Ready, Set, STEM!

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Overview

• What is STEM?
• Why engage young children in STEM?
• How can I bring STEM into my classroom?
What is STEM?
Science
Technology
Engineering
Mathematics
Science

Common assumptions: Only very smart people can be successful in science. When you are good at science you know a lot of facts. Scientists often work long hours alone in a lab.

In reality: Science can be accessible to everyone. Science is a social activity and it is very creative.

Doing science involves:

- Building theories and models
- Collecting and analyzing data from observations or experiments
- Constructing arguments
- Using specialized ways of talking, writing and representing phenomena
Mathematics

Common assumptions:

– Mathematics is about learning to compute (+, -, x, ÷)
– Math is about “following rules” to guarantee correct answers.

In reality:

• Mathematics is about problem solving. It is a constantly evolving field that involves finding systematic patterns and continuing invention.
Technology and Engineering

Common assumption: Honestly, I’m not sure what “technology and engineering” mean in STEM. Maybe technology is using computers.

**Engineering** -- a systematic practice of design to achieve solutions to particular human problems

**Technology** -- all types of human-made systems and processes. Technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants.
Elements of “Doing STEM”

• Understanding concepts (knowledge)
• Using practices or strategies effectively
• Reasoning/reflecting (metacognition)
• Productive engagement (enjoyment, persistence, self-regulation)
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 from evidence
8. Obtaining, evaluating, and communicating information
Mathematical Practices

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning
Science and Engineering

S1. Asking questions and defining problems
S3. Planning and carrying out investigations
S4. Analyzing and interpreting data
S8. Obtaining, evaluating, and communicating information

S2. Developing and using models
S5. Using mathematics and computational thinking
S6. Developing explanations and designing solutions
S7. Engaging in argument from evidence
S8. Obtaining, evaluating, and communicating information

Mathematics

M1. Make sense of problems and persevere in solving them
M2. Reason abstractly and quantitatively
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Summary

• Memorizing facts or algorithms does not lead to proficiency in STEM
• Learning STEM subjects involves using knowledge not just acquiring it
• Children must DO science, engineering and mathematics in order to learn them
Why engage young children in STEM?
(Three part answer)
Part 1: STEM opens opportunities for work and life

- We live in an increasingly technical world
- More and more careers require STEM knowledge and skills
- Learning STEM helps children develop thinking, reasoning and problem solving skills – ALSO literacy, language and social skills

***BUT – we have an opportunity gap***
Fourth Grade NAEP Science (2015)

- White
- Black
- Hispanic
- Asian/Pacific Islander
- American Indian/Alaska Native
Fourth Grade NAEP Science (2015)

Free and reduced meals

No FARMS

2009  2015
Opportunity gaps start in kindergarten

- White students
- Asian
- Black
- Hispanic

Subjects:
- Science
- Mathematics
- Reading
Part 2: They are capable and show early STEM related strengths
Children’s Competence

• Children are surprisingly competent. Even young children have substantial knowledge of the natural world.

• They are *not* concrete and simplistic thinkers and can use a wide range of reasoning processes that form the underpinnings of scientific thinking.
Children’s Knowledge of the Natural World

• Some areas of knowledge may provide more robust foundations to build on than others.
  – Physical mechanics
  – Biology
  – Matter and substance
  – Naïve psychology (theory of mind)

• These appear very early and appear to have some universal characteristics across cultures throughout the world.

• Earth science and cosmology – not early and universal
Research with Infants
Children’s Reasoning

- Young children can think in sophisticated, abstract ways. For example, they:
  - Distinguish living from non-living
  - Identify causes of events
  - Know that people’s beliefs are not an exact representation of the external world
Counting

- One-to-one correspondence
- Stable order
- Cardinal
- Abstraction
- Order irrelevance
Reasoning from Prior Understanding

• Understanding is constructed on a foundation of existing understanding and experiences.

• Prior understanding can support further learning

• Prior understanding can also lead to the development of conceptions that act as barriers to learning
Prior understanding and “misconceptions” in science

- Children’s understandings of the world sometimes diverge from accepted scientific explanations. These are often described as “misconceptions” to be overcome.

- But students’ prior knowledge also offers leverage points that can be built on to advance students’ science learning.

- Emphasis on eradicating misconceptions can cause us to overlook the productive knowledge they bring.
Constraints on Children’s Learning

• Conceptual knowledge – children are universal novices

• Nature of the task

• Awareness of their own thinking (metacognition) – their knowledge is often implicit

• Self-regulation (executive function)
Part 3: Children Love it!
How can I bring STEM into my classroom?
Three-Dimensional Learning in Science and Engineering
### Three Dimensions

#### 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
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#### Crosscutting Concepts
- Patterns
- Cause and effect
- Scale proportion and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change

#### Disciplinary Core Ideas
- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Engineering, Technology, and the Applications of Science
Real-world Phenomena

• Anchor learning in phenomena children can experience first-hand that will spark interesting questions

Examples:
- Observing changes in the weather
- Documenting plant growth
- Experimenting with balls and toy cars rolling down ramps
- Playing with shadows
- Exploring different materials and their properties (wood, metal, plastic, fabric etc.)
Focus on the Practices

• Provide opportunities for children to engage in the practices at THEIR level

  Plan an investigation to answer a question (with help)

  Identify a simple problem to solve

  Ask questions based on observations

  Record information (data)

  Create a simple model (a picture, diagram, or 3-D representation)

  Explain observations and how they might help answer a question
Collaboration and Discussion

• Encourage children to work together
• Help them explain their thinking to each other and help them express their ideas and questions verbally
• Discussions in science help students reflect on their understanding, critique evidence and generate new questions or designs
• “Math talk” can clarify students’ prior understanding, clarify their strategies, and help them “debug” their wrong answers
### Talk Moves for Teachers

<table>
<thead>
<tr>
<th>Teacher Move</th>
<th>Example</th>
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<tbody>
<tr>
<td>Re-voicing</td>
<td>“So let me see if I’ve got your thinking right. You’re saying ________?” (with space for student to follow up)</td>
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<tr>
<td>Asking students to restate someone else’s reasoning</td>
<td>“Can you repeat what he just said in your own words?”</td>
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<tr>
<td>Asking students to apply their own reasoning to someone else’s reasoning</td>
<td>“Do you agree or disagree and why?”</td>
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<td>Prompting students for further participation</td>
<td>“Would someone like to add on?”</td>
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<tr>
<td>Asking students to explain their reasoning?</td>
<td>“Why do you think that?”</td>
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<td></td>
<td>“What evidence helped you arrive at that answer?”</td>
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<tr>
<td>Using wait time</td>
<td>“Take your time…. We’ll wait.”</td>
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Designing STEM Experiences

• Think about the trajectory of learning you want to see
• Plan links among the STEM subjects and to literacy
• Use a variety of structures – whole group, small group, individual, exploration and free play
• Build in explicit support to help students reflect on what they are learning
Create a STEM Learning Community in the Classroom

- Learner-centered with intentional support
- Allow time for discussion and reflection
- Avoid emphasis on right answers