Engineering is Elementary®

Prep Lesson

Preparatory Lesson

What is Engineering? Tower Power

Preparation: 10-15 minutes

Lesson: 75-90 minutes

Vocabulary

- Engineering Design Process
- Ask
- Imagine
- Plan
- Create
- Improve

Guiding Question:

- How do engineers design technologies?

In this lesson, students will

- engage in a common engineering design challenge.
- describe the steps they use to solve the engineering challenge
- become familiar with the five-step Engineering Design Process that forms the backbone of the EiE units.

Students learn that

- there can be many different solutions to a problem.
- the Engineering Design Process is a process engineers use to help them design technologies to solve problems.
- there are five steps in the Engineering Design Process: Ask, Imagine, Plan, Create, and Improve.

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Objectives

Students will be able to

- work with others to design a solution to an engineering problem.
- recognize that there are many different solutions to an engineering problem.
- understand how their actions fit into the five steps of the Engineering Design Process.
- identify an engineered solution as a technology.

Overview

As a creative process, engineering can look different from person to person, team to team, and project to project. However, despite all of these possible differences, it is still useful to think about engineering as a process: a series of steps that engineers use to solve problems. In EiE, a five-step Engineering Design Process helps organize students' engineering efforts.

In this Preparatory Lesson, students are presented with a problem they need to solve. Students are then encouraged to ask questions about the problem and what they need to do in order to solve it. Students then work in small groups to design a solution to the problem using simple materials. Groups test and present their designs in front of the entire class. Then, in whole-class discussion, students reflect on their problem-solving process and compare it to the Engineering Design Process that engineers use to solve problems.

This lesson is intended as a companion preparatory lesson to Technology in a Bag, which is included in all Teacher Guides. This lesson should be taught after students have an understanding of technology and before students begin Lessons 1-4 of an *Engineering is Elementary* unit.

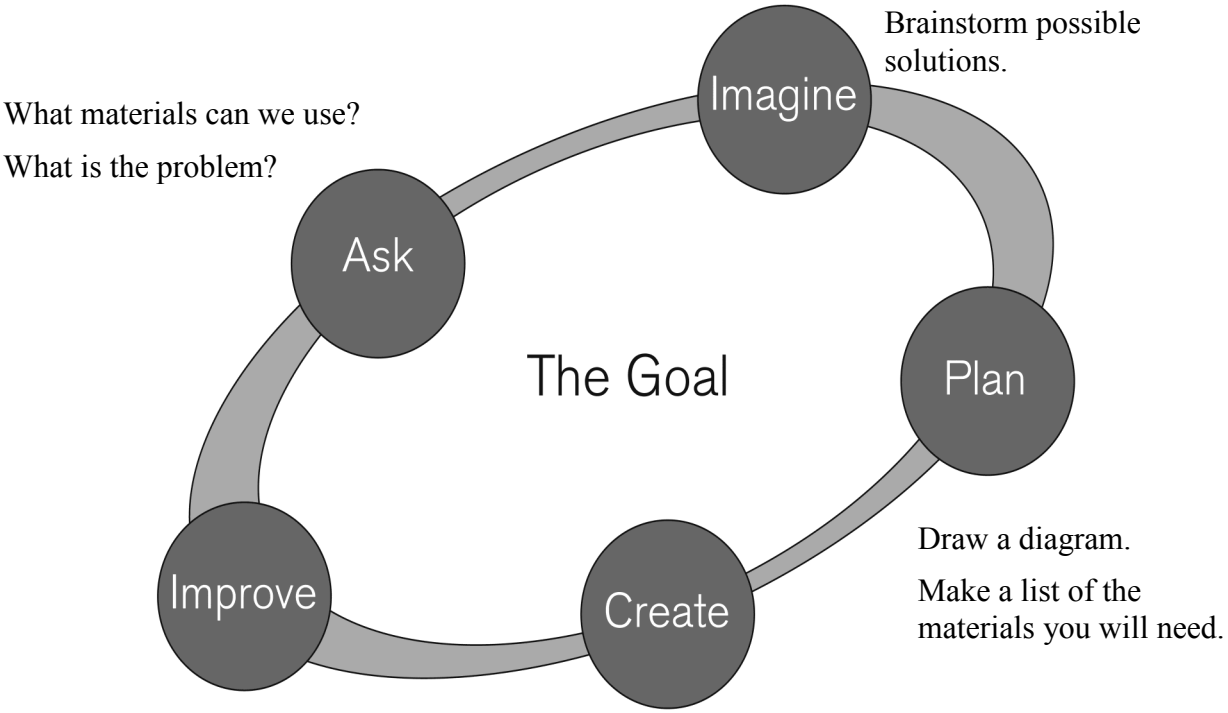
Background

The Engineering Design Process is a series of steps that engineers use to guide them as they solve problems. Many variations of the model exist, although all versions share common threads. Because EiE focuses on young children, we have created a simple process that depicts fewer steps than other renditions and uses terminology that children can easily understand.

While this guide is useful for novices who are learning about engineering, it is important to note that practicing engineers do not adhere to a rigid step-by-step interpretation of the Engineering Design Process. The Engineering Design Process is cyclical and can begin at any step, or move back and forth between steps numerous times. In real life, engineers often work on just one or two steps and then pass along their work to another team.

On the following page is the Engineering Design Process as presented in every EiE unit.

Here are the steps of the Engineering Design Process used in every EiE unit:



After engineers improve their design once, they often begin the Engineering Design Process all over again to refine the technology. The Engineering Design Process can be used again and again!

Student Learning

Look for the following misconceptions:

- There is only one correct solution to any problem.
- Engineers design technologies using a very complicated process.
- Only trained engineers can design technologies.

Look for the following insights:

- There are many possible solutions to an engineering problem.
- The Engineering Design Process is a natural problem solving process.
- Anyone can engineer.

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Teacher Tip

Try substituting other materials for the index cards in this activity, for example:

- paper cups
- scrap paper
- newspaper

The most successful materials are those that are simple and can be cut/manipulated in many ways to create a tower.

Teacher Tip

Consider giving your students unlimited tape if you think the constraint will hinder their ability to engage in the design challenge. This works particularly well for younger students.
Alternatively, to increase the challenge of this activity, consider limiting the tape further or increasing the height requirement of the towers.

Materials

For the Class:

- chart paper or board
- markers
- poster or large-scale print out of the Engineering Design Process (optional)
- small stuffed animal, approx. 6" tall, 2-4 oz., that is able to sit or rest stably on its own
- stopwatch, clock, or other timer

For Each Group:

- 1 pack of 100 index cards (3" x 5" (7.6 x 12.7 cm))
- 2 feet (61 cm) of cellophane tape
- ruler

For Each Student:

- Scissors

Preparation

1. Measure and cut two feet (61 cm) of cellophane tape for each group of students.

Introduction

1. Explain to students that in this lesson they will figure out how engineers design technologies. Begin by asking students, as a review:
   - **What is technology?** *Something designed by humans to solve a problem or meet a need. Examples include pencils, cups, cell phones, processes to clean water, etc.*
   - **What is an engineer?** *Someone who uses his/her knowledge of science, math, and creativity to design technologies to solve problems.*
2. Tell students that for the next hour, they will be engineers and will design a technology to solve a problem.
3. Introduce the activity by stating that you have a problem that you need students' help to solve.
4. Present the problem to students by saying that you would like to put a stuffed animal outside of your classroom that will help students know which classroom is yours. Show students the stuffed animal and explain that this is the animal you will put outside of your classroom.
5. Place the stuffed animal on the floor. Ask:
   - **What is the problem?** *The stuffed animal is too small and no one will be able to see it; people might step on it; etc.*

Teacher Tip

Feel free to propose an alternate scenario that you think will resonate with your students. The only requirements are that:

- the animal needs to be held at least one foot off of a surface.
- the animal needs to be supported for an extended amount of time.

For example, the animal may live in a swamp inhabited by hungry alligators, and needs a safe place to sleep at night that is out of the alligator's reach.

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Teacher Tip

If students are having trouble coming up with questions, try giving an example to get them started, like "how much time do we have?" You may also want to prompt students to ask questions about any information they are missing, such as criteria/constraints, relevant science background, and how to test and evaluate the success of their designs.

Teacher Tip

Students' wording will likely differ from the sample questions here, which is okay.

6. On a piece of chart paper, write "What is the problem?" Record student responses underneath.

7. Tell students that it is their job, as engineers, to solve this problem by engineering a tower to lift the stuffed animal higher. Ask:

   - **You need to solve this problem. What questions do you have before you start?**

   On the same piece of chart paper, write "What do you need to know?" Give students several minutes to think about this with a partner or a small group. Come together as a class and have students share their ideas. Record students' questions on the piece of chart paper. Encourage students to restate their ideas as questions if needed. It is important that students ask questions about criteria and constraints, relevant science knowledge, and how to evaluate success. Important questions include:

   - *What materials can we use?*
   - *How much time do we have?*
   - *How tall does our tower need to be?*
   - *How will we know if our tower is successful? How will we test our tower?*
   - *Where will we build our towers?*
   - *How much space do we have to build?*

8. One by one, answer all of the questions students asked, recording the responses on the chart for future reference. Make sure to include the following information:

What is the problem?
The problem is the animal is too low.
What do you need to know?
What materials can we use?
How much time do we have?
Etc.

- Students will work in groups.
- Each group can use 100 index cards and two feet (61 cm) of tape to build their tower.
- Each group can use the scissors and ruler as tools, but they may NOT be used as part of the tower.
- Towers must be at least one foot (30.5 cm) tall.
- Towers need to hold up the stuffed animal for at least 10 seconds.
- Groups will have 25 minutes to design their towers.
- Students can hold the stuffed animal briefly, but they may not test their towers with it until the 25 minutes are up.
- Groups don't need to decorate their tower at this point.
- Groups may not tape their towers to their desks.

9. Divide students into groups of three.
10. Distribute five index cards, a piece of tape, and a pair of scissors to each group.
11. Tell students they will have five minutes to brainstorm different ways they can build using the index cards before they design their tower. You may want to prompt students by asking:
    - **What happens if you fold the cards?**
    - **What happens if you roll the cards into columns?**
    - **How else do you think you could build with these cards?**
12. Have groups share their ideas with each other so that everyone has access to multiple tower building strategies.

Teacher Tip

Step 11 is a great way to give students some time to experiment with the materials before the design challenge begins. Feel free to skip this step if you feel your students are able to move directly into the design challenge.

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Activity

1. Remind students that their goal is to design a tower at least one foot (30.5 cm) tall that can support the stuffed animal for 10 seconds.
2. Distribute 100 index cards, two feet of tape, rulers, and scissors to each group.
3. Set the timer for 25 minutes and start it.
4. As students work, visit each group with the stuffed animal and allow them to hold it and get a sense of its mass.
5. To get students talking about their designs, ask:
   - **Can you tell me about your design?**
   - **Why do you think your design will work well?**
6. As you are circulating, keep track of the time and every five minutes let students know how much time they have left. Once the 25 minutes are up, have students stop working.
7. Have students carefully get up and step away from their towers so that they can see all of the different towers that were created. Ask:
   - **What do you observe is the same about all of these towers?** *They are all made of the same materials; they all have layers of index cards; certain shapes might be repeated in multiple designs; etc.*
   - **What do you observe is different about all of these towers?** *They are made with different techniques, such*

as folding, rolling, cutting, etc.; they are made up of different shapes (triangles, circles, squares, etc.); some are larger at the base and smaller on top; some are the same size at all levels; etc.

8. Point out that every group engineered a different solution to the same problem. In engineering, there is no right or wrong answer; instead, there are multiple solutions to the same problem.
9. Go around the room and have each group test their tower by first measuring to see if it is at least one foot (30.5 cm) tall, and then by placing the stuffed animal on top and seeing if it can stay in place for ten seconds. Before they test, ask each group some of the following questions:
   - **Can you explain your design to the class?**
   - **What part of your design do you think will work well?**
   - **What do you predict will happen when you test your design?**
10. After each group tests, regardless of whether or not their tower met the criteria, ask:
   - **How do you think you could improve your design if you had more time?**
   - **Why do you think that idea will improve your design?**

Teacher Tip

Asking all students how they might improve their design helps students value their ideas and the problem-solving process, not just the end result.

Teacher Tip

See the Extension and Reinforcement section on p. 12 if you have time for your students to improve their designs.

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Teacher Tip

Instead of showing students the Engineering Design Process right away, you can have students reflect on their own process, first.
After reviewing the term "process" with students, ask them to brainstorm "action words" that describe what they did as they designed their towers. Record their words on the board.
Then, ask students to put their words in order. For example, which did they do first—fold or brainstorm?
As students put their action words in order, they will naturally place them into categories representing the five steps of the Engineering Design Process.
Refer to their own process as you introduce the Engineering Design Process to them and encourage them to point out the similarities.

Reflection

1. Have students return to their seats.
2. Tell students they are going to take some time to reflect on the process they used to solved the problem. Ask:
   - **What do you think the word 'process' means?** *A way of doing something, steps in an order, etc.*
   - **What are some examples of a process?** *The writing process, the process for going out to recess, etc.*
   - **Do you think you used a process to help you design the tower? Why?** *Accept all responses.*
3. Tell students that engineers use a process to help them solve problems, called the Engineering Design Process.
4. Draw the Engineering Design Process on a piece of chart paper and have a volunteer read the steps.
5. Point out the "Goal" in the center of the diagram. Ask:
   - **Did you have a goal in your engineering challenge? What was your goal?** *Yes, to design a tower to hold the stuffed animal one foot in the air.*
6. Have students work in groups for five minutes to discuss whether they think they used any of the steps of the Engineering Design Process. Ask:
   - **Do you think you used any of these steps when you designed your tower? Why do you think so?**

7. Have students give examples of how they used each step. Record student ideas next to the relevant step on your drawing of the Engineering Design Process.
8. Point out to students that the Engineering Design Process is a circle. Ask:
   - **Why do you think the Engineering Design Process is shaped like a circle?** *For now, accept all responses.*
9. Guide students to understand that the process is cyclical and can be repeated. You may want to ask questions like:
   - **Did you only ask questions at the beginning? When else did you ask questions?** *We asked each other questions as we designed. We asked how we would improve it after we tested it.*
   - **Did you improve your tower only once, or did you improve it many times?** *We improved it many times.*
10. Have students reflect on the work they did designing their towers. Ask:
    - **Do you think you engineered today? How do you know?** *Yes, we used the same process engineers use; we solved a problem; etc.*
    - **Is the tower you designed a technology? Why do you think so?** *Yes, because we designed it; yes, because it solves a problem.*
    - **What other problems do you think the Engineering Design Process can help you solve?**

Extension and Reinforcement

Improve the Towers
Give students time to improve their towers and test them again. This time, encourage students to pay attention to their own process. You might want to ask students to keep track of how they use each step of the Engineering Design Process as they improve their tower on a group chart on the board or something more individual at their desks. Students may be surprised to realize that they will move through all five steps again as they ask more questions, imagine possible improvements, make a new plan, create their idea, and brainstorm future improvements.