Bioengineering Challenges and Middle School Life Science

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SEPUP
Issue-Oriented Science

Next Generation Science Standards

Performance Expectations

- Science and Engineering Practices
- Disciplinary Core Ideas
- Crosscutting Concepts

Links to Common Core

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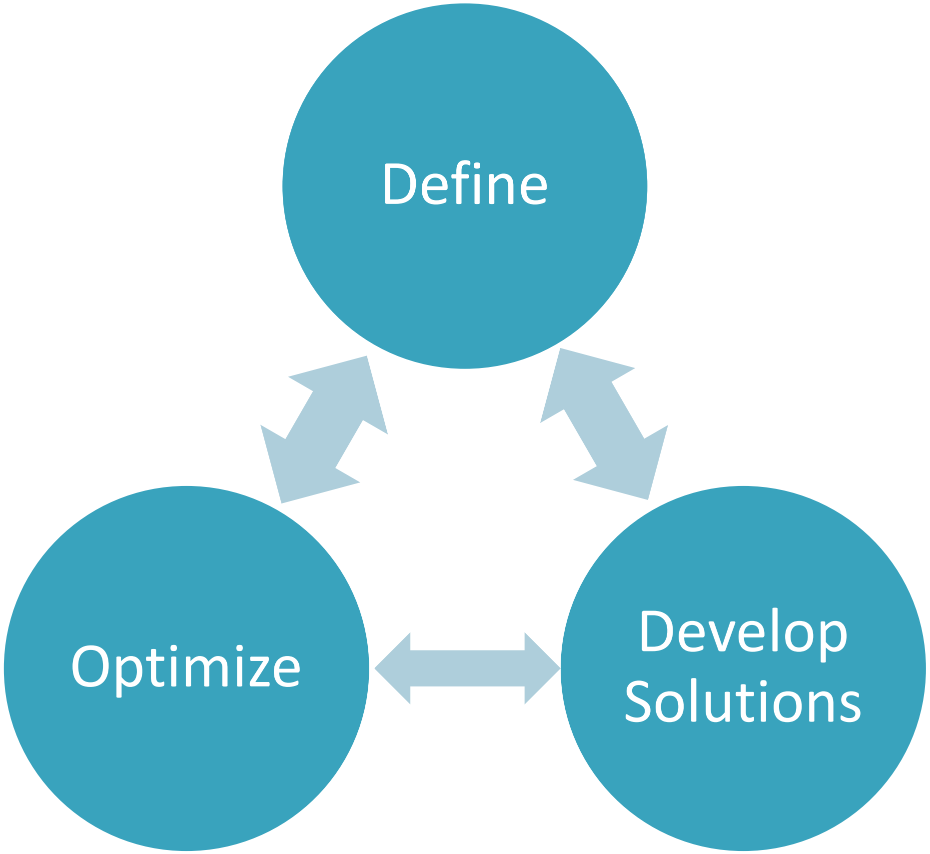
Engineering

- How do we define Engineering?
- What do Engineers do?
- How is Engineering similar to science?
- How is Engineering different from science?

Engineering Design



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NGSS Appendix I

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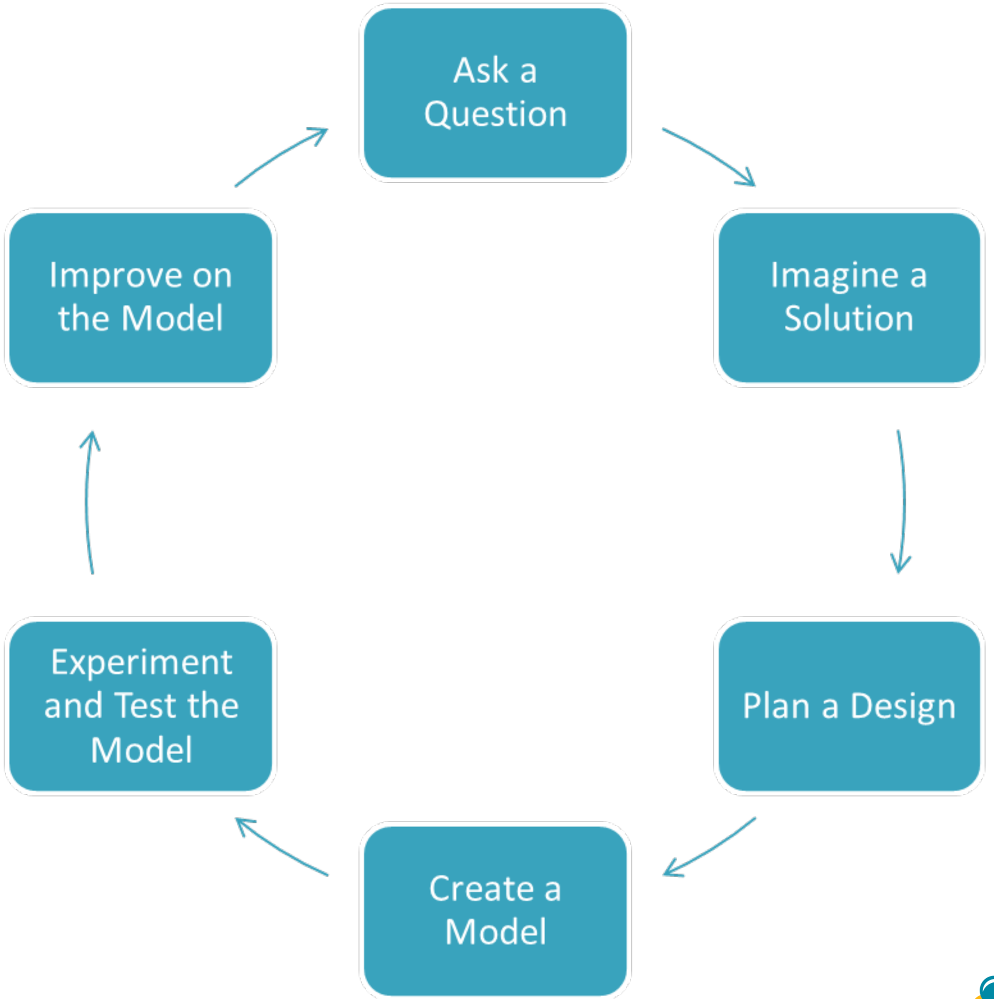
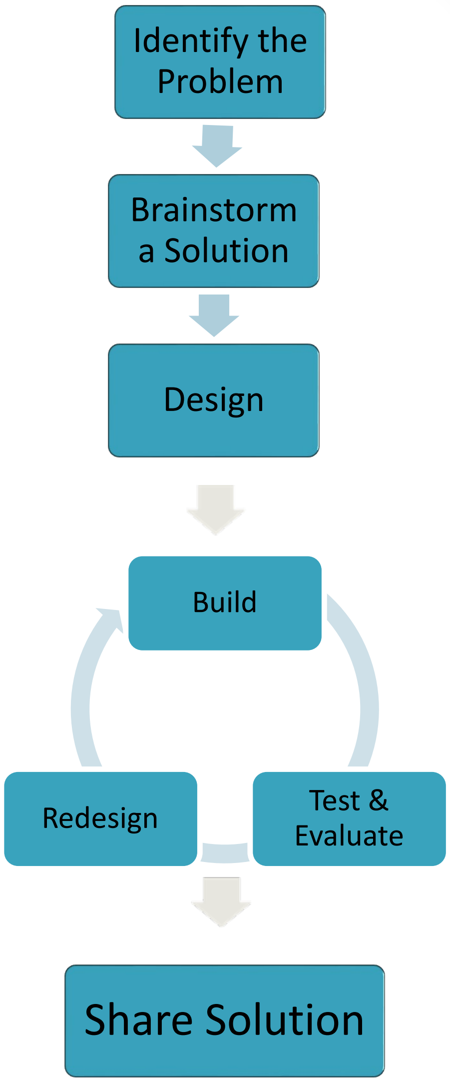
Design Process



Design Process



PBS Kids

Criteria and Constraints

- **Constraints**
  - Limits that apply to solving a problem
- **Criteria**
  - Desired features of a design or solution

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Designing Artificial Heart Valves

- **The Challenge**
  - How can you design a heart valve prototype out of common materials?
- **The Task - Designing a Prototype**
  - *As an assignment for your college course in biomedical engineering, you are asked to design a prototype heart valve. Your professors want you and your fellow students to learn more about how the heart works while exploring the design process and the advantages of different valve designs. They require that your valve* ***allow fluid to pass quickly in one direction****, while allowing* ***less than 30 mL through every 10 seconds in the other direction****.*

Criteria and Constraints

- **Constraints**
  - Time (20 minutes) and materials (on hand)
- **Criteria**
  - Fast flow in one direction
  - No more than 30 mL/10 seconds in reverse direction

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The Procedure

- Design
- Build
- Test
- Discuss how you could improve the design
- Refine the design – select a factor to change
- Build
- Test
- Discuss
- Refine……

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The Materials

- Medium non-toxic latex glove finger(s)
- Medium plastic glove finger(s)
- Latex dishwashing glove finger(s)
- Smaller diameter plastic tubes
- Larger diameter plastic tubes
- Transparent tape
- Small amount of modeling clay
- 1 30-mL graduated cup
- 1 marble
- 2 plastic cups
- 1 Student Sheet, "The Design Process/Refining Valve Prototypes"

Items to be shared: paper towels, timing device, supply of water, scissors

Share and Compare

- Present your best valve prototype
- Test other’s prototypes
- Discuss the factors that influenced your design
- What other design requirements could be introduced to improve the device?

Criteria and Constraints

- **Constraints**
  - Time (15 minutes) and materials (on hand)
- **Revised Criteria**
  - At least 60 mL/10 seconds in forward direction
  - No more than 10 mL/10 seconds in reverse direction

Disciplinary Core Ideas

- LS1.A
  - In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
- ETS1.B
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
  - Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
  - Models of all kinds are important for testing solutions.
- ETS1.C
  - 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.
  - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of test results leads to greater refinement and ultimately to an optimal solution.

Science and Engineering Practices

- Analyzing and Interpreting Data
- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Planning and Carrying Out Investigations
- Using Mathematics and Computational Thinking

Crosscutting Concepts

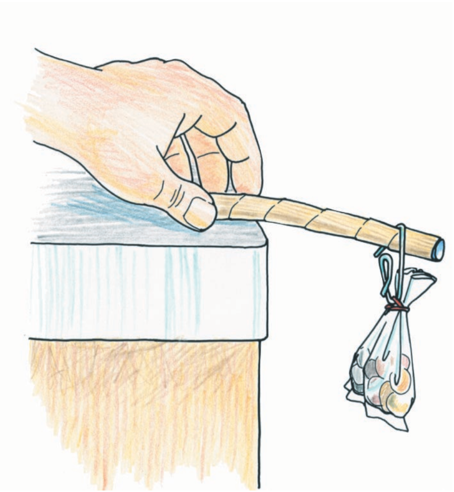
- Cause and Effect
- Energy and Matter
- Patterns
- Scale, Proportion, and Quantity
- Stability and Change
- Structure and Function
- Systems and System Models

Performance Expectations

- Middle school examples:
  - **MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
  - **MS-ETS1-3** Analyze data from tests to determine the similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success

Engineering Design

Designing and testing an artificial limb in life science



Designing an energy bar

Testing, redesigning, and retesting a solar collector in physical science

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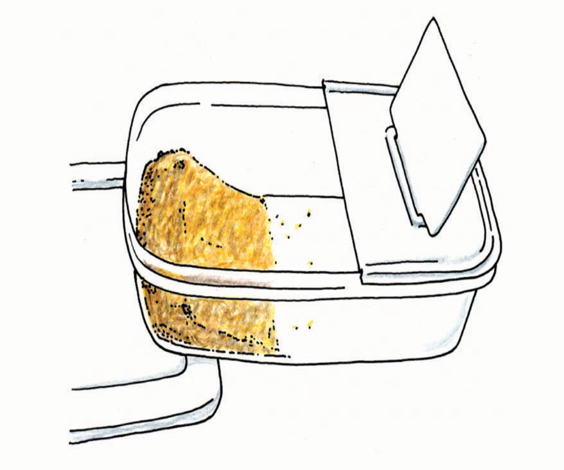
Engineering Design



Designing a structure to prevent beach erosion in earth science.

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This slide show can be found at sepuplhs.org/news