LESSON

Shipwreck Shelters

The Tech Challenge 2023
Grade Levels: 4-12
Duration: 60 min

Learners will work in teams to build structures that can withstand a natural hazard. They will visit three "islands" (stations) and build a structure with only two or three materials.

Outline

Frame the Challenge	10 min total
Activate Prior Knowledge	5 min
Introduce the Challenge	5 min
Design Challenge	**50 min total**
Prototype (Build and Test)	35 min
Island Tour	10 min
Debrief	5 min

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Concepts/Skills
Rapid prototyping, materials exploration, collaboration

Objectives
Students will:
- Explore the properties of different materials.
- Consider methods for building a structure that can withstand a natural hazard.
- Explore multiple ways to create a structure using limited building materials.

The Tech Challenge

This lesson can be used to prepare students for the 2023 Tech Challenge: Survive the Storm, presented by Amazon.

This lesson will give students experience with...

- Building within a time limit.
- Creating structures that can withstand simulated natural hazards.
- Designing a solution with limited materials.
- Collaborating with a team to prototype different structures.

Materials and Preparation

Materials

This activity challenges students to build a stable structure with minimal materials. Each station should have a different combination of **one** building material and **one** connector.

Create your own combinations, or try some of our favorite mash-ups below:

			
• Cardboard tubes • Paper clips	• Pencils • Rubber bands	• Cardstock • Small binder clips	• Straws • Pipe cleaners

Here are some other material suggestions for creating your own combinations. Don't limit yourself to the items on this list — be creative!

Building Materials *(30 total per station)*	**Connectors** *(60 total per station)*	**Tools** *(1 set per station)*
☐ Aluminum ☐ Cardboard tubes ☐ Cardstock ☐ Chopsticks ☐ Paper ☐ Pencils ☐ Straws	☐ Paper clips ☐ Pipe cleaners (chenille stems) ☐ Rubber bands ☐ Small binder clips ☐ String	☐ Ruler ☐ *Optional*: Hole punch ☐ *Optional*: Scissors

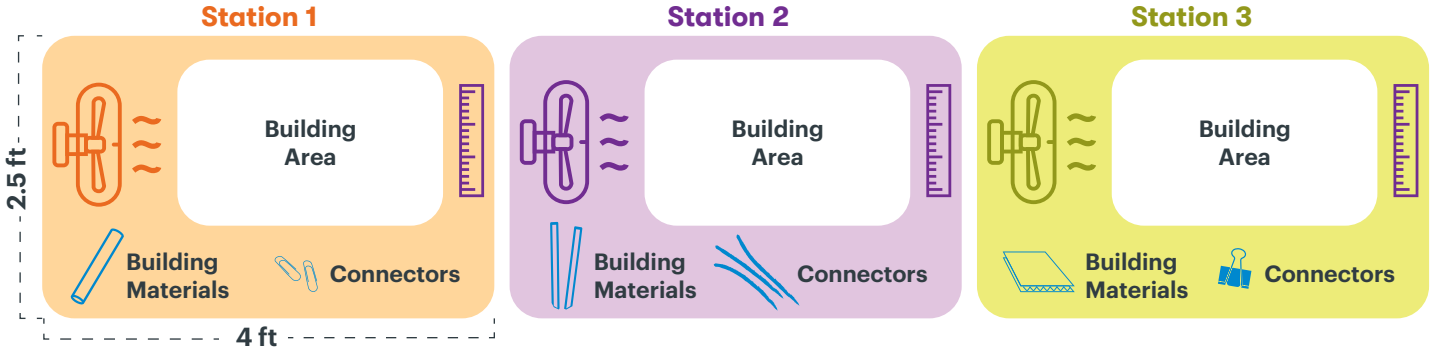
We recommend no tape or glue. Why? Because building without tape or glue lets you change your designs faster and makes it easier to reuse materials.

Testing Setup

1. Designate three areas to act as building stations, ideally in different parts of the classroom to avoid having natural hazard tests from other stations affecting each other.
   - Each island area (aka building station) will need enough room to accommodate multiple structures.
     - We recommend using a table or taping out a space on the floor that is at least 2.5 ft x 4 ft.
   - ***Note***: Adjust the setup based on class size. *For example*, with a class of 30 students, plan to have two teams build at each station or set up another set of stations.
2. Choose **one** natural hazard to test at all three stations. Each station should have the same test and testing materials. (See below for some options of hazards and testing set-up.)

Natural Hazard	Testing Materials	Set Up	Testing
Option 1: Hurricane 	□ 3 portable fans	• Have a portable fan available at each station. • If you do not have enough fans, try substituting a hair dryer or using a binder to fan the air.	• Students will point the fan at their structure and turn the fan on for 10-15 seconds. • If the fan has multiple speeds, encourage students to run a test for each speed, starting with the lowest.
Option 2: Earthquake 	□ 3 flat surfaces (*e.g.* cutting boards, textbooks) Choose surfaces that will move minimally during building, but can be shaken during testing. □ Clamp (*optional*)	• Instruct students to build their structures on the flat surface. • If the surfaces don't stay still during building, try clamping the surface down to the table.	• Remove clamps or anything else securing the flat surface and preventing it from moving during building. • Students will perform a shake test by shifting the surface side to side for five seconds.
Option 3: Landslide 	□ 3 flat surfaces to act as an incline (*e.g.* folder, plastic tray) □ Small objects for landslide (*e.g.* Legos, Lincoln Logs, Dominos)	• Have landslide materials available at each station.	• Students will position the tray at an incline and slide the small objects toward the structures.

Sample Setup for Option 1: Hurricane



Preparation

1. Collect, organize and set up building materials and connectors at each station.
   - Choose some of our suggested combinations or make your own by choosing two or three materials to place at each station.
2. Choose **one** natural hazard and collect testing materials.
   - **Tip:** Try connecting the natural hazard to your content standards.
3. Try building with the materials from each station ahead of time. This will give you practice with the materials and tools in order to anticipate student questions.

Frame the Challenge

Activating Prior Knowledge *(5 min)*

1. Ask students to list some of the materials that are used to build structures like houses and other buildings.
   - Encourage them to think about how those materials have differed throughout history and around the world.
   - Students may notice that...
     - Building materials can include all kinds of natural and man-made materials (snow and ice, straw, glass, wood, sand, etc.).
     - The materials used may be dependent on what is available.
     - The strength of a structure can vary depending on the materials or the way it is constructed.
2. Introduce students to the term **natural disaster** and ask what they imagine when they hear this term.
   - Let them know that natural disasters refer to the negative impacts caused by **natural hazards**, or natural phenomena that can be potentially dangerous.
3. Explore what students know about natural hazards and their potential consequences. **Guiding Questions** can include:
   - *What are some examples of weather that can be a natural hazard?*
   - *What are some examples of natural hazards that are not weather related?*
   - *What are some potential effects natural hazards have on large structures like houses or other buildings?*
4. With this in mind, ask students what they might need to consider when building a structure in some of these areas. *For example:* Different locations will be exposed to different natural hazards.

Content Connections

This design challenge aligns well with content on climate change, the availability of natural resources, and the effects natural hazards can have on human populations. Check out these websites to...

- See existing data on natural disasters.
- Learn more about why natural disasters occur.
- Explore how climate change impacts natural disasters.
- Find out how to prepare and stay safe during a natural disaster.

- "Natural Disasters," National Geographic website
- "Natural Disasters," Our World in Data website
- "Severe Weather 101," NOAA National Severe Storms Laboratory
- "Natural Disasters and Severe Weather," Center for Disease Control website

Explore solutions to the climate crisis by visiting the Solve for Earth exhibit at The Tech Interactive. Learn more at Solve for Earth.

Introduce the Challenge *(5 min)*

1. Introduce the **design scenario**:

> *You and your team are shipwrecked on an archipelago (an island chain). You need to build a structure to withstand a natural hazard. Each time you face the hazard, you will move to a new island and try rebuilding with a different set of available materials. You will need to observe the ruins from previous inhabitants (teams) and decide how to build a new structure that can survive the same natural hazard.*

2. Introduce the design problem, criteria, and constraints.

Design Problem	Build three structures using different materials that can withstand a natural disaster.	
Criteria	Structures need to... • Stand upright on their own. • Be at least eight inches tall.	• Withstand the natural hazard test. • Have at least one aspect that is different from the previous group.
Constraints	• Use only the materials provided at your island. • Complete all three stations within the time limit.	

3. Let them know they will work as teams to build structures at three different stations.
   - Introduce them to the different materials at each station. Remind them that they will only be able to use those materials to create their structure.
4. Demonstrate the natural hazard test. Tell teams that they will need to perform the test before they can move on to the next station.
   - Emphasize that they will face the same kind of natural hazard at each station. So they will perform the same test on each structure that they build.
5. Inform students that they will leave their structure up after they complete the station, so each island will have multiple structures by the end of the prototyping period.
   - Emphasize that they can learn a lot from the ruins left by previous inhabitants. Teams can consider which parts of the ruins survived the disaster.
   - ***Note***: While they can get inspiration from the structures from previous teams, they will need to be able to share at least one thing they did differently with their structure.

Adaptations for Younger Engineers

- Turn the hurricane hazard into the story of the Three Little Pigs. Ask learners to build structures that can protect the pigs from the big bad wolf's mighty breath.
- Try offering two or three types of connectors at each station, instead of just one. This will give beginning engineers more options for building the structure.

Adaptations for Advanced Engineers

In addition to the criteria listed above, consider adding the following for older or advanced engineers:

- Include a small object that the structure will protect. It must fit inside the structure.
- Add additional height or weight constraints.

Design Challenge

Prototype (Build and Test) *(35 min)*

1. Put students into teams of four or five, depending on the size of the class.
2. Assign teams to stations. Let them know they will have 30 minutes to rotate between stations, so they will only have about 10 minutes per station.
3. As teams build and test, walk around and support them.
   - Help students focus on the process, rather than on the success of their designs. If their design fails, ask them how many things they have tried, what they notice about what isn't working and what they might try next.
4. Ask open-ended questions to encourage students to reflect on their process.
   - *What kind of shapes and designs do you think would make a sturdy structure?*
   - *What happens when you bend, twist, or fold this material?*
   - *What have you discovered about how to connect these materials?*
   - *What do you think will happen to these materials during testing?*
   - *How could you change the way you have used these materials to improve your design?*
5. Keep teams updated on the time so they know when they should be testing and switching stations.
   - Help students celebrate after each test — even if their design fails! Emphasize the value of learning from failure in a group setting.

Collaboration

Collaboration is critical to engineering a successful solution. Encourage teams to reflect on how they are collaborating within their own team as well as with the larger class.

This challenge encourages students to look at each other's designs for inspiration and teams may naturally borrow ideas from each other. Remind them that this is a common practice in engineering as long as they "copy with credit." For example: "After seeing how the Green team used rubber bands, we changed how we approached the design. Thanks Green team for the idea!"

See the **Innovator Mindsets Tech Tip** (**PDF** and **Video**) for more ideas on how to support collaboration and other critical mindsets during a design challenge.

Island Tour *(10 min)*

1. Once building time is up, have the class take a tour of the islands.
   - Go to each station for a few minutes and have teams briefly share their structures.
   - In addition to sharing their designs, teams should share what they learned from previous inhabitants (other team's structures).
2. Celebrate all the structures by highlighting what can be learned from damaged or incomplete ones.

Debrief *(5 min)*

1. Lead a short debrief with some of these questions. Possible **Debrief Questions** include:
   - *What was it like building with only a limited number of materials?*
   - *How were some materials more challenging to build with than others?*
   - *How were some materials similar? Did you find that you could build the same type of structure with different materials?*
   - *What did you notice about the structures at different stations (similarities and differences)?*
   - *What were some elements that made the structures successful?*
   - *What if it had been a different kind of natural disaster? Do you think your structures would have survived it?*
   - *If you were to do this activity again, what materials would you want to use (including ones not used today)?*

Investigating Materials

Exploring different materials is an important aspect of engaging in an engineering project. Spending time investigating the properties of the materials can help learners make informed decisions about what they are building and how they can continue improving on their design. Try these tips for encouraging learners to deeply explore their materials:

- Try using simple, minimal materials, like in this lesson. Using fewer materials can help learners focus on how each material moves or responds during testing.
- Ask learners to do a materials investigation brainstorm before they start building. Have each person select a different material and share ideas for how it could be used in their group's solution. For more details, check out our **Brainstorming Tech Tip** (PDF).
- Encourage learners to "think with their hands" by tinkering with and manipulating materials while they come up with ideas and imagine solutions.
- Create real-world connections by introducing learners to careers in Materials Science. These scientists investigate materials to develop new products and solve problems.

For more ideas on how to use materials see the **Materials Strategies for Engineering Design Tech Tip** (PDF, Video).

Standards Connections

Next Generation Science Standards

Grade	Standard		Description
3-5	ETS1-2	Engineering Design	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.
	4-ESS3-2.	Earth and Human Activity	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.
MS	ETS1-2	Engineering Design	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
HS	ETS1-3	Engineering Design	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints; including cost, safety, reliability, and aesthetics as well as possible social, cultural and environmental impacts.
Additional Standards			• 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. • HS-ESS3-1 Earth and Human Activity: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Vocabulary

For more tips on vocabulary and common engineering terms see our **Tech Tip: The Language of Engineering**.

- **Natural disaster:** The negative impact on a community or the environment following a natural hazard.
- **Natural hazard:** A natural phenomenon that could potentially have negative impacts on humans, other animals, or the environment.