Hands-on Activity: **Super Slinger Engineering Challenge**

Contributed by: Inquiry-Based Bioengineering Research and Design Experiences for Middle-School Teachers RET Program, Department of Biomedical Engineering, Worcester Polytechnic Institute

Quick Look

Grade Level: 7 (6-8)
Time Required: 110 minutes
(15 minutes for engineer illustration and discussion + 20 minutes to define problem + 55 minutes to build + 20 minutes test and debrief = 110 minutes)

Expendable Cost/Grp : US $2.00
Group Size: 3
Activity Dependency : None
Subject Areas: Science and Technology

Like engineers, students in this activity follow the engineering design process to create and build their designs.

Summary

Students are challenged to design, build and test small-scale launchers while they learn and follow the steps of the engineering design process. For the challenge, the "slingers" must be able to aim and launch Ping-Pong balls 20 feet into a goal using ordinary building materials such as tape, string, plastic spoons, film canisters, plastic cups, rubber bands and paper clips. Students first learn about defining the problem and why each step of the process is important. Teams develop solutions and determine which is the best based on design requirements. After making drawings, constructing and testing prototypes, they evaluate the results and make recommendations for potential second-generation prototypes.

Engineering Connection

The engineering design process is a universally accepted method for achieving a desirable solution to an identified problem. This activity walks students through the engineering design process, which is critical to all engineering fields, as they apply basic engineering concepts to a design problem.

Learning Objectives

After this activity, students should be able to:

- Identify and describe the parts of the engineering design process.
- Utilize the engineering design process to develop solutions to the assigned problems.
- Explain the reasons for their selected designs and material choices.

Educational Standards

- Next Generation Science Standards: Science
- Common Core State Standards: Math
- International Technology and Engineering Educators Association: Technology
- Massachusetts: Science

Suggest an alignment not listed above

Materials List

Each group needs:

- piece of drawing paper, for engineer illustration, one per student
- 1 cardboard box cover (such as the cover from a box that contains 10 reams of copy machine paper)
- Ping-Pong ball
- masking tape
- 10 feet (305 cm) string
- 4 plastic spoons
- 4 film canisters
- 6 pencils
- 4 plastic cups
- 12 rubber bands
- 12 paper clips
- (optional) 1 mouse trap (see Safety Issues section)
- Engineering Design Process Worksheet, one per student
- Engineering Challenge Design Packet, one per student

Introduction/Motivation

What does the phrase "necessity is the mother of invention" mean? (Listen to student ideas.) In general, it means that new designs are created because we need solutions to problems. Engineers are today's problem solvers. By following the steps of the engineering design process, engineers systematically approach and define problems and then arrive at viable solutions. Today we are going to go through the engineering design process and learn just how engineers create effective solutions!

Vocabulary/Definitions

constraint: A limitation or restriction. For engineers, constraints are the limitations that must be considered when designing a workable solution to a problem.

engineering design process: The iterative process through which engineers develop solutions to meet an objective. The steps of the process include: identifying a problem, brainstorming, designing, constructing, testing, analysis and evaluation, redesigning, retesting, and sharing a solution. Science, mathematics and engineering science concepts are applied throughout the process to optimize the solution.

functions: The capabilities or tasks that an engineering solution is able to perform.

objectives: Desired outcomes for an engineering design or product.

problem statement: A sentence or two that describes the identified problem or challenge an engineer or engineering team is working to solve.

prototype: An early functional version (a model, a mock-up) of a design to help move the design process forward by improving the team's understanding of the problem, identifying missing requirements, evaluating design objectives and product features, and getting feedback from others.

requirements: The overall objectives, functions and constraints of a project.

Procedure

Background

The engineering design process is a series of systematic steps that lead to the development of effective and appropriate solutions to identified problems. Engineers use their science and math knowledge to explore all possible options and compare many design ideas. This is called open-ended design because when you start to solve a problem, you don't know what the best solution will be. The process is cyclical and may begin at, and return to, any step.

1. The first step is to **identify a problem** and understand the need to solve it. This includes developing a problem statement and any functions, objectives and constraints required for an ideal solution.
2. Conducting **research** is important for gathering information about the issue at hand and understanding any solutions that have been tried in the past.
3. The next step is to **brainstorm as many solutions as possible**. Creativity and innovation are key in this step.
4. Analysis of possible solutions leads to the **selection of one design**—the team's most promising idea.
5. The next step is to **create a plan**, which often includes making **drawings** and assigning **roles** for everyone on the engineering team for building and constructing a solution **prototype**.
6. After construction, the prototype design is **tested and evaluated**.
7. The end solution is **shared and communicated** in an appropriate way to ensure that the original problem is addressed.
8. In the **redesign** step, improvements are made to the design (or recommended), and revised prototype solutions are tested again. The redesign, retest, analysis cycle is iterated as many times as necessary.

See additional information about the engineering design process at https://www.teachengineering.org/engrdesignprocess.php.

Before the Activity

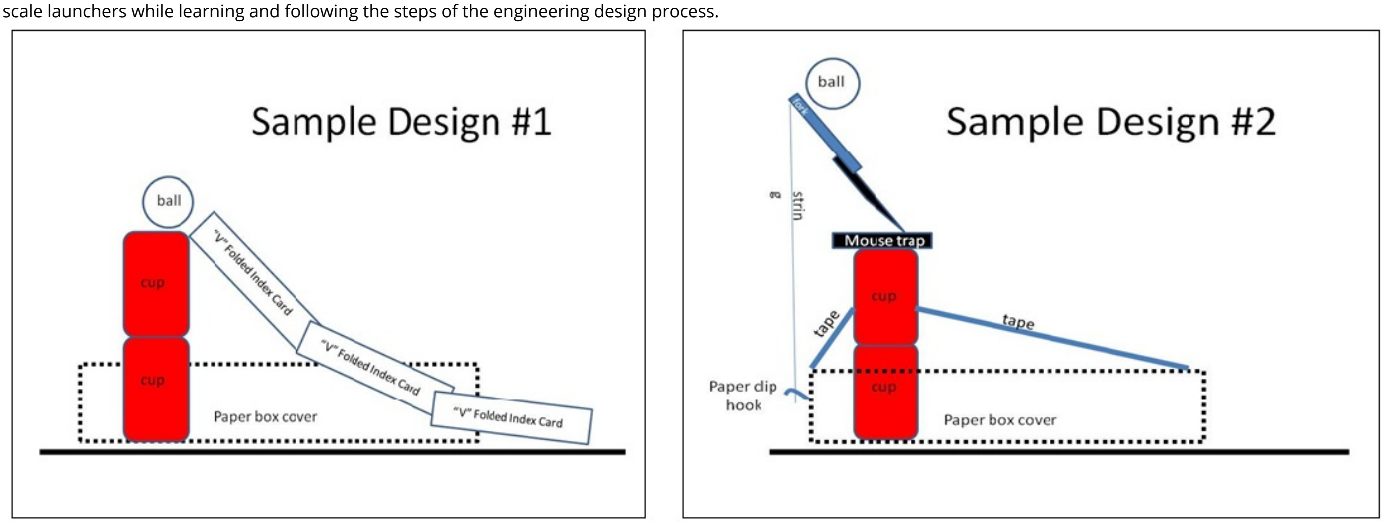
- Gather materials and make copies of the Engineering Design Process Worksheet and the Engineering Design Challenge Packet, one each per student.
- Divide the class into groups of three students each.

With the Students

1. Hand out drawing paper to the students.

- Ask each student to create an illustration/diagram of an engineer.
- Have 4 or 5 students share their illustrations with the class.
- Discuss the preconceived notions the students have regarding engineers. (Point to make: Engineers might look like anyone you know or anyone you see on the street.)

2. Provide students with a brief overview about the challenge. Inform them that this is a "practice" challenge with a focus on learning and following the steps of the engineering design process. As students work through the challenge, make sure they consciously recognize all the steps they must take during the challenge, which step they are working on at any point, and the importance of each step. Once this is established, describe the student challenge for this activity: To design, build and test small-scale launchers while learning and following the steps of the engineering design process.



Example innovative engineering launcher designs created by students following the steps of the engineering design process.

3. Hand out the worksheets.

- Complete the engineering design process section (page 2, blank circular diagram) together. As a class, walk students through the steps of the engineering design process, explaining each step and providing clear examples for why each step is important. This could take considerable time, but it is worth the extra effort now so the remainder of the unit runs smoothly. A great reference for clear examples for each step of the engineering design process is the Creative Engineering Design unit, which includes individual activities dedicated to each step of the design process. A quick scan through each activity provides a wealth of useful examples for each step of the engineering design process. As necessary, also refer to the Background section and the vocabulary definitions.
- Then have students complete the first page (vocabulary terms) on their own, either in class or as homework to turn in for grading.

4. Hand out the packets.

As part of the engineering design process, students create and test design prototypes.

- Introduce students to the materials available to design launcher prototypes.
- Have students use the packet to guide them through the process, composing their own descriptions of the problem statement, function, objective and constraints for this challenge.
- Have each student develop one possible solution to share with his/her group.
- Have groups review each design idea and brainstorm further, weighing the positives and negatives, choosing the most promising design. Help them determine which potential design (or combination) is the "best" based on the design requirements.
- Based on their chosen designs, have groups plan and construct their launchers. During this step, have students accurately represent their designs using multi-view drawings or scale models, as well as construct functional prototypes.
- Once launchers are created, have students test them, collecting and recording test data.
- Then have groups evaluate the effectiveness of their designs by examining the test results. Based on test data and any background research conducted, have them recommend recommend specific suggestions for improvements for their designs (next-generation prototypes).
- Have students complete the packet write-up and turn it in for grading.
- If time permits, have a launcher competition.

5. Debrief with each group to help them understand and reflect upon how what they did was part of the cyclical engineering design process.
6. As time permits, show students a movie or film that shows people overcoming disabilities through the assistance of engineered technology. See suggestions in the Additional Multimedia Support section.

Attachments

Engineering Design Process Worksheet (pdf)
Engineering Design Process Worksheet (docx)
Engineering Design Challenge Packet (pdf)
Engineering Design Challenge Packet (docx)

Safety Issues

Many successful designs have been created without using mousetraps, but if mousetraps are used, attach a piece of wood to each mousetrap base to increase the surface area that can be handled, as a way to prevent potential injury. Do this by using wood glue to adhere a flat, larger piece of wood to the bottom of the mousetrap.

Assessment

Pre-Activity Assessment

Pre/Post Unit Engineer Sketch: First thing (before opening the topic and challenge), give students five minutes to each make a sketch of an engineer. Save and set aside the sketches. Repeat at unit end and compared sketches.

Class Discussion: During the introduction to the topic and the engineering design process, informally evaluate students' prior knowledge about engineering and the design process. Ask the students:

- What is the engineering design process?
- How does the engineering design process work?
- Why use the engineering design process?
- What are the parts of the engineering design process?

Activity Embedded Assessment

Vocabulary: Evaluate students' understanding of the vocabulary words and definitions through observation in group discussions of their comfort and accuracy in using the terms.

EDP Steps: Have students use the attached Engineering Design Process Worksheet to aid them in understanding the steps of the engineering design process as a problem-solving tool. Complete the circular diagram (page 2) together, through class discussion. Then, in class or as homework, have students individually compose definitions to the page 1 vocabulary terms. Evaluate these descriptions to gauge their understanding of key design process components. For answers, refer to the Background and Vocabulary sections.

Drawings and Prototypes: Evaluate students on their ability to accurately represent their launcher design solutions using multi-view drawings, scale models and/or prototypes.

Post-Activity Assessment

Launcher Challenge Steps: Evaluate students' completed Engineering Challenge Packets to gauge their understanding of and ability to follow the engineering design process steps to create their launchers. Make the assessment focus on each student's correct use of the engineering design process, rather than his/her ability to build a successful launcher. Example answers:

- Problem Statement: We need a machine to launch a Ping-Pong ball to hit a target. We must follow the steps of the engineering design process to create a successful launcher.
- Function: Our launcher should be able to aim and launch a Ping-Pong ball.
- Objective: To successfully launch a Ping-Pong ball into the goal area.
- Constraints: Use only using the provided materials and complete the activity in the 110 minutes provided.

Additional Multimedia Support

Show students the one-minute "Let's Build a Filter" scene from the Apollo 13 movie, in which NASA engineers are challenged to construct a carbon dioxide filter using only materials available on the spacecraft; available at YouTube: http://www.youtube.com/watch?v=Z3csfLkMJT4.

Show students a movie or film that shows people overcoming disabilities through the help of engineered technology. Suggestions: *Kiss My Wheels* by Miguel Grunstein and Dale Kruzic (56 minutes), *Not on the Sidelines: Living and Playing with a Disability* by Ben Achtenberg and Karen McMillan (26 minutes), available at Fanlight Production http://www.fanlight.com/.

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Supporting Program

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