NextGen Teacher Prep Engineering Working Group: Engineering Unit Design

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Fundamental Difference Between Science and Engineering

- Science is a *reflective conversation* with Nature about *objects and phenomena* that already exist or are presumed to exist
- Engineering design is a *reflective conversation* with a *design situation* that addresses a problem or need and brings into existence something that did not previously exist
- Engineering design synthesizes and applies what has been learned in science and catalyzes the creation of new scientific knowledge

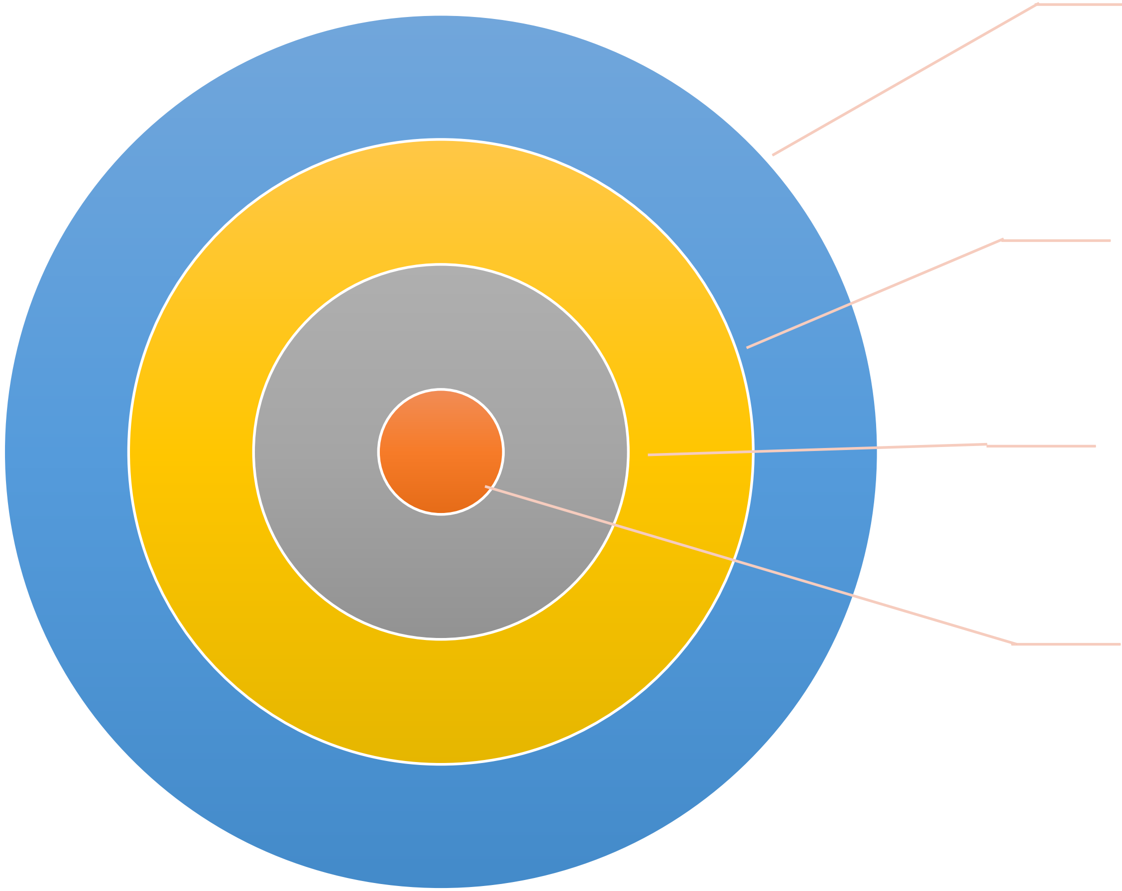
What Will Happen During This Time?

You'll Have Experiences With

An Engineering Design Process (EDP)

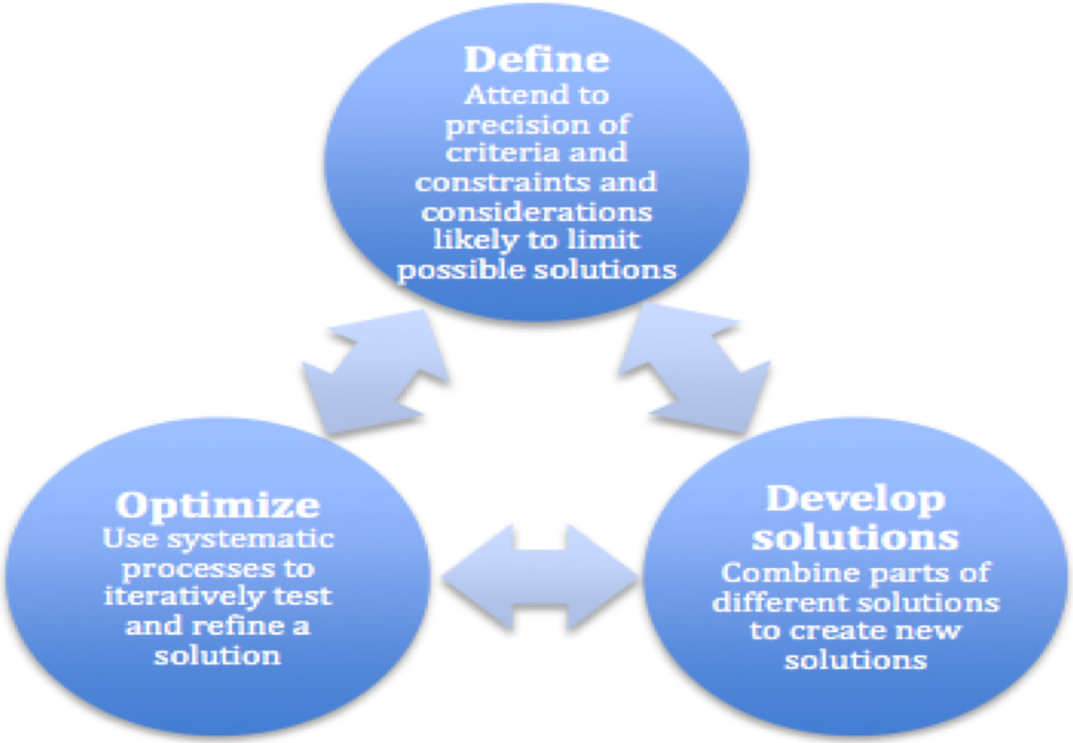
- Identify the problem or need
- Research the problem or need
- Brainstorm solutions to the problem or need
- Choose a solution to prototype
- Construct a prototype
- Test and evaluate the solution
- Communicate the solution
- Redesign

Our Shared Objectives Around an Engineering Design Process (EDP)

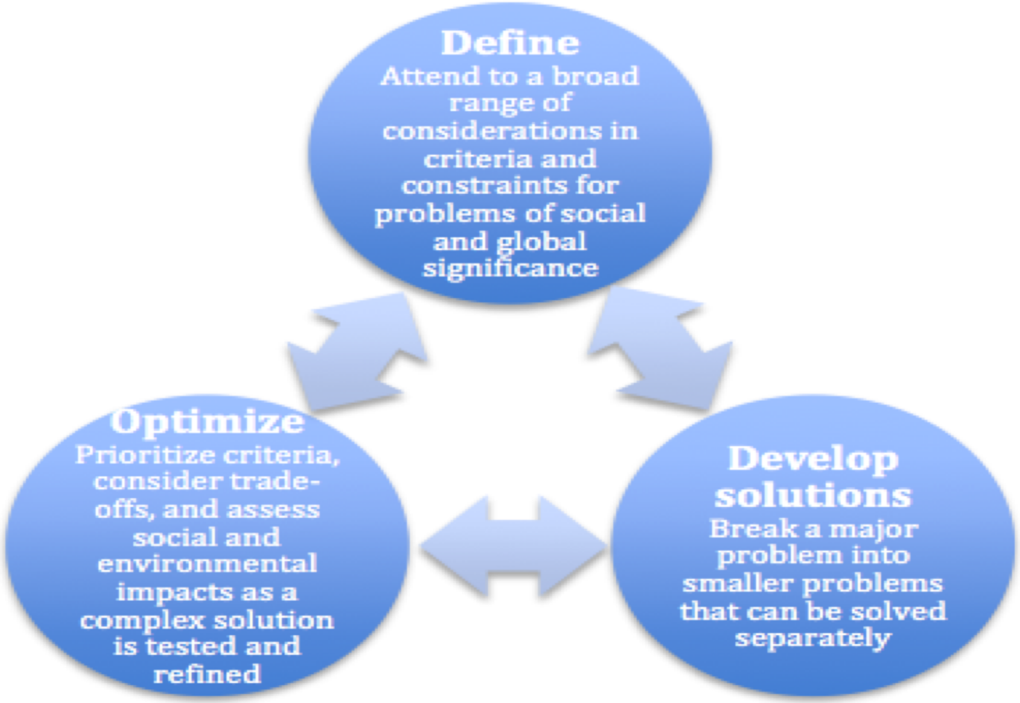


Engineering Design in NGSS Appendix I

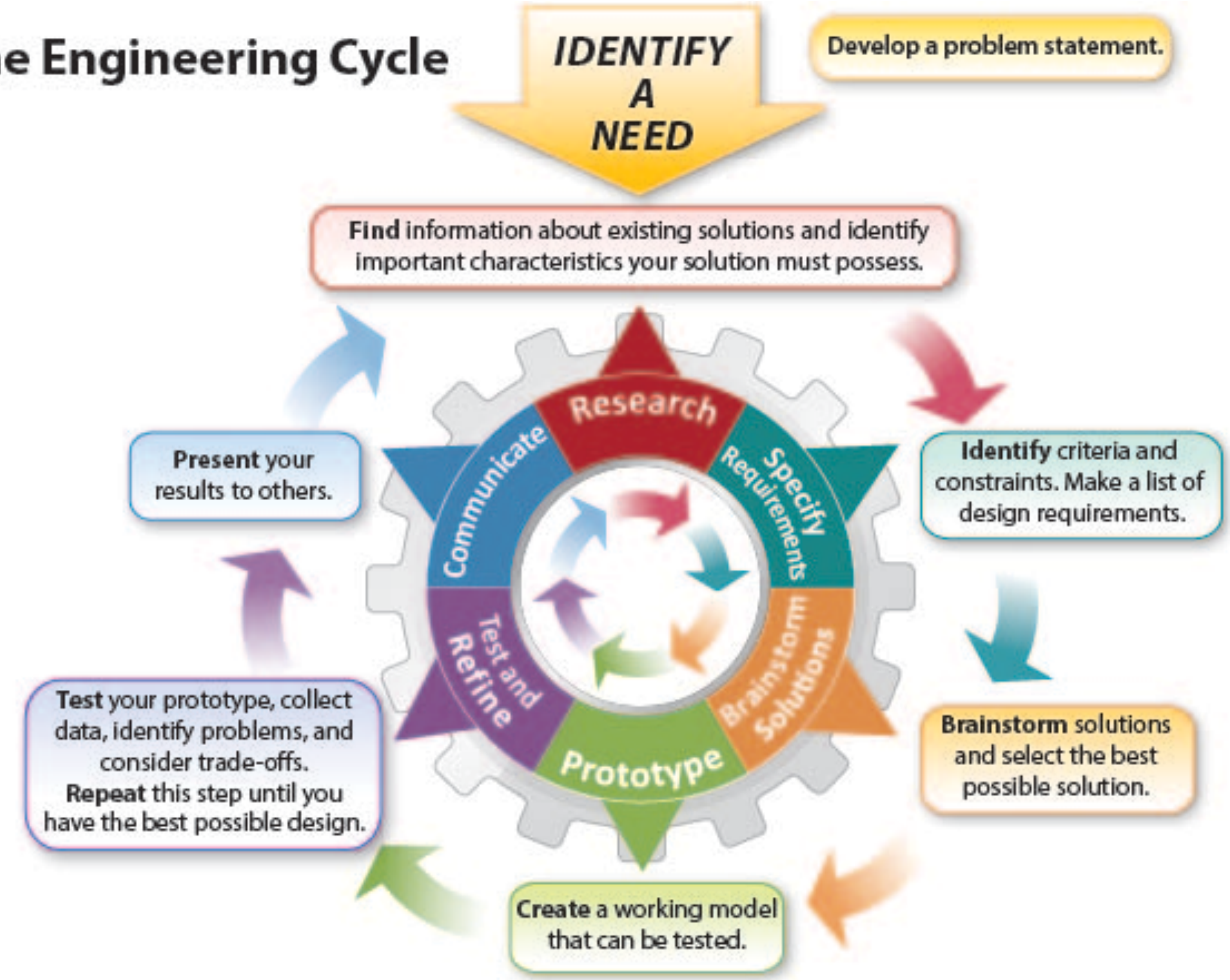
Grades 6-8



Grades 9-12



The Engineering Cycle

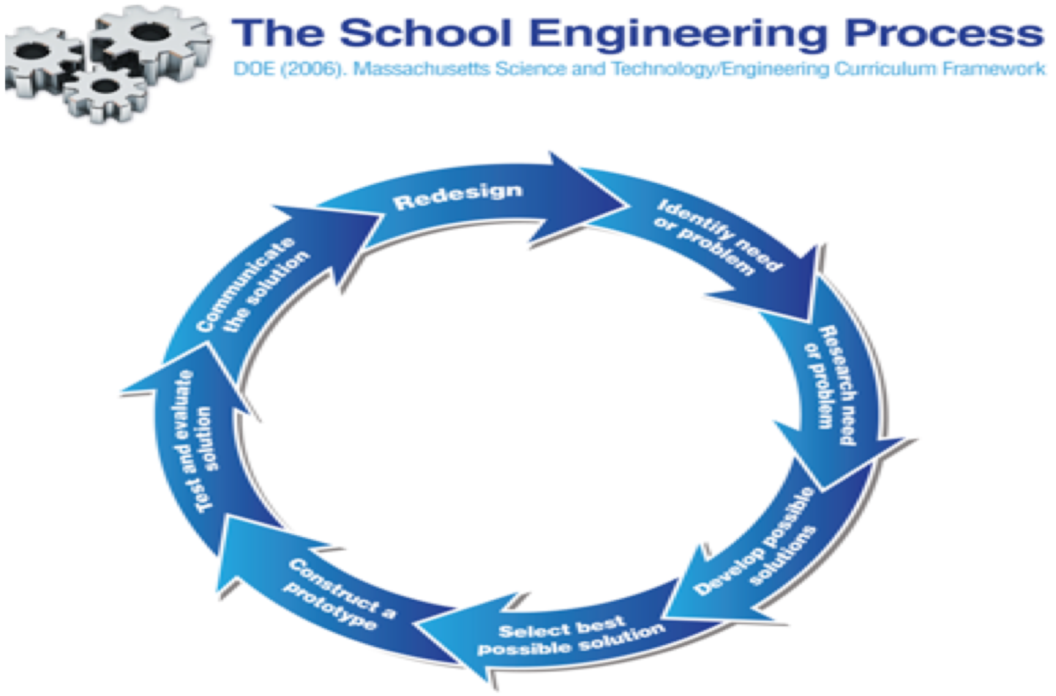


Engineering Practices and the Engineering Design Process (EDP)

Science and Engineering Practices (NGSS)

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

Engineering Design Process



The Engineering Design Process (EDP)

(2006 Massachusetts Department of Education Frameworks)

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What is engineering?
Elaborating the nature of engineering for K-12 education

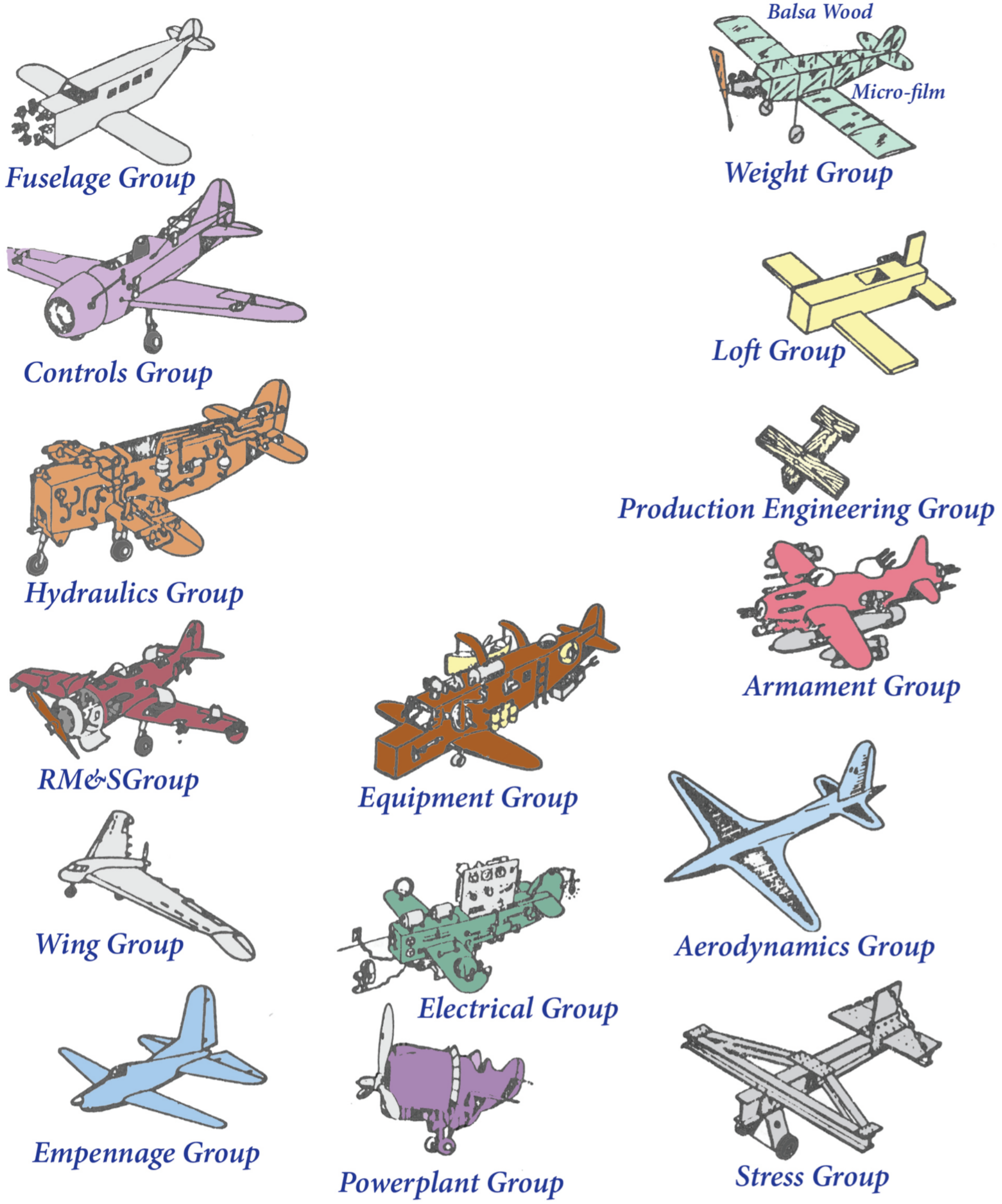
Jacob Pleasants and Joanne K. Olson

1. Design in engineering
2. Specifications, constraints, and goals
3. Sources of engineering knowledge
4. Knowledge production in engineering
5. The scope of engineering
6. Models of design processes
7. Cultural embeddedness of engineering
8. The internal culture of engineering
9. Engineering and science

Dream Airplanes
by C. W. Miller

Optimal airplane design from the perspective of engineers of different specialties.

From *Fundamentals of Aircraft and Airship Design: Volume I – Aircraft Design (p. 4)*, by L. M. Nicolai and G. E. Carichner, 2010, Reston, VA: American Institute of Aeronautics and Astronautics. Copyright 2010 by L. M. Nicolai and G. E. Carichner. Reprinted with permission.



Invention vs. Innovation

- Invention is the creation of an object, process, or system that didn't exist before.
- Innovation is the creation of an improvement upon an existing object, process, or system.
- The definition of the problem or need determines whether invention, innovation, or both are used in the solution.

The EDP Requires Its Users to Constantly and Consciously Manage Uncertainty and Ambiguity

- Engineers rarely have all the information they want or need when they begin the EDP.
- Sometimes defining the problem and its parameters in more detail narrows the field of possible solutions.
- Engineers gather additional information through research and trade studies (the systematic comparison of one or more possible solutions) before prototyping.
- Making many “quick and dirty” prototypes and noticing how they fail can yield the most useful information quickly and cheaply.

Define the Problem or Need Around Which You Will Rapid Prototype a Unit

Problems and needs may be stated in one of the following forms:

- We need a [object, process, system] that does [function1], [function2], and [function3]. *(Invention)*
- [Object, process, system] doesn't work well. How can we improve the [object, process, system]? *(Innovation)*

How you define the problem or need will determine the range of possible solutions. Define carefully and thoughtfully!

Criteria for Problem or Need

- As a test of open-endedness, think of three or more **unique** solutions to the problem or need *that students might propose.* If you can't think of at least three, redefine the problem or need.
- Connect the knowledge and skills that students need to produce each solution to as many of the following as possible:
  - one or more learning objectives in science,
  - one or more learning objectives in math,
  - one or more learning objectives in English language arts,
  - one or more learning objectives in social studies, music, art, health, and physical education
  - one or more community resources.

Design an Engineering Unit Using the EDP

- We invite you to use the EDP to create a prototype of a unit for your students that requires them to use the EDP.
- There is no “right” way to design your unit. If you ask us to tell you how to do it, we will be wrong because we are not the unit’s user – you and your colleagues are. Draw upon the wisdom and experience in this room!
- The challenge of creating the prototype of a unit will make you uncomfortable. That is expected and normal. Your students will feel the same way when you challenge them with your unit. Engineers face their feelings about uncertainty and ambiguity every day in their work because the EDP is inherently messy.
- Your unit will not be a finished product. We do not expect perfection, and neither should you. Taking risks, failing, and redesigning based on feedback are good engineering practices!