

GRADE LEVEL: 3-8 | TIME REQUIREMENT: 4 HOURS

# ENGINEERING SKILLS

1 READING | 3 ACTIVITIES

## INTRODUCTION

STEM is the most powerful way to teach science because it integrates science content with problem solving, communication, and calculation. The resources in this section all explore topics using a STEM approach.

### NGSS SEP

Asking Questions and Defining Problems, Analyzing and Interpreting Data, and Engaging in Argument from Evidence

### NGSS CCC

Patterns, Scale, Proportion and Quantity

## OBJECTIVE

Pair the reading with one or more of the activities. The most natural pairing is between **Kaiser Ship Building** and **Assembly Lines**. **Necessity Cards** can be used to encourage students to think creatively and to take on challenges themselves. Depending upon your objectives and on your estimation of student background knowledge, you might ask students to use only existing technologies in the **Necessity Cards** activity. **Inspected By** presents a chance for students to engage in quantitative analysis. Again, evaluating a process reminds them that engineering is not just for products, but for processes as well. These last two activities could also be used as stand-alone exercises to practice collaboration (**Necessity Cards**) or quantitative skills (**Inspected By**).

## PERFORMANCE EXPECTATIONS

### 3-5-ETS1-1

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

### 3-5-ETS1-2

Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

### 3-5-ETS1-3

Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

### 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.

## STANDARDS

### NGSS DCI ETS1.A

Defining and Delimiting Engineering Problems

### NGSS DCI ETS1.B

Developing Possible Solutions

### NGSS DCI ETS1.C

Optimizing the Design Solution

### NGSS DCI ETS2.B

Influence of Engineering, Technology, and Science on Society and the Natural World

## READING (1)

### 1. KAISER SHIP BUILDING

#### Description

A short reading describing how an assembly line was optimized to meet production needs. It is valuable for students to understand that processes, not just products, are engineered. This reading describes how the traditional process of ship building was adapted to make it faster and more efficient.

## ACTIVITIES (3)

### 1. ASSEMBLY LINES

#### Description

An activity in which students optimize their own hands-on assembly line. Using only ballpoint pens, students work in groups to quickly assemble the pens. Groups practice and optimize their process and then compete together to see which group had the fastest method. Differences in group size can become a discussion point, and a debriefing of how the different groups collaborated to improve their process is a chance for a productive discourse on effective teamwork and problem solving. We suggest using the activity at the beginning of their school year to set expectations for group work and collaboration.

#### Supplies

6 “Clickable” ballpoint pens per group

#### Instructions

Show the students how to take apart and reassemble a pen. Show how many parts there are and make sure they all know how to put them back together. Explain that students need to work in their team to optimize an assembly line to put the pens together. They can practice and iteratively improve their process, competing against the clock for 10-15 minutes. The pens have to be assembled correctly and have to work. After the practice times, have the teams compete to see which can put six pens together fastest. (It’s a good idea to keep extra pen parts on hand.)

### 2. NECESSITY CARDS

#### Description

An activity in which students brainstorm solutions to problems. In groups, students are presented with challenges faced by the Allies in World War II. To fit your needs, you can adjust how much time they spend brainstorming and how they present their products. You could go as far as having them draw plans and make prototypes, or you could be as brief as an outline of ideas. The real key to the success of this activity is getting students to participate in accountable talk and into thinking of constraints and possibilities in innovation.

#### Supplies

Copies of the cards at the end of the activity.

#### Instructions

Divide students into teams and have each team take a card. Individually, students write down their ideas for solutions, then share them with the group, with the goal of creating a consensus solution. If you have more time, you can have groups get really involved and make prototypes and presentations, or you can just let them brainstorm and share ideas.

### 3. INSPECTED BY

#### Description

An activity in which students practice their quantitative skills to consider quality control. Groups count up the number and color of M&Ms in the bag they are given. Students then graph the number of each color and calculate percentages. When they compare their results across the class and pool them, there is another chance for students to practice using productive, accountable talk. In this activity students will also gain experience looking at variation and how pooling data can sometimes hide variation.

#### Supplies

1 Bag of plain M&Ms per team

#### Instructions

Explain that the candies are not to be eaten until after the investigation. Students in groups will count the number of candies per color and the total number of candies. You can then ask students to make a bar graph of results. Compare bar graphs across the class: Is the same color always the most frequent? Is the total number of candies consistent? What do the results tell you about the process of bagging candies?

---

## ADDITIONAL RESOURCES

To learn more about the use of engineering in World War II, try these books:

+ *Engineers of Victory* by Paul Kennedy, Random House

+ *Freedom’s Forge* by Arthur Herman, Random House

## READING

## KAISER SHIP BUILDING

On July 30, 1942, a passenger ship named the *SS Robert E Lee* was carrying 407 crew and passengers steaming towards New Orleans. Waiting off the coast of Louisiana, a German submarine (U-boat) shot a torpedo at the ship, sinking it. Twenty-five people died, and the rest were rescued by a civilian tugboat and two US patrol boats.

The *Robert E Lee* wasn't the only victim of U-boats. By July 1942, in the Gulf of Mexico and off the East Coast of the United States, U-boats had sunk over 300 ships. Supplies to the United States were threatened, as were food and military supplies sent to Great Britain.

While the military sought solutions to decrease the threat of U-boats, the US government saw the need to quickly make many new transport ships. These new ships were needed to bring resources to the United States, to replace ships sunk by U-boats, and to ship manufactured goods overseas to support the war effort.

One of the companies that responded to government requests to build transport ships, which came to be called Liberty Ships and Victory Ships, was Kaiser. Kaiser was a company that had helped build the Hoover Dam—one of the biggest engineering projects in history. One of Kaiser's great innovations and contributions to the war effort was prebuilding parts and assembling them in place.

Kaiser Shipyards built plants to make Liberty and Victory ships on the West Coast of the United States, near San Francisco,

California, and Portland, Oregon. Using their new assembly processes, Kaiser Shipyards built 1,490 ships during the war. At Kaiser a ship took two-thirds of the time and one-fourth of the money to produce than at other factories.

Traditionally, the hull of a ship was made first. The hull is most of what you see of a ship: the outside part that floats in the water and rises up to hold the decks and deckhouses. After the hull was made, all the workers making the parts inside the ship climbed in and out of the ship, making for a slow process.

Engineers at Kaiser came up with a new idea. While the hull was being built, the pieces for the decks and deckhouses would be assembled in another part of the factory. Then when the hull was finished, the decks and other parts would be lowered into the hull and welded in place. All the parts had to be exactly the right size so that they would fit. Eventually Kaiser engineers got the production time down to between 40 and 50 days for one ship. Imagine that—a ship 442 feet long and weighing about 32 million pounds being built in 45 days.

Kaiser engineers **adapted** the ship building process, optimizing it for speed. They did this in two ways: by using what they had learned about premaking pieces of a large structure during their construction of giant dams, and by using the experience of automakers to make a more efficient assembly process. With their new process, Kaiser's ships helped win the war by bringing supplies and materials to the battlefronts.



The Liberty ship *SS George Poindexter* is launched from Delta Shipbuilding Company shipyard, New Orleans, Louisiana, May 18, 1943. (Image: The National WWII Museum, 1999.060.004.)

NAME:

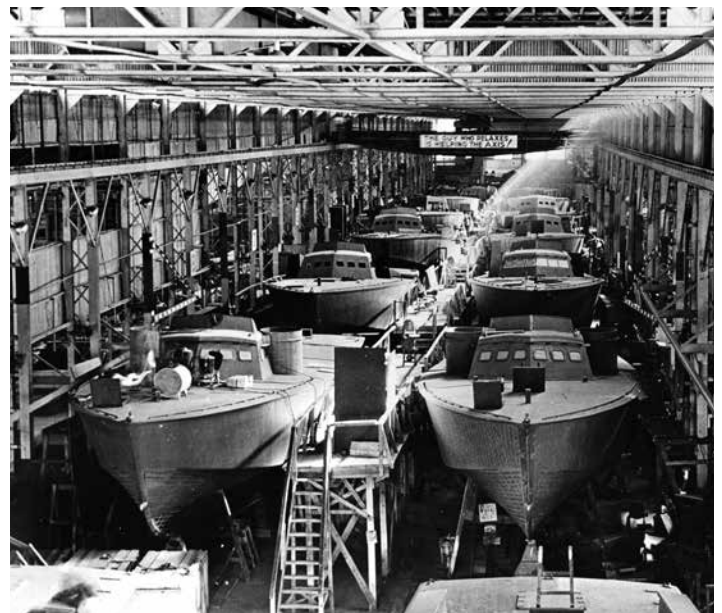
DATE:

1. What is a process you use at home or at school that could be more efficient? (Like getting ready for school, packing lunch, putting away your clothes.) What could you do differently, and how would it change the process?

2. The reading describes the Kaiser Shipyard process as an **adaptation**. Do you agree? Can an argument be made that it is an adoption or application instead? Explain your thinking.



Shipyard workers building an aircraft carrier, Newport News Virginia, January 21, 1944. (Image: The National WWII Museum, 2011.102.411.)



View of a Higgins boat assembly line, where PT Boats are being made. New Orleans, Louisiana circa 1941-1945. (Image: The National WWII Museum, 2008.280.002.)