“Extending the CTE-STEM Pipeline into Middle Schools”

Green Engineering

Introduction to the Engineering (Part 1)

Solutionary Phase	Fundamentals
Lesson # and title	Lesson 1: Introduction to Engineering (Part 1)
Duration	45 minutes

Lesson Overview

The beginning of this unit introduces students to the basics of engineering, some types of engineers, and the steps of the engineering design process. Engineers use the engineering design process when brainstorming solutions to real-life problems; they develop these solutions by testing and redesigning prototypes that work within given constraints.

This lesson also introduces the Three Little Pigs Engineering Design Challenge, where students will team up to build houses for the Three Little Pigs out of index cards and masking tape. After subjecting the constructed houses to a wind test, teams will have the opportunity to rebuild or reinforce their structures before a second wind test!

Learning Objectives

After this activity, students should be able to:

- Explain the stages/steps of the engineering design process.
- Identify the engineering design process steps in a case study of a design/build example solution.
- Understand project criteria and constraints.
- Apply the engineering design cycle steps to future engineering assignments.

Content Standard(s)

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. (Grades 6 - 8)

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (Grades 6 - 8)
CTE.EA.B.6.1. Understand the steps in the design process.
CTE.EA.B.6.5. Demonstrate the process of developing multiple details, within design constraints, into a single solution.
CTE.EA.C.3.2. Produce proportional two- and three-dimensional sketches and designs.
CTE.EA.C.2.1. Employ engineering design equipment using the appropriate methods and techniques.

College and Career Connection(s)

Engineers apply their in-depth understanding of scientific and mathematical subjects to design and create devices, structures and systems that improve our lives. While scientists investigate what already exists and discover new knowledge by peering into the unknown, engineers create what has not been—they make things that have never existed before. Engineering teams follow the steps of the engineering design process: understand the need/problem, brainstorm different designs, select the best design, make a plan, create and test a prototype(s), and improve it until a satisfactory solution is achieved. The process is cyclical and may begin at, and return to, any step.

Equipment, Instructional Resources, and Materials

TEACHER ACTIVITY SET-UP SHEET
Building Materials (not used until part 2)

- 3 x 5 Index Cards: 16 cards per team of students and 9 more for second try
- Two-Inch-Wide Masking Tape: One roll. Each team of students will need a one-foot strip of tape.
- Platforms: Each team will need one platform. The foundation of the houses will need to be built/taped onto the platform. Mini-whiteboards or cut out cardboard will work well.
- Rulers: One per team
- Scissors: One pair per team
- Roof: Each team will need a roof, provided in the template in this link. Print and make copies of the roof template on 11x17 paper. Students cut out the template and fold as indicated on the lines. Use the tab to tape or glue the roof together. (Do this in advance if time is limited)

Experiment Materials

- Student Instruction Sheet: This can be printed or given to students digitally.
- Fan: One “Squirrel fan” or carpet dryer for the entire class. Most school janitors have a fan that can be borrowed in order to conduct the wind test.
- Measuring Tape: One measuring tape to be used alongside the fan.

Technology Tools:

- 1:1 Computers (optional)
- Access to projector and Google Apps for Education
- Book Creator App: (optional) for Engineering Notebook and for student Reflection (Google Slides can also be used as a Engineering Design Notebook)

Optional Materials (not used until part 2)

- Little Toy Pigs: 1” x 1” x 2” (approx.) toy pig figurines that can fit through the door of the constructed houses
- Wolf Mask: One mask to be placed on the fan to enhance the story connection

Suggested Student Grouping

- Whole group: Review Engineering Design Process and Introduce Engineering Design Challenge
- Small groups (~3 students): Help save the three little Pigs

Vocabulary

- **design:** Loosely stated, the art of creating something that does not exist.
- **engineering:** The use of science and mathematics to solve problems to improve the world around us.
- **engineering design process:** A series of steps used by engineering teams to guide them as they develop new solutions, products or systems.The process is cyclical and may begin at, and return to, any step.
- **criteria:** What the design needs to do in order to be successful--its requirements (purpose, form, style, etc).
- **constraint:** A restriction on the degree of freedom one has in providing a solution to a problem or challenge.
- **prototype:** A model of a product that is used for testing before it is manufactured. Prototypes help designers learn about the manufacturing process of a product, how people might use it, and its durability.

The Lesson

Preparation

Prior to Class

- Gather and prepare all materials in advance.
- Set up the Wind Test Area. The measuring tape should be taped down on the table next to the fan (cm side up with 0 at the fan)
- Decide on the number of team tables needed to complete the Engineering Design activity.
- Assemble desks into groups if necessary.
- Have the following materials out on each team's table prior to the beginning of class:
    - 16 Index Cards for Round#1 and additional 9 cards for Round#2
    - Scissors
    - Platform
    - Ruler
    - Tape (can cut 1ft strips in advance)
- Copies of Roof template (cut and fold in advance if time is limited)

Lesson Procedure

Link to Lesson Slide Deck:

Activity/Task	Description	Time (min)
Slides 1-4 Introduce engineering	• Show students the pre-unit quiz questions (slide 2). This can be a written pre-assessment, a discussion, or you can use tech tools, such as Jamboard, Mentimeter, or Pear Deck, to capture student answers digitally. • Show the video clip on slide 3. Watch and discuss the clip (if there is extra time, watch the rest of the video and discuss) • Go through information on slide 4.	7 mins

Slides 5-6: Career Exploration Group Activity	• Ask students what design challenge they would like to solve? - Assign them to the following reading groups based on their answers.
	  ○ 1: Aerospace Engineering
	  ○ 2. Mechanical Engineering
	  ○ 3. Electrical Engineering
	  ○ 4. Biomedical Engineering
	  ○ 5. Civil Engineering
	  ○ 6. Chemical Engineering
	  ○ 7. Agricultural Engineering
	  ○ 8. Environmental Engineering
	  ○ 9. Computer Engineering
	• Group students according to their interest. Let students know that Engineering is sometimes split into more or fewer disciplines, but today we will be zooming in on the ones above.
	• Give them the printout of their engineer. Ask them to take turns and read the handout.
	• Have groups share their takeaways from the handout with other groups.
	  ○ Extension: Have students Each group has to come up with a prop, drawing, etc. that represents their engineering discipline
	  ○ Additional resources to explore (if time):
	  ■ 7 Types of Engineering | Sphero Blog
	  ■ Choosing your engineering discipline
	  ■ Engineering Disciplines at LIT
	• Tell students that engineers:
	• Help others by solving all sorts of problems. Use one of their most important tools: their own creativity. Work in design teams. Use cool tools such as computers, microscopes, testing machines, etc. Communicate with lots of people about problems they need solved. Share ideas and solutions with others through presentations and/or writing.
		13 mins

Slides 7-13: Introduce Engineering Design Process	• Show students the Grand Challenges facing engineers on slide 7.
	  ○ Tell students that the National Academy for Engineering (NAE) has identified these 14 Grand Challenges for Engineering in the 21st Century. The Grand Challenges are a call to action and serve as a focal point for society's attention to opportunities and challenges affecting our quality of life.
	  ○ Ask students, how do you think engineers will be able to solve these challenges?
	  ○ Show students the skills that engineers use to solve problems on slide 8.
	  ■ Source: http://www.engineeringchallenges.org/challenges.aspx - More information on each challenge can be found here. If time, have students explore the challenges on this website
	• Introduce the Engineering Design Process:
	  ○ Show slide 9: Tell students that engineers solve complex problems by using the engineering design process.
	  ○ Show slide 10: Tell the students that there are many different versions of the engineering design process that they might encounter. Have students discuss what they notice about all of the different versions shown on the slide.
	• Watch the video on the Engineering Design Process (slide 11)
	  ○ Ask students to follow along using KQED's engineering design process graphic and to pay attention to each of the steps of the process as it relates to the taco party.
	  ○ Periodically, pause the video to have them predict what will happen next.
	  ○ After watching, have them discuss the main takeaways.
	• Show slide 12 (make sure you are in present mode so that each step appears one at a time) Ask students if they recall the steps of the engineering design process from the video.
	  ○ Remind students:
	  ■ To solve engineering problems, engineers follow a series of steps called the "Engineering Design Process" (EDP)
	  ■ Anyone can do it!
	  ■ EDP is a cycle—there's no official start or end point. You can begin at any step, focus on just one step, move back and forth between steps, or repeat the cycle.
	• Show slide 13: Tell students that in order to help define a problem, engineers focus in on a user (a person with a need or problem). A user can be a single person, a group of people, or even a part of the system, but the thing they all have in common is that the problem and solution will directly affect them. Once
		10 mins

	an engineer designs a solution, the user will also provide feedback or data on if the solution actually works as they put the solution into action.	

Slides 14-16: Introduce their Engineering Design Challenge	• As engineers, the students will work as a team to Help save three little pigs by building a house with the given constraints and materials. Divide the students in groups of three or four depending on your space and materials.
	• Watch the video on structural engineering
	  ○ Tell students that they will be approaching this challenge the way a structural engineer would. Structural engineers are types of civil engineers whose main focus is making sure a structure is stable in the face of different forces.
	  ○ Optional Extension: Have students learn about Joseph Strauss, the engineer who designed the Golden Gate Bridge: https://www.goldengate.org/bridge/history-research/bridge-construction/joseph-strauss/
	• Describe the challenge
		5 mins

Slide 17-21: Define/Identify	• Pass out the student worksheets for the challenge (or have students access the worksheets on a computer).
	• Have students discuss and answer the “define” questions with their small group.
	  ○ Model filling in the problem statement. Example: The pigs need a stable house to hide in because the wolf wants to eat them and can blow down unstable houses.
	  ○ Tell students that they will be watching part of the original Disney animation of the 3 Little Pigs from 1933. As they watch, they should be thinking about the Define step of the engineering design process. (skip if short on time)
	• Discuss definition of criteria/constraints. Ask students to discuss, “Which of the building guidelines would be considered criteria? Which would be constraints? Are there any other criteria/constraints that your team may want to consider?”
	• Review the building materials
	• Have students quickly discuss/answer the “identify” questions with their small group.
		10 mins

Slide 22: Brainstorm/Select	• Have students spend about 2 minutes independently writing/sketching ideas before discussing with the group. • Once students have determined their selected design, all group members should draw the plan to check that they understand how they will be building it tomorrow	10 mins

	(the labeled diagrams should match)	
Slides 23-24: Gather Materials, Build Roof, Preview Next Day	• Have students gather their materials and build the roof in preparation for the next day. • Have students make a plan for the build day. • Preview what the students will be doing on their build day	If there is extra time

Assessment/Extension		
Sides 25-26 (optional)	Slide 25 Bonus/Extension - This can be assigned as a reflection (in-class or homework) or introduced at the beginning of the lesson for students to take notes in during the lesson. Students can be given the choice in how they would like to capture their notes/reflections such as pencil/paper, Google slides, or Book Creator. Sample Book creator link:(optional) - Suggestion: Have students choose which reflection questions they would like to answer. Slide 26 Optional Extension (if time): Review game to play with class - Depending on the amount of time in the class period, you could have students begin building and move this to the end of the fundamentals.	10-20 mins
Grade Student Instruction Sheet (optional)	Student instruction sheets (Part 1) can be collected and reviewed as an optional formative assessment. An Engineering Design Rubric can be helpful in assessing students.	N/A