Abstract

This parent lesson offers students the background information necessary to understand the eight steps of the Engineering Design Process. In this introduction, students will examine a specific, real-world problem that allows them the opportunity to learn about steps themselves and see the way the steps work together to facilitate the work engineers do.

Time: 10-15 Minutes

Objectives: Engineering: A. Engineering Design Process (EDP)

1. The learner will recognize the engineering design process is a method of problem solving used to create a system, a product, or a process that meets an identified need.

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* Complete the parent lesson and at least one of the appendices listed.
E 3.1.1.4. Engineering: A. Engineering Design Process (EDP)
Parent Lesson Plan: Introduction to Engineering Design Process

**Student Materials**

See each activity description for list of materials needed.

**Pertinent Information**

» **Required Appendix**: This parent lesson plan must be completed along with one of the approved accompanying appendices listed on page one.

» **Activity Planning**: This parent lesson can be introduced into your schedule in two ways: prior to your first EDP lesson or as a review activity directly after you complete one of the approved appendices listed on page one.

» **Scheduling Reminder**: The information in this lesson is a significant resource to students as they work through the STARBASE curriculum. It is strongly suggested that this information be introduced early in your program’s schedule.
Instructor Background Information:

Key Vocabulary

*Engineering Design Process*—A cyclical method of problem solving used to create a system, a product, or a process that meets an identified need.
What Is the Engineering Design Process?

The Engineering Design Process is a series of steps that aid in the design of an effective solution for a given problem. Engineers use different versions of the steps. Here is one example of the steps of the process:

- Define
- Research
- Develop
- Choose
- Create
- Test and Evaluate
- Communicate
- Redesign
Define: The Engineering Design Process always begins with a need, or a problem that must be solved. It may also involve an improvement to an existing design. The main challenge at this point is to define exactly what the need is, including any specific requirements. A complete understanding of the need will make the solution easier to design.

Research: Once a need has been established, the next step is to ask questions about the nature of the problem and to do any necessary background research. Other people may have tried to solve a similar problem in the past. Engineers may incorporate past work into their own design process, but they must be careful to not use someone else’s idea without permission.

Develop: This is essentially the brainstorming phase of the process, which gives engineers a chance to be creative. It’s important to remember that there may be more than one solution to a problem, and, in many cases, there are multiple solutions. Once a list of ideas has been generated, the engineers can select the most promising idea to work on.

Choose: Planning involves taking an idea and filling in all the details that will bring the idea to life. While developing the idea, engineers will break the design into smaller parts to determine exactly how each part will function, draw diagrams, and compile a list of necessary materials. As they develop their solutions, engineers often call on their own knowledge of math and science, but they may have to do additional research to complete their design.

Create: After the planning stage is complete, engineers build a prototype of their design, then come up with effective ways to test it.

Test and Evaluate: Once the design has been tested, engineers use the results as a basis for possible improvements. They examine what worked, what didn’t work, and what could work better.

Communicate: In this stage, engineers use this data from their tests to make improvements on their design. This is also a good time for peer review and feedback.

Redesign: Upon receiving feedback, engineers may make further improvements on their design until they are satisfied with the final version. The process seems linear, but in practice, the steps may blend into each other, occur out of order, or repeat several times. Engineering is the process of trying, creating, testing, and then re-trying until the design works. It can be a lengthy and drawn-out process, and it is rare that a design works perfectly the first time.
Instructor Preparation: See each activity for specific instructions.
Lesson:

1. Lead students to define an engineer as someone who solves problems by developing new or improving existing products or ways of doing things.

   Someone who solves problems for a living must have a problem-solving method. Engineers have followed the same basic method or process for thousands of years.

2. Choose the appropriate activity from the options below:
   
   **Activity 1: Toothbrush Investigation:** Use this activity to introduce this parent lesson before your students complete the approved appendix chosen.
   
   **Activity 2: Reviewing the EDP Wheel:** Use this activity to review the information in this parent lesson after your students completed the chosen approved appendix.

3. Conduct the activity using the information available in each activity’s description below.

Strategic Questions:

- **What does an engineer do?**
  (An engineer uses knowledge and skills to solve problems.)

- **Why does an engineer take so many steps to solve a problem?**
  (These steps will often help guide an engineer or engineering team to the best possible solution.)

The two activities outlined here complement each other and can be used together to reiterate the EDP process for students. If using Activity 1: Toothbrush Investigation, consider using Activity 2: Reviewing the EDP Wheel while students complete the chosen approved appendix.
Activity 1: Toothbrush Investigation

Time: 15 minutes

Student Materials

Per group of 2-4 students

- 1 Plastic cup
- 4 Toothbrushes, all of different designs

Instructor Preparation

✓ Collect materials for each student group.

Activity

1. Direct students to investigate the toothbrushes at each of their tables. Have them look for similarities and differences.

2. Discuss with students how the engineers that worked on the design of these toothbrushes had to think of important features to include in their design.

   Ask: What are some of the questions they must have considered while they were working on their design? (Answers will vary. Possible answers include: What way should the toothbrush bend? What shape should the head of the toothbrush be? What is the most comfortable shape for the handle?)

3. Explain to students that engineers constantly ask themselves “why,” and questions like it, all the time. When engineers are designing something, they cannot just think of one aspect of their designs. To be successful, they have to investigate over and over to make sure they have thought of as many ideas as possible.

4. Overview the Engineering Design Process steps:

   A. Define the problem
   B. Research the problem
   C. Develop possible solutions
   D. Choose the best solution
   E. Create a prototype

Please note that the toothbrushes utilized for this activity can be purchased for a dollar from any discount store. Just make sure they are all of different designs.

Caution students that they should not put the toothbrushes in their mouths.
F. *Test and evaluate* the prototype

G. *Communicate* results

H. *Redesign* if necessary

* Go through process again *(Repeat)*

5. Using the chart on page 10, walk students through an example of engineering a product —such as the PTC software design of the *Braun* toothbrush—so they can understand the steps in action.
Define the problem:
People need to have a device to apply toothpaste to their teeth to remove plaque and germs.

Research the problem:
Look up what other people use, study other toothbrushes, study plaque accumulation on teeth, etc.

Develop possible solutions:
Brainstorm everything you can think of related to brushing teeth; every bristle configuration, construction material, length, width, etc.

Choose the best solution:
Out of all the ideas, choose one or a combination of several that you think would work the best.

Create a prototype:
Make a model of the design you have chosen.

Test and Evaluate:
Use the model and complete several tests. Use the model several times and assess the results. What worked well and what needs improvement?

Communicate:
Discuss the results with others and brainstorm solutions to problems and possible improvements. Perhaps the tests showed that your back teeth were not getting clean enough, but it was difficult to position your hand in a way that the toothbrush could reach those teeth adequately. You decide to bend the handle of the toothbrush to angle it to reach your back teeth better.

Redesign:
You decide to start the process all over again to make a new prototype with the angled handle.

*Define the problem:
Now you have a new problem: How do I angle the toothbrush to get maximum cleaning of the back teeth? The process continues.
Activity 2: Reviewing the EDP Wheel

Time: 15 minutes

Student Materials

Per pair of students
- 1 Set of laminated pie wedges of the engineering design process wheel (see attached graphic)
- Sandwich bag
- Presentation system (optional)

Instructor Preparation

- Cut and laminate a set of engineering design wheel pie wedges for each pair of students.
- Place each set of eight pie wedges in a plastic sandwich bag, and distribute to student pairs.

Activity

1. **Ask:** What is a process? (*A series or steps taken to reach an end.*)

2. **Ask:** If a process is the steps in which something occurs, what do you think the Engineering Design Process is? (*A series of steps that aid in the design of an effective solution for a given problem. The steps in which an engineer designs something.*)

3. In pairs, have students place the eight pie wedges in order according to how they think the Engineering Design Process occurs using the blank EDP wheel in their activity log. Give the students two minutes to put them in order.

4. Review the correct order, or project the complete wheel for the students. Direct students to correct any mistakes they may have made in their order.

5. Explain that the activity (appendix) you just completed was an example of the EDP process.

6. Have students move the correct EDP wheel order off their activity log and onto the table. Give them a few minutes to complete the blank EDP wheel with the steps of the activity they just completed.

7. Review the results with the whole class.
Engineering Design Process Steps
**Engineering Design Process Steps**

*(Please note Operation Bridge Quest was used here as example.)*

1. **Define the Problem:** Design and construct a bridge that will allow supplies to be delivered to the town.
2. **Research the Problem:** Research types of bridges that could be built.
3. **Develop Possible Solutions:** Come up with as many bridge designs as possible.
4. **Choose the Best Solution:** Pick the bridge design that best solves the problem.
5. **Create a Prototype:** Construct your bridge.
6. **Test & Evaluate:** Test your bridge design.
7. **Communicate:** Discuss the results of your prototype.
8. **Redesign:** Make adjustments to your bridge design.

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**Introduction to EDP**

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Suggested Final Assessment Questions

1. The steps of the Engineering Design Process are listed below. Put them in the correct order.

   ____ Choose the Best Solution
   ____ Communicate
   ____ Research the Problem
   ____ Create a Prototype
   ____ Test and Evaluate
   ____ Define the Problem
   ____ Redesign
   ____ Develop Possible Solutions

2. Please explain how the redesign step is essential to the process using today’s activity as an example.

3. Please describe a situation when an engineer would use the Engineering Design Process.

4. Why is it important to plan a design carefully before you build it?

5. If a team of engineers reported that their prototype was not as successful as they had hoped, what should they do next?
   a. Retest the prototype.
   b. Research more information about the problem.
   c. Give the problem to another team to solve.
   d. Try to sell the product, since they have put in a lot of time in developing it.
Introduction to EDP

Suggested Final Assessment Questions

**Knowledge**  
1. What are the Engineering Design Process steps?
   - Choose the Best Solution
   - Communicate
   - Research the Problem
   - Create a Prototype
   - Test and Evaluate
   - Define the Problem
   - Redesign
   - Develop Possible Solutions

**Comprehension**  
2. Please explain how the redesign step is essential to the process using today’s activity as an example.
   
   **Possible answer:** It is essential to redesign the parachute to improve it because I wanted my parachute to go slower.

**Application**  
3. Please describe a situation when an engineer would use the Engineering Design Process.
   
   **Possible answer:** Answers will vary. Students could talk about parachutes for Mars missions, seat belts, airbag, toothbrushes, etc.

**Analysis**  
4. Why is it important to plan a design carefully before you build it?
   
   **Possible answer:** If you build without planning, the design is more likely to have problems. Planning first can save time and money.

**Application**  
5. If a team of engineers reported that their prototype was not as successful as they had hoped, what should they do next?
   
   a. Retest the prototype.
   
   b. **Research more information about the problem.**
   
   c. Give the problem to another team to solve.
   
   d. Try to sell the product, since they have put in a lot of time in developing it.