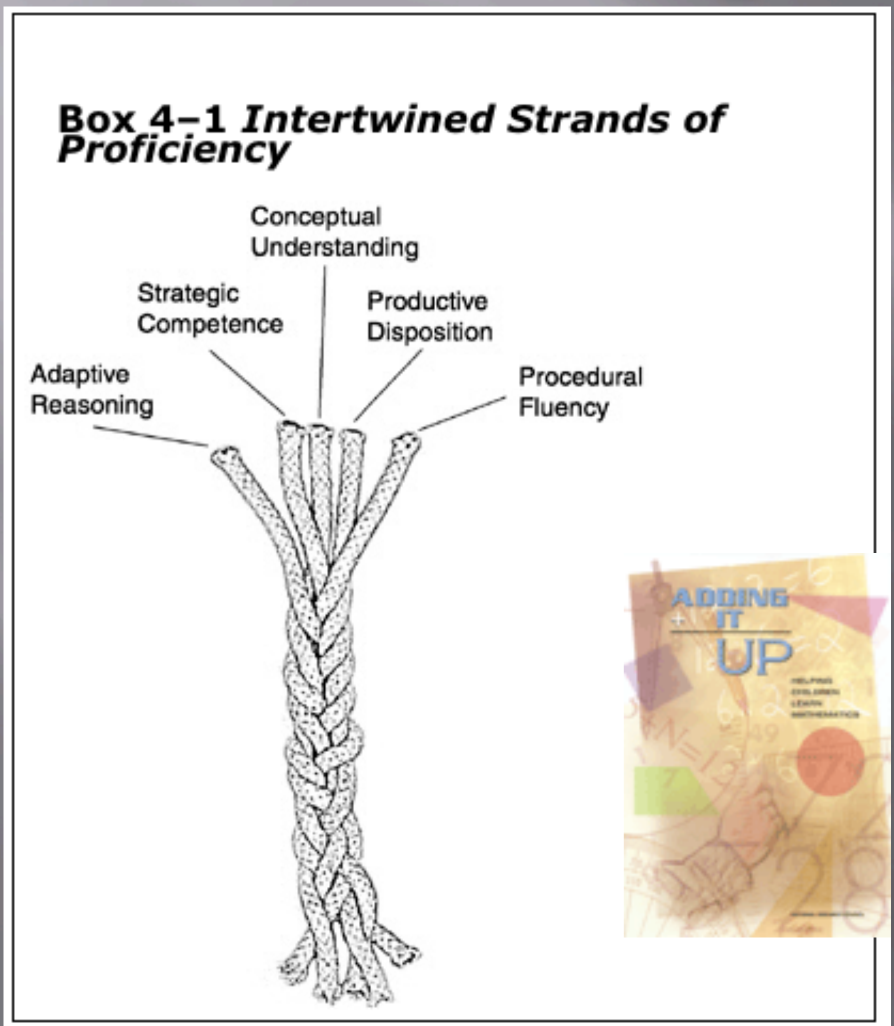
5.0 The student can perform data analysis and evaluation of evidence.

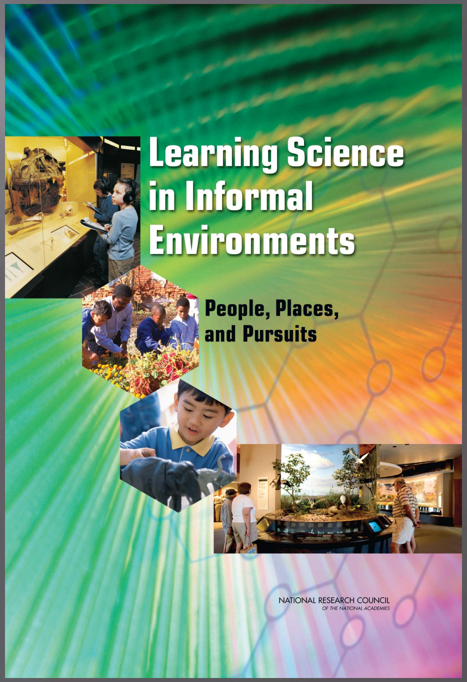
6.0 The student can work with scientific explanations and theories.

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

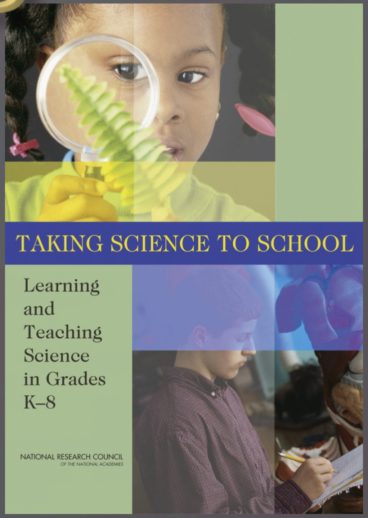
Source: College Board

Not separate goals: intertwined strands during effective learning and teaching





6 strands – incorporates affective domain



4 strands

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

And there is an emerging undergraduate STEM education research community - DBER Goals

- Understand how people learn the concepts, practices, and ways of thinking of science and engineering.
- Understand the nature and development of expertise in a discipline.
- Help to identify and measure appropriate learning objectives and instructional approaches that advance students toward those objectives.
- Contribute to the knowledge base in a way that can guide the translation of DBER findings to classroom practice.
- Identify approaches to make STEM education broad and inclusive.