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.

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**).

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

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

NGSS CCC
Patterns, Scale, Proportion and Quantity

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.

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

ACTIVITY

INSPECTED BY

INTRODUCTION

When things are produced on a large scale, whether they are cars, planes, or candies, someone needs to make sure they came out right. This is called Quality Control.

Quality Control Engineers, or Inspectors, examine products carefully to make sure they meet their requirements. In this activity, you will act as quality control inspectors.

Take the package of candy your teacher gives you. Open it, but don't eat it!

1. Make a data table to record information about the contents.

DID YOU KNOW

Did you know that M&Ms were a WWII invention? Throughout the war they were only available to the military. Chocolate and sugar were rationed during the war, so sweets were hard to get.

NAME: **DATE:**

2. Record the number of pieces of candy in each color; also record the total number of candies in the bag.

3. Make a bar graph to show the number of pieces of each color. Calculate the percent of each color of candy in your bag. Share your data with the class.

4. What are the percentages of each color across the whole class?

5. Was anyone's bag very different from the rest?

6. Were the numbers of candies in each bag the same across the whole class?

7. If you had a giant container of these candies that held 5,000 of them, how many of each color would you expect to find?

8. What does the data tell you about the process for putting candies in a bag? Do you think someone is checking to make sure all the bags are filled the same?