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

A Presentation to the MSP Community

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Advisers to the Nation on Science, Engineering, and Medicine

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Science for All Students

- Science, engineering and technology are cultural achievements and a shared good of humankind
- Science, engineering and technology permeate modern life
- Understanding of science and engineering is critical to participation in public policy and good decision-making
- More and more careers require knowledge of science

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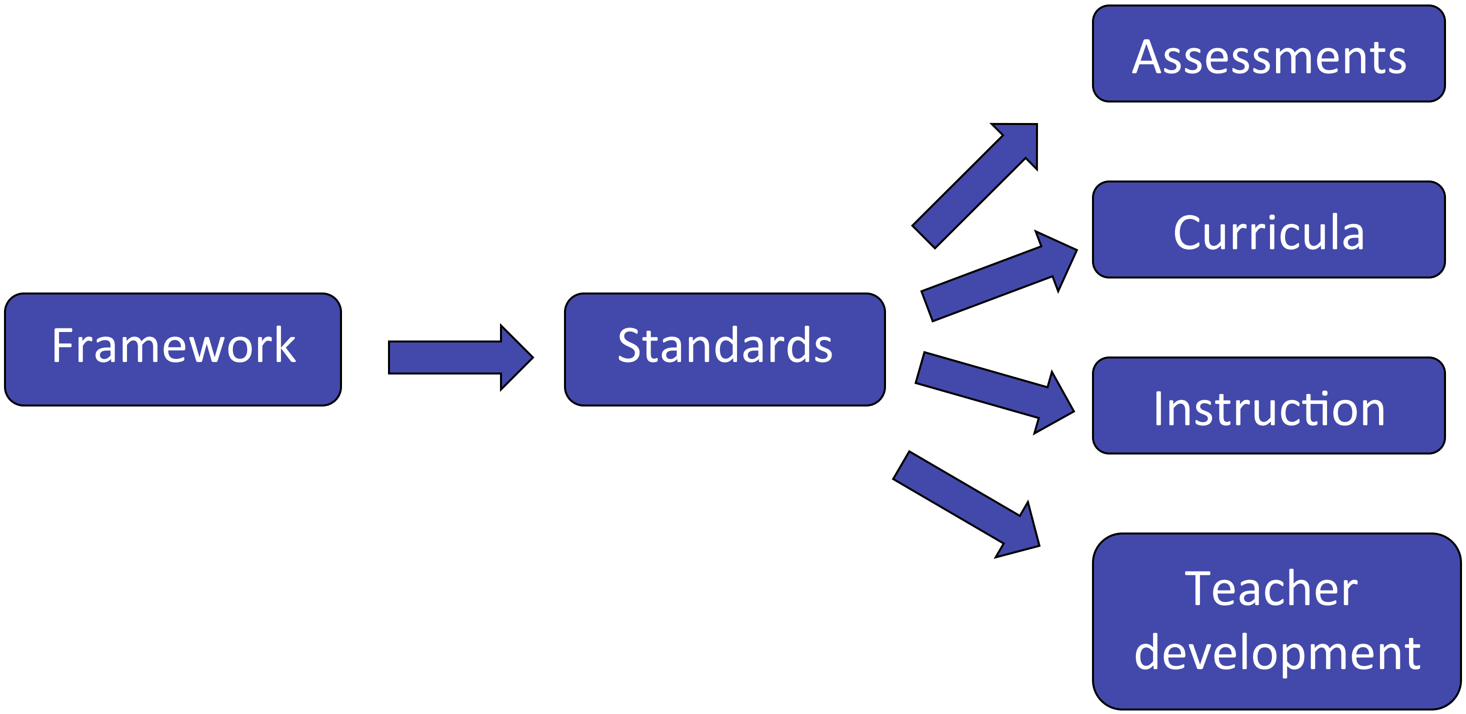
Why is a K-12 science framework needed?

- Improved knowledge about learning and teaching science
- Opportunities to improve current teaching practice
- Advances in scientific knowledge


Framework
Standards
Assessments
Curricula
Instruction
Teacher development

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Goals of the Framework

- Coherent investigation of core ideas across multiple years of school
- More seamless blending of practices with core ideas and crosscutting concepts

Question & Answer

Learning Develops Over Time

- More expert knowledge is structured around conceptual frameworks
  - Guide how they solve problems, make observations, and organized and structure new information
- Learning unfolds overtime
- Learning difficult ideas takes time and often come together as students work on a task that forces them to synthesize ideas
- Learning is facilitated when new and existing knowledge is structured around the core ideas
- Developing understanding is dependent on instruction

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Three Dimensions

- Scientific and engineering practices
- Crosscutting concepts
- Disciplinary core ideas

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Scientific and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument
8. Obtaining, evaluating, and communicating information

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Crosscutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

A core idea for K-12 science instruction is a scientific idea that:

- Has broad importance across multiple science or engineering disciplines or is a key organizing concept of a single discipline
- Provides a key tool for understanding or investigating more complex ideas and solving problems
- Relates to the interests and life experiences of students or can be connected to societal or personal concerns that require scientific or technical knowledge
- Is teachable and learnable over multiple grades at increasing levels of depth and sophistication

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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

Disciplinary Core Ideas: 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

Disciplinary Core Ideas: Earth and Space Sciences

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

Disciplinary Core Ideas:
Engineering, Technology and Applications of Science

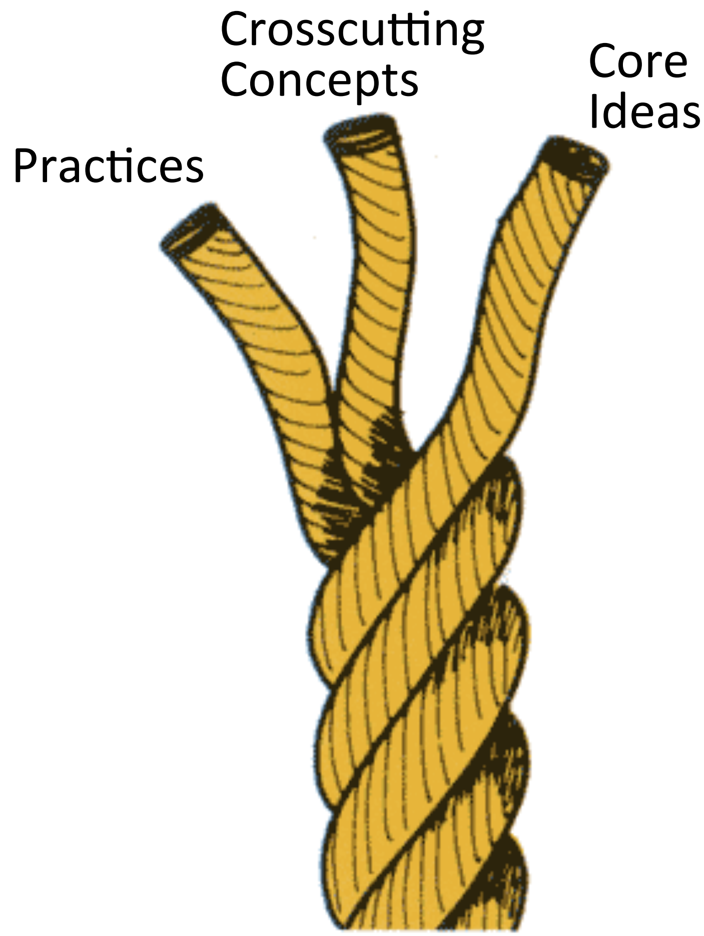
- ETS1 Engineering design
- ETS2 Links among engineering, technology, science and society

Integrating the Dimensions

- To facilitate students' learning the dimensions must be woven together in standards, assessments, curriculum and instruction.
- Students should explore a core idea by engaging in the practices and making connections to crosscutting concepts.

Implications

- Not separate treatment of "content" and "inquiry" ***(No "Chapter 1")***
- Curriculum and instruction needs to do more than present and assess scientific ideas – they need to involve learners in using scientific practices to develop and apply the scientific ideas.



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Development of Core Ideas: Typical Curriculum & Instruction

	Physics	Chem	Earth Science	Life Science
6th			Energy	
7th	Energy			
8th		Energy		Energy
Student Understanding	**Little understanding**			

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Development of Core Ideas, Crosscutting Concepts and Practices: Progression Over Time

	Physics	Chem	Earth Science	Life Science
6th	Energy& explanation	Energy & Explanation		Energy&explanation
7th				
8th		Energy & Explanation		
Student Understanding	Integrated, Useful & Meaningful			

Implementation: Aligning Components of the System

- Standards
- Curriculum and instructional materials
- Assessment
- Pre-service preparation of teachers
- Professional development for in-service teachers

Diversity and Equity

- Equalizing opportunities to learn
- Inclusive science instruction
- Making diversity visible
- Value multiple modes of expression

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Summary

Less

- Focus on eradicating misconceptions
- Inquiry as activity
- Science as just a body of knowledge
- Only older children able to learn science
- Focus on ambitious learning goals for select students

More

- Build on prior knowledge
- Practices which embody inquiry as how one does and learns science
- Science is content learned through practices
- Young children are quite capable and interested
- Focus on ambitious learning goals for all students

Question & Answer

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Guidance for Standards Developers

- Set rigorous learning goals for all students
- Emphasize all 3 dimensions
- Include performance expectations
- Be organized as progressions that support learning over multiple grades
- Attend to issues of diversity and equity

Key Areas of Research

- Learning progressions
- Scientific and engineering practices
- Curricular and instructional materials
- Assessment
- Supporting teachers' learning
- Evaluation of the impact of standards

Next Steps

- Outreach and dissemination of the framework by the NRC
- State-led development of Next Generation Science Standards, coordinated by Achieve
- Progress on critical steps toward implementation

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- NRC Staff
- Expert reviewers

Free PDF version of *A Framework for K-12 Science Education* is available at:

http://www.nap.edu/catalog.php?record_id=13165

Updates on Science Standards:

http://nas.edu/BOSE

http://achieve.org/next-generation-science-standards

Question & Answer