Do you want to integrate engineering into your classroom?

Why integrate engineering into your classroom?

Integrating engineering into your classroom helps students to do what they do best - solve problems. As natural problem solvers, students learn how to define a problem, use the resources they have available to them, develop possible solutions, and iterate to improve and optimize their solutions. Engineering uses science, technology and math to improve upon something that already exists or invent something new. Enjoy the process as you and your community become more comfortable putting the E into STEM.

In what key ways do science and engineering differ?

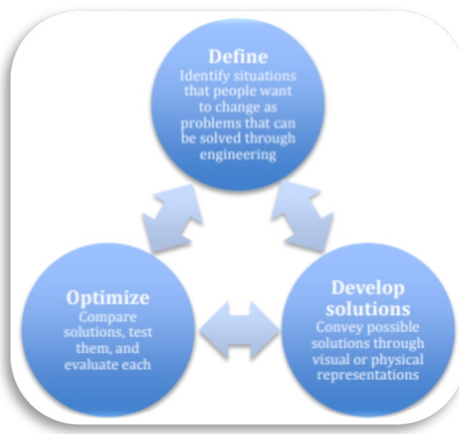
In science, students ask questions and test hypotheses about the natural world. In engineering, students find and define problems and develop solutions. Both science and engineering benefit from addressing community-based issues that engage your students.

> **RESOURCE:** Read [Bybee, R.W. 2011] for a detailed comparison of science versus engineering principles as aligned to the Next Generation Science Standards (NGSS).

What is the engineering design process?

The three main components of the engineering process are: 1) define a problem, 2) develop a solution, and 3) optimize/improve the solution. A key component is to make sure students have an opportunity to generate multiple solutions, choose one to test, and optimize/improve their solution.

It is important to note that engineering is not simply building an object by following instructions. Creativity, tinkering, idea sharing, and failure all play important roles in the engineering process. In fact, although building a physical object is often part of a solution, it is not a requirement of engineering (e.g., students can engineer a *process*).



NGSS Appendix I - Engineering Design in NGSS, Pg. 3

> **RESOURCE:** The NGSS Appendix I – Engineering Design in the NGSS is a great starting resource for NGSS-aligned engineering vocabulary, practices, and key concepts.

What vocabulary words/academic language are important in teaching engineering?

Problem definition, design criteria, constraints, optimize, iterate, trade-offs, prototype

How to embrace failure?

An important part of engineering education is learning from each trial/prototype. Students may feel disappointed when their prototype doesn't work, but engineers welcome the failure of a prototype as a chance to improve the design. It may be helpful to share real life examples of how engineers continue to optimize their solutions. For example, WD-40 is called WD-40 because it took 40 tries to get the formula optimized for sale. Penicillin was discovered as a result of an accidental failed experiment. Velcro was invented by a Swiss engineer who noticed the tiny hooks on the cockleburs that stuck to the looped fabric of his pants after hunting in the mountains. Now there exist many forms of and uses for this hook and loop fastener. As a teacher, it is important to create a classroom where taking risks is encouraged and failure is embraced as a learning opportunity. [This video – Engineering the aluminum can] discusses 60 years of engineering the aluminum can.

> **RESOURCE:** See STEM Teaching Tool #36 – Failing Forward: Managing Student Design Frustration During Engineering Projects for more tips on managing frustration and failure.

Ready to start brainstorming engineering lesson plans? Consider these questions:

- What problems are important to my students? *Ask them*
- Is there a local partner that has a problem that needs to be solved?
- What are important problems within the context of what we are already studying?
- Can my students identify their own engineering problems within a theme?
- Do you have an existing lesson that could be better aligned to the engineering process through more open-ended design solutions or giving students the opportunity to generate multiple solutions, choose one to design, then optimize their design?
- Can students engineer a piece of lab equipment?

> **RESOURCE:** See STEM Teaching Tools #31 How to launch STEM investigations that build on student and community interests and expertise and #39 How can students' everyday experiences support science learning through engineering design?

Now that you have an idea of the lesson, make sure your lesson incorporates the key aspects of the engineering design process by considering these questions.

Have students worked on defining with specificity the problem to be solved? Are there multiple possible solutions to the problem? Have students considered multiple possible solutions before choosing one to prototype and test? Does the activity include evidence of iteration of the solution(s)? Are students given the opportunity to design, test, **AND** get an opportunity to improve their design solution and test again?

Does the activity motivate culturally-responsive student problem-solving by utilizing student questions and prior experiences in the context of the student's home, neighborhood, and community? Does this activity incorporate the identities of all students in your classroom?

Example Activities

Example engineering activities in different science contexts can be found in the Activities section of the NextGen-WA STEM website, see HERE. Although the majority of these activities were written for use in preservice teacher education courses, most were written to be taught in the field in K-12 classroom contexts, and could easily modified for K-12 classroom use. Other good resources for example engineering activities include: https://www.teachengineering.org/- https://pbskids.org/designsquad/ - https://www.nasa.gov/stem/foreducators/k-12/index.html - https://tryengineering.org/teachers/ .

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