Engaging students in evidence-based reasoning in engineering design

Lisa Marco-Bujosa
Villanova University
lisa.marco-bujosa@Villanova.edu
lisamarcobujosa.weebly.com

Agenda

1. Introductions and welcome
2. Activity: Engineering design
3. Video: To the Moon!
4. Tools to Support Evidence-Based Reasoning in Engineering Design
5. Take Aways

1. Introductions and Welcome

- Introductions
  - Grades/subject areas that you teach
  - Familiarity with scientific argumentation

Not familiar

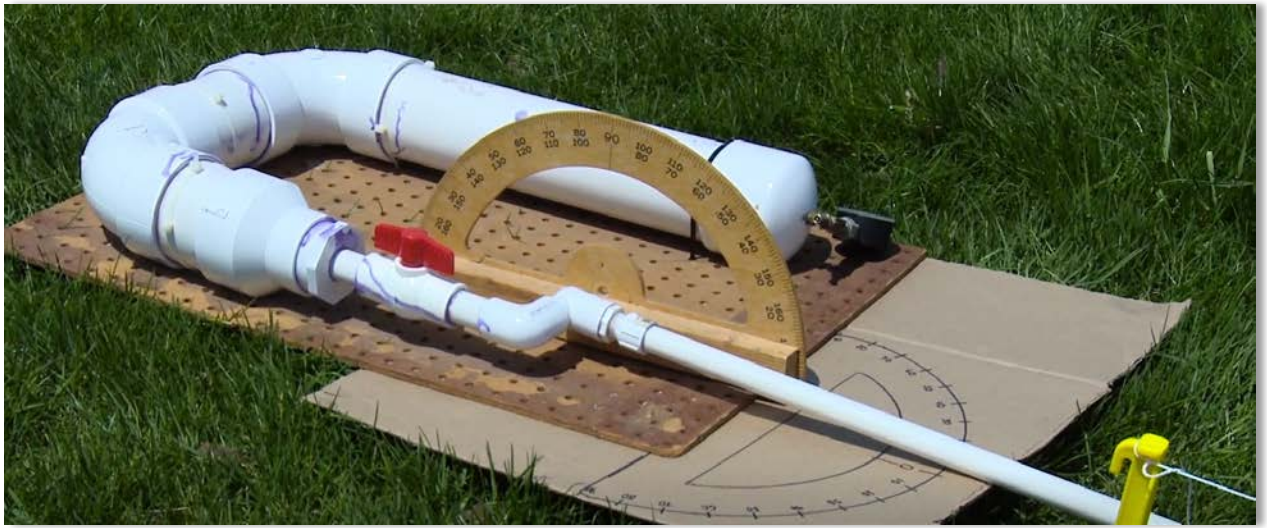
Very familiar

2. Engineering Design: Instructional Context

The Task:

- The students will apply mathematical and scientific concepts and utilize the iterative process in their efforts to guide an air compressed, construction paper rocket to hit a target 50 yards away from the launching pad.

The Launcher:



Materials:

Air Compressed Rocket Launcher

An Air Compressor

PVC Pipe

Construction paper

Masking Tape

Stop Watch

Measuring Tape

Twine

2. Engineering Design: Instructional Context

- 8th grade unit on the laws of motion and forces of flight
- Design Challenge: design a rocket that hits "the moon"
- Unit incorporates physical science concepts and mathematics
- Teacher emphasis on students collecting data and analyzing this data to inform their design choices

- (A few) Standards Addressed (NGSS and Common Core):

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

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 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.

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

CCSS.Math.Content.8.SP.A.4 Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables.

2. Engineering Design: Instructional Context

Science and Engineering Practices

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

2. Engineering Design: Individual Design

The Task:

- Design a “rocket” that can hit a target 50 meters away using the specified materials

- **Stage 1:** Individual Design (<5 min)
- **Stage 2:** Group Design (<5 min)
- **Stage 3:** Test, Data Analysis, Redesign (video)
- **Stage 4:** Present Final Design (time permitting)

Individual Design

Design Idea	Data/Evidence
• Plan including drawing, labels of materials used, and labels of what each part does	• List science and mathematics concepts or evidence to explain your design decision

2. Engineering Design: Discussion

- What did you consider for your individual design?
  - Science concepts and knowledge; background experience
- What did you talk about in the “group design” phase?
- How can you envision your students engaging in this activity? What would work well? What challenges would they have?

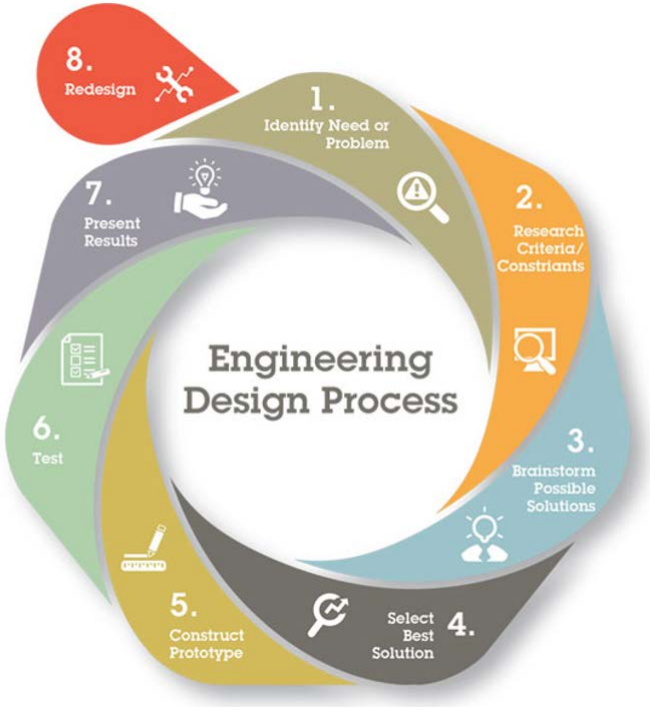
3. Video: To the Moon!

Watch this video of an engineering activity from The Teaching Channel.

Discussion Questions:

1. How did the teacher support student use of evidence to justify their design decisions?
2. How can you create a culture that would promote engineering design in your class?

How can teachers effectively integrate science content in engineering design tasks?



4. Tools to Support Evidence-Based Reasoning in Engineering Design

Science and Engineering Practices

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

4. Tools to Support Evidence-Based Reasoning in Engineering Design

Student Scaffold

Individual Design

Design Idea • Plan including drawing, labels of materials used, and labels of what each part does	**Data/Evidence** • List science and mathematics concepts or evidence to explain your design decision

Justification - Why do you think this design idea will work?
- Explain how your data and evidence support your design idea in order to meet criteria/constraints.

From EngrTEAMS: https://sites.google.com/a/umn.edu/engrteams/home

4. Tools to Support Evidence-Based Reasoning in Engineering Design

Student Scaffold

Evidence-Based Reasoning Tool

Directions: Use the reasoning tool template to explain how the pieces of evidence justify your design decisions.

Evidence	This evidence matters because…	Therefore…

Adapted from: argumentationtoolkit.org

Takeaways

Develop an understanding of engineering design as a social process in which students build, critique, and revise design solutions using evidence and reasoning.

Introduce design and reasoning tools to scaffold student use of evidence and science concepts in engineering design.