

# Analytical Thinking in New Science and Engineering Standards

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# New expectations in science standards

- Currently:
  - Strong conceptual (content) focus
  - Inquiry skills separate
  - Design process presented as content
- Upcoming revisions:
  - Inclusion of science and engineering practices *with* content to promote *analytical thinking*

# What does it mean to be “college ready” in science?

Basic elements include:

- General knowledge and skills in a range of science subjects
- Scientific and technological literacy
- Interest and ability to think analytically

# Sci & Tech/Eng are closely related

“Exponential advances in knowledge, instrumentation, communication, and computational capabilities have created mind-boggling possibilities, and students are cutting across traditional disciplinary boundaries in unprecedented ways. Indeed, the distinction between science and engineering in some domains has been blurred to extinction”

(Charles Vest, 2006)

# What does college readiness look like?

- In revision of state science framework:
  - Breadth of exposure
    - General knowledge and skills in a range of science subjects
  - Depth of experience
    - Opportunities for in-depth learning, projects, laboratories, designs, field work, etc.
    - Advanced study: upper-level science options
    - Capstone projects
- HS Courses and Pathways:
  - Many course options
  - Many course pathways



# Inclusion of Engineering beyond MA

- National Research Council (NRC) *Conceptual Framework for New Science Standards*
  - NRC draft includes engineering & technology as strand equivalent to other sciences
  - NRC draft incorporates design practices together with inquiry practices
- Achieve, Inc., to facilitate process of writing standards based on the NRC document

# Thinking Analytically: Common Practices

<b>Scientific Inquiry</b>	<b>Engineering Design</b>
Formulate a question	Define a problem
Research how others have answered it	Research how others have solved it
Articulate hypotheses that may explain a phenomenon, and fit conditions and limitations	Design solutions that may solve a problem, and fit design criteria and constraints
Design and conduct tests of experiments or models	Design and conduct tests of prototypes or models
Analyze data	Analyze data
Model natural processes and systems	Model designed processes, systems and products
Modify hypothesis and experimental procedure based on results	Redesign solution and prototype based on results
Articulate conclusions using evidence	Finalize design using evidence
Write and present technical information	Write and present technical information

# Integrating practices with content

- Include inquiry and design practices (STE skills)
  - For example, predicting, investigating, designing, or modeling
- Verbs in standards will reflect those skills and be strategically integrated with content
- Will include full list of STE skills and a statement emphasizing that students should continue to engage in full inquiry and design processes

# Integrating STE practices (potential samples)

- Integrate skills of *testing and analyzing data* with concept of *optimization*:
  - “Design tests and use resulting data to determine if a design has been optimized.”
- Integrate skill of *modeling* with concept of *energy transfer*:
  - “Develop a model demonstrating how energy can be transferred from one system to another.”



# HEI STEM programs changing

- Engineering and science much more closely associated
- Much more authentic & project-based learning
- Students engaged earlier in engineering (more and more often at the freshman level)
- Recognition that students need to “experience” engineering and science in order to persist
- More reliant on a pre-college pipeline of students interested in engineering and science

## A comprehensive STEM education and pipeline

“Exposure to engineering may be most profound in grades 3 through 8. In these formative years, hands-on engineering experiences, conveyed through inquiry-based, design-oriented instructional methodologies, can support the learning of standards-based science and mathematics while stimulating student learning and making engineering come alive.”

(Jacquelyn Sullivan, 2006)

# Questions and Discussion

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