Engineering for STEM Literacy in Support of Workforce Readiness

Presented by: Wendy Binder, NSTA

And Teacher Fellows from the

Promoting excellence and innovation in science teaching and learning for all
Together we will:

Experience an authentic need to integrate science and engineering ideas to solve a problem, making the interdependence of science and engineering explicit.

Explore an example of a lesson that integrates engineering and provides access for all students grounded in sensemaking; and

Discuss real-world engineering and the integration of workforce skills that support students to be career ready.
Welcome

Round One:

What is your “Why” for teaching STEM/Science/Engineering?
### Job Outlook 2021 – National Association of Colleges and Employers (NACE)-Top Ten Attributes employers are Seeking

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>% OF RESPONDENTS</th>
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<tbody>
<tr>
<td>Problem-solving skills</td>
<td>91.2%</td>
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<td>Ability to work in a team</td>
<td>86.3%</td>
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<tr>
<td>Strong work ethic</td>
<td>80.4%</td>
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<tr>
<td>Analytical/quantitative skills</td>
<td>79.4%</td>
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<td>Communication skills (written)</td>
<td>77.5%</td>
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<tr>
<td>Leadership</td>
<td>72.5%</td>
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<tr>
<td>Communication skills (verbal)</td>
<td>69.6%</td>
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<tr>
<td>Initiative</td>
<td>69.6%</td>
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<tr>
<td>Detail-oriented</td>
<td>67.6%</td>
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<tr>
<td>Technical skills</td>
<td>65.7%</td>
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Common Employability Skills

PERSONAL SKILLS
- Integrity
- Initiative
- Dependability & Reliability
- Adaptability
- Professionalism

PEOPLE SKILLS
- Teamwork
- Communication
- Respect

APPLIED KNOWLEDGE
- Reading
- Writing
- Mathematics
- Science
- Technology
- Critical Thinking

WORKPLACE SKILLS
- Planning & Organizing
- Problem Solving
- Decision Making
- Business Fundamentals
- Customer Focus
- Working with Tools & Technology
Your Students

Alone Zone:

What should be your students “why”?
All Standards, All Students: *Flip*

**Traditional**
- Scientists & Teachers

**Contemporary**
- Students as Scientists and Engineers

**Future**
- Students as ??

- Knowledge of Science Disciplines
- Making Sense of Phenomena and Designing Solutions to Problems

- Some Students
- All Students
- All Students
Round Two:

What is one way you are trying to create a STEM centered classroom? What do you think makes a high quality STEM Lesson/unit?
NGSS has Raised the Status of Engineering in the Science/Math Classroom

The NGSS [and other state-standards based on the Framework] explicitly includes practices and core disciplinary ideas from engineering alongside those for science, raising the expectation that science teachers will be expected to teach science and engineering in an integrated fashion.
Science and Engineering

• Engineering is the branch of science and technology that’s involved with the design, building and use of engines, machines, and structures.

• Scientists seek to describe and understand the natural world. Engineers consider various constraints in order to design solutions to problems that better the lives of humans, animals and/or the environment.
Science Instructional Shifts

Shift 1. **The Why (ENTHUSIASM)**
Explain phenomena and design solutions to problems

Shift 2. **The How (SKILLS)**
*Doing science* (three-dimensional learning)

Shift 3. **The Why (ENTHUSIASM)**
Coherent learning progressions over time

**The What (KNOWLEDGE)**
## K-12 Engineering Design - Appendix I

<table>
<thead>
<tr>
<th>Topic</th>
<th>Primary School (Grades K-2)</th>
<th>Elementary School (Grades 3-5)</th>
<th>Middle School (Grades 6-8)</th>
<th>High School (Grades 9-12)</th>
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<tbody>
<tr>
<td><strong>Engineering, Technology, and the Application of Science</strong></td>
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<tr>
<td>ETS1: Engineering Design</td>
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<tr>
<td>ETS1.A: Defining and Delineating an Engineering Problem</td>
<td>A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1-1) (secondary to K-PS2-2)</td>
<td>Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) (secondary to 4-PS3-4)</td>
<td>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (MS-ETS1-1) (secondary to MS-PS3-3)</td>
<td>Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) (secondary to HS-PS2-3) (secondary to HS-PS3-3)</td>
</tr>
<tr>
<td>ETS1.B: Developing Possible Solutions</td>
<td>Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-1) (secondary to K-ESS3-3) (secondary to 2-LS2-2)</td>
<td>Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)</td>
<td>A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-2) (secondary to MS-PS1-6)</td>
<td>When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural, and environmental impacts. (secondary to HS-LS2-7) (secondary to HS-LS4-6) (secondary to HS-ESS3-2), secondary to HS-ESS3-4) (HS-ETS1-3)</td>
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<td></td>
<td>At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)</td>
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<td>There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) (secondary to MS-PS3-3) (secondary to MS-LS2-5)</td>
<td>Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) (secondary to HS-LS4-8)</td>
</tr>
<tr>
<td>ETS1.C: Optimizing the Design Solution</td>
<td>Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-1) (secondary to 2-ESS2-1)</td>
<td>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) (secondary to 4-PS4-5)</td>
<td>Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. (MS-ETS1-3) (secondary to MS-PS1-6)</td>
<td>Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (HSET-1-2) (secondary to HS-PS1-6) (secondary to HS-PS2-3)</td>
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Sensemaking

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Student Sensemaking

Lesson Level

• Students have a common experience with the phenomenon (no one student is at an advantage or disadvantage)

• Students connect to the phenomenon through their experience with related phenomena

• In trying to explain the phenomenon, students recognize gaps in their knowledge which leads to questions they want to answer
Engineering for Science Literacy

- Opportunities to develop and/or use targeted science and engineering ideas through engaging in science and engineering practices.
- Provide access to all students through shared classroom experiences, drawing on students’ experiences and interests, and sharing and building on ideas.
- Create authentic need to integrate science and engineering ideas to solve a problem (interdependence of science and engineering explicit).

**students-as-engineers**
How Can we Land a Payload Safely?
https://www.nsta.org/lesson-plan/how-can-we-land-payload-safely
Building a rocket is hard. But building a parachute is boggling—

*Los Angeles Times Dec. 19, 2019*
Engineering design lessons can help move all students toward science literacy:

• What are the targeted science and engineering ideas?
• How does experiencing the problem to be solved provide access to all students?
• What SEPs are students engaged in?
• Do students authentically need the science and engineering ideas to solve the problem?

How Can we Land a Payload Safely? https://www.nsta.org/lesson-plan/how-can-we-land-payload-safely
What makes phenomena *instructionally productive*?

- They make students wonder and want to ask questions - *What’s up with that?!*

- Understanding HOW or WHY the phenomena occur requires the use of science ideas

- Interesting and accessible to ALL students in your classroom (supported by *everyday* phenomena)
Engineering lessons focus on **trial and error** activities that don’t require science or engineering knowledge.

**students-at-play**

Engineering lessons require **students** to **acquire and use** elements of disciplinary core ideas (DCIs) from **physical, life, or Earth and space sciences** **together with** elements of DCIs from **engineering design** to solve problems.

**students-as-engineers**
How is what we do in the classroom in STEM compare to real-world engineers work lives?

What do we need to think about when modeling real-world engineering?
Engineering can support students as they make sense of science ideas they build

What are some integration points for an engineering design problem into a unit of instruction?
At your tables, share in what ways you have integrated engineering into your units.
When to Infuse Engineering:

- When engineering is used in the **beginning of a unit**, the need to learn more physics is driven by the need of the engineers in the classroom. Many teachers already have a collection of these activators. The challenge for teachers is to carefully choose the activity that will generate the need for specific physics concepts or to be comfortable enough to see what concepts and questions arise naturally.
When to Infuse Engineering:
As an application, engineering can be used to contextualize physics concepts during the middle of the unit. The goal here is to build a foundation for the science to drive the engineering decisions and to emphasize how that science and the mathematical models provide the data for an informed design process.
When to Infuse Engineering:
The **culminating project for a unit** can be a capstone with multiple physics concepts used in the satisfactory completion of an engineering project. Students who know that they will be transferring their physics knowledge to an engineering challenge rarely ask, "Why do I have to learn this?" This reflects how actual problems are solved when each component contributes to the function of a complex system.

This excerpt is from the NSTA Press book: *Beyond the Egg Drop*
By Arthur Eisenkraft
Three-Dimensional Learning: Sensemaking to Solve a Problem or Explain a Phenomenon

Problem or Phenomenon
What specific ideas about student sensemaking do you want to start to implement? What strategies are most important to help students explain phenomena and solve problems? (STEM Teaching Tool, #28)

Lenses on Engineering
How can engineering design be integrated into a unit and help broaden participation of all students?

Workforce Skills
What skills do you want to integrate?
What is STEM Education Trying to Achieve?

STEM education focuses on Four key STEM objectives:

- Promoting creative problem solving in real world situations through the application of engineering and technology practices;
- Developing STEM literate citizens;
- Raising awareness of the importance of being life-long learners;
- Modeling the power of a collaborative workforce.
Engineering for STEM Literacy in Support of Workforce Readiness

https://www.nsta.org/

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