INNOVATION GENERATION
Making an Impact

CLASSROOM ACTIVITY 1

Protective design

How do face masks and shields keep us safe?

Key Learning Topics

In this activity, students will

- Skilled service trades
- Industrial skills
- Engineering design process
- Building models

Overview

In this activity, students will examine how face masks and shields are designed to keep workers safe and even prevent the transmission of harmful germs from person to person. Groups of students will be given criteria and constraints to design a mask for a target audience. The criteria and constraints will include masks for protection from viruses as well as eye and face protection for safety in the workplace. After students sketch and annotate their design, they will develop a procedure to test the effectiveness of their masks using water to simulate germs and an egg to simulate eyes and skin.

Target Audience

Grades 5–9 // Engineering, Health

Activity Duration

Two class periods, 45–60 minutes each

Essential Question

Is it possible to design a mask that prevents the transmission of germs and/or provides safety in the workplace?

Materials

- Four different types of masks—fabric masks, respirators, face shields, sports masks, etc. to show as examples (can be shown virtually if you can't find actual masks)
- **Mask Design** student capture sheet
- **Mask 2.0** student capture sheet
- **Mask Testing and Refining** student capture sheet

- Mask materials (suggested, but many materials can be substituted):
    - Cotton t-shirts (1 per group)—or, cotton rags, fabric, old t-shirts
    - Acetate sheets (1–2 per group)—or, plastic that can be cut
    - Thin Styrofoam and/or foam strips (1–2 pieces per group)—or, packing material from delivery boxes,
    - Elastic or fabric strings for tying
    - Needle
    - Thread
    - Tape
    - Glue
    - Ruler
    - Scissors
- Testing materials:
    - White paper
    - Eggs (2 per group)
    - Egg holder (2 per group, can be made from cardboard or cut from an egg carton)
    - Spray bottle
    - Water
    - Food coloring

Background Information/Links

Masks are essential gear for many places of work—medical workers, construction workers, manufacturers, and athletes all wear masks in the workplace. These masks vary in materials, design, and function. For instance, a baseball umpire's mask is made of lightweight aluminum, plastic, and foam. This face mask's wire cage structure is strong enough to withstand a hit from a wayward fastball, but it wouldn't be very good at preventing the transmission of harmful germs. Surgical masks, by contrast, are lightweight and made of nonwoven material. They would be pretty lousy at stopping a fastball, but they are fluid resistant and effectively reduce the transmission of germs from one person to another. Those qualities make them ideal for use in a healthcare setting.[1] As the world sometimes grapples with pandemics, a great deal of attention has turned to masks. The Centers for Disease Control and Prevention recommends that all Americans wear cloth masks to prevent the spread of viruses.[2] This recommendation is spurring ongoing innovations in mask design. The National Science Foundation has even provided a rapid response research grants for a self-sanitizing face mask.[3] New mask designs will be important in addressing community health needs and occupational safety standards.

[1] https://www.cdc.gov/niosh/npptl/pdfs/UnderstandDifferenceInfographic-508.pdf

[2] https://www.cdc.gov/media/releases/2020/p0714-americans-to-wear-masks.html

[3] https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=300476&org=NSF&from=news

Teachers' Note

This activity can be modified for virtual learning by taking the following steps:

1. Distribute virtual examples of different types of masks.
2. If technology allows, use the breakout groups function to complete the jigsaw exercise at the beginning of the lesson.
3. Instead of having groups work together to create a 3D model, have groups collaborate using Google Slides, Google Sketch or another virtual presentation/CAD platform to construct a 2D model.
4. Adjust the evaluation so that instead of physically testing the masks, students collaborate to design a testing procedure. Remove the **Mask Testing and Refining** student capture sheet.

Procedure

Lesson 1

Introduction | 10 Minutes

- Divide students into four groups. These will be students' "expert groups" as they participate in a jigsaw activity. To facilitate the jigsaw activity, provide each student with a **Mask Design** student capture sheet.
- Provide each expert group with one of the four masks to research. Allow 5 minutes for groups to observe their masks and write down their findings.
- Direct each expert group to count off by fours. Regroup students according to their numbers.
- Rotate the four masks between the groups. As each group receives a new mask, have members of the "expert" group share their findings on the mask. Other group members will write down their learnings on the **Mask Design** student capture sheet. Repeat three times until each group has had each mask.
- When each group has learned about all four of the masks, instruct students to return to their expert groups. Ask the following summarizing questions:
- What are your general observations about the masks? Highlight some of the similarities and differences your groups discussed.
- How important do you think the materials the mask is made from are to the overall function of the mask? Why?
- Each of the four masks offers a different kind of protection. Is there a mask in the group that would work the best to prevent the spread of germs while also offering protection from common workplace injuries in manufacturing settings (eye injuries, burns, protection from inhaling harmful chemicals, etc.)?

Classroom Activity | 35–40 Minutes

- Distribute the **Mask 2.0** student capture sheet prompt to groups.
- Read through the prompt and illustrate how students can complete each step of the engineering design process. Explain that today's activity will focus on steps 1–5 of the cycle, culminating with the creation of a mask prototype. The next lesson will focus on testing and refining the mask design—steps 6 and 7 of the cycle.
- Provide each group with the listed mask materials.

- Allow roughly 30 minutes for students to work on their prototypes. Check in and answer questions as needed.
- Ensure that each student group has a 3D prototype of a mask when the lesson concludes.

Lesson 2

Evaluation | 30–40 Minutes

- Divide students back into their expert groups and provide each group with its prototype.
- Distribute the testing materials to each group. Provide each group with copies of the **Mask Testing and Refining** student capture sheet.
- Allow 20–30 minutes for groups to test and refine their prototypes.
- When groups have completed their tests, ask each group to share the changes it made to its mask after each test and to show how testing impacted the final mask design.

Lesson Summary | 10 Minutes

- Conclude the lesson by asking students the following summarizing questions. Solicit a few student responses for each question:
    - What specific needs of a pharmaceutical manufacturing worker did your mask need to address? How would the design of the mask change if you were designing it for a clothing manufacturer? A food processing plant worker?
    - What design features, if any, did your group add to the mask to make it more comfortable to wear? Do you think comfort is an important part of the mask design? Why or why not?
    - Were you surprised by the results of your test? Why or why not? Why are testing and refining important parts of the engineering design process?

National Standards

Next Generation Science Standards (NGSS)

- 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-ETS1-4: 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.

International Society for Technology in Education (ISTE) Standards

- **4a**: Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
- **7c**: Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

Common Core Standards for Mathematics

- MP.2: Reason abstractly and quantitatively. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4)

Mask Design

Use the chart below to write down your observations and learnings about the different mask designs.

	Mask #1	Mask #2	Mask #3	Mask #4
Name				
Materials Used				
Intended Purpose				
Professional Uses				
Design Features				
Additional Observations				

Mask Design 2.0

The Occupational Safety and Health Administration (OSHA) has put out a call for engineers and designers to submit prototypes for a new type of mask. This mask will be designed specifically for pharmaceutical manufacturers and will be a combination respirator and face shield mask meant to serve two purposes:

1. To prevent the spread of harmful viruses in the workplace
2. To provide protection from harmful chemical agents by preventing inhalation/eye exposure

The new mask design must adhere to the following OSHA guidelines[4]:

1. Fits tightly around the nose and mouth
2. Can be adjusted to ensure proper fit
3. Protects from inhalation of harmful chemicals
4. Protects eyes from exposure to chemical irritants
5. Eye barrier must be thin enough for employees to maintain proper visibility

Imagine you and your group mates are a team of engineers, designers and occupational safety experts. Use what you have learned about different types of masks to design a prototype of a new mask to submit to OSHA. Follow the engineering design process[5] to develop your prototype:

Step	Result
Step 1: Identify the Need and Constraints	
Step 2: Research the Problem	
Step 3: Imagine Possible Solutions	
Step 4: Plan by Selecting a Promising Solution	
Step 5: Create a Prototype	

[4] https://www.osha.gov/SLTC/etools/eyeandface/ppe/chemicals.html

[5] https://www.teachengineering.org/activities/view/cub_creative_activity1

Mask Testing and Refining

Evaluate the effectiveness of your mask by completing the final two steps of the engineering design process: testing your prototype and redesigning it as needed. Complete three trials of your mask, recording the results in the table below after each test.

Testing Procedures:

1. Add water and a small amount of food coloring to a spray bottle—this will simulate harmful germs and chemicals, and demonstrate how effectively your mask prevents them from getting through to the wearer
2. Place each egg in an egg holder, labeling one "control" and one "variable"
3. Place your mask on the egg marked "variable"
4. Spray each egg three times
5. Evaluate the results of the test and write down your observations in the chart below
6. Assess what changes your group should make to the mask design to prevent more spray from getting through
7. Write down the improvements you made
8. Repeat steps 4–7 two more times
9. Share your final prototype with the class, explaining how you refined your design along the way

TEST 1

Step	Result
Step 6: Test and Evaluate the Prototype	
Step 7: Improve and Redesign as Needed	

TEST 2

Step	Result
Step 6: Test and Evaluate the Prototype	
Step 7: Improve and Redesign as Needed	

TEST 3

Step	Result
Step 6: Test and Evaluate the Prototype	
Step 7: Improve and Redesign as Needed	