SHELTER ENGINEERING CHALLENGE

LESSON OVERVIEW

Grade Levels: 3-8

In this lesson students will use the Engineering Design Process to construct a model shelter that could be used for protection from the falling ash that results after a volcanic eruption.

STANDARDS

NGSS 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.
NGSS 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.
NGSS 3-ESS3-1	Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.
NGSS 4-ESS3-2	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.
NGSS MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
NGSS 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.
NGSS MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

OBJECTIVES

- Students will design and build a model shelter that will not collapse as cups of flour, representing the ash from a volcanic eruption, are poured onto the structure.
- Students will apply the Engineering Design Process to ensure that they successfully build a shelter that will not collapse under the weight of more and more flour.
- Students will engage in multiple tests to make observations that can lead to the best possible final design for their structures.
- Students will share their creations with their peers to determine what the most successful structures have in common.

MATERIALS

- Large index cards (5” by 8”)
- Construction paper
- Masking tape
- Straws
- Scissors
- Flour

PROCEDURES

STEP 1: Students should work in groups of 3 to 4. Each group will be tasked with constructing a model shelter that could withstand the pressure of the accumulated ash that results after a volcanic eruption. Each can use the following materials to construct their shelters:

- 4 large index cards
- 1 sheet of construction paper
- 1 foot of masking tape
- 4 straws

STEP 2: Instruct students to use these materials to construct a shelter that:

1. Will not cave as more and more ash (flour) is poured on top of it.
2. Will prevent ash (flour) from accumulating inside the shelter.

Encourage students to use the Engineering Design Cycle to construct the best possible shelter that can meet these specifications.

STEP 3: Give students time to brainstorm and discuss with their group members what type of roof would best withstand volcanic ash build-up. Encourage them to create diagrams showing the different types of roofs or shelters to test.

STEP 4: Allow students to test their designs with flour throughout the design process, but caution them that no additional construction materials will be provided.

STEP 5: Once all of the students have completed shelters, test them to see which structures would best withstand accumulating ash. Have each group bring their shelters to the front of the room so that the rest of the class can see what they designed. Allow each group to briefly explain their design and why they think it will be effective. Test each prototype using a small cup or sifter to pour a consistent amount of flour on top of the roof. Count how many cups of flour each shelter is able to hold before collapsing or filling. You may use a scale to weigh the amount of flour needed for collapse.

STEP 6: If time allows, have students make improvements to their shelters based on the results.

STEP 7: Ask these follow-up questions:

- What did the most successful shelters have in common?
- What type of roofs should be built on homes and buildings near volcanos?
- What changes did you make to your shelter based on your observations during testing?
- It is not uncommon for falling ash to be accompanied by rain due to the weather changes that can occur after a volcanic eruption. What effect do you think adding water to this activity would have on your results? How would you need to change your design if water were added to the flour before it was poured onto your house?
- Name some geographical locations where homes may need to withstand ash accumulation.
- What other types of natural phenomena might impact the way roofs are constructed? Would the

design you created for an ash fall be appropriate in these situations?

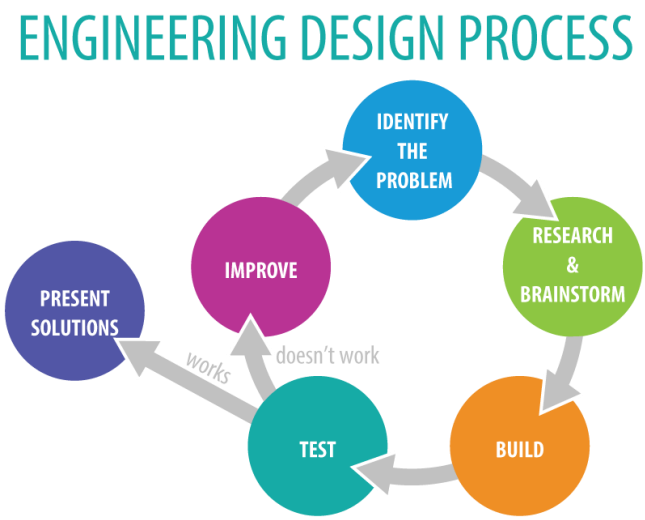
STEP: 8 OPTIONAL: Task students with investigating various volcanos around the world to determine where a large-scale eruption could next occur. Have them provide evidence to support their chosen location including data that supports their claim. Then have students write recommendations for how structures in this area should be built. Students can explain how these recommendations differ from the way structures are built where the students live or in other areas that are prone to different natural disasters.

GUIDING INFORMATION

Explosive volcanic eruptions can result in large quantities of ash being shot into the sky and carried by wind up to thousands of miles away. This volcanic ash then falls from the sky in the areas surrounding the volcano and can result in build-up of several inches and even feet. Not only is the ash hazardous to breathe, but it can challenge the structural integrity of homes and buildings. Because the ash is dangerous to inhale, many people hide in their homes or nearby buildings until the ash stops falling. However, as the ash accumulates on buildings, it causes strain that can lead structures to collapse, which is an even great danger to those inside. Volcanic ash is not only heavier than snow, but it also does not melt and disappear as the weather gets better. Many buildings that may be able to hold a great quantity of snow are unable to remain standing under the pressure of large quantities of ash. It is recommended that any homes built in an area at risk of being involved in a volcanic eruption be built to withstand a large amount of ash fall. In general, flat roofs are more prone to collapse than roofs with a steep slope. Steep-pitched roofs will allow the ash to fall away from the roof instead of accumulating. Adding reinforcements to a house to make the walls and roof stronger may also help protect against collapse.

Note: We encourage you to provide students with very little instruction on how to construct shelters. This allows students to be creative and try multiple solutions. For this activity, students are given constraints on the materials they may use. They are told only that their shelter must be able to hold the weight of added flour without caving and that it must prevent ash from accumulating inside. No other instructions or constraints are given. If you feel your students need more instruction than this to be successful, here are some suggestions:

- Instruct students to use the index cards as the base of their shelter and the construction paper as their roof.
- Provide them with various roof shapes (rounded, pitched, flat) to test to determine which best protects against ash fall – this is only recommended with younger students.



RUBRIC

	Target (3)	Meets (2)	Partially Meets (1)	Does Not Meet (0)
SHELTER DESIGN	Does a great job designing a prototype for a specific purpose.	Does an okay job designing a prototype for a specific purpose.	Tries but has great difficulty designing a prototype for a specific purpose.	Does not show an understanding of designing a prototype for a specific purpose.
COLLABORATION	Works well with others and discusses ideas in a fair, respectful, encouraging way and is considerate of the feelings of others.	Works okay with others and discusses ideas in a fair, respectful way, but may not have been encouraging. Considers the feelings of others.	Works with others, but does not contribute a fair share of work OR is discouraging and does not consider the feelings of everyone.	Does not work well with others and/or discusses ideas in an unfair, disrespectful way.
REQUIREMENTS	Meets all of the requirements for the project.	Meets most of the requirements for the project.	Meets some of the requirements for the project.	Does not meet the requirements for the project.
DEMONSTRATION OF KNOWLEDGE OF CONTENT IN DISCUSSIONS AND ACTIVITIES	Does a great job showing an understanding of the content covered in class.	Does an okay job with showing an understanding of the content covered in class.	Tries but has a difficult time showing an understanding of the content covered in class.	Does not show an understanding of the content covered in class.
TOTAL				/12