

# Lessons 12–16

## Engineering Challenge

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### Prepare

In previous lessons, students developed an understanding of the warming effect of sunlight. In Lessons 12 through 16, students use that knowledge to solve a problem during an Engineering Challenge. Students follow the engineering design process to build a model of a shelter that would protect archaeologists working at a dig site from the warming effects of sunlight. In Lesson 12, students define the problem that the archaeologists face. In Lesson 13, students test various materials to determine which ones make more shade and, therefore, would keep the archaeologists cooler. In Lessons 14 and 15, students plan, create, and improve their shelters. In Lesson 16, students share their shelters with the class and consider that shelters are designed for many purposes, including protection from the weather.

### Student Learning

#### Knowledge Statement

People can use the engineering design process to create shelters for shade.

### Application of Concepts

#### Task

Engineering Challenge

#### Phenomenon Question

How can we help archaeologists feel cooler when they work?



## Objectives

- Lessons 12–16: Apply the engineering design process to create a shelter that helps archaeologists feel cooler when they are working in the sunlight.

## Texas Essential Knowledge and Skills Addressed

- 1.2A **Ask questions about** organisms, **objects**, and events **observed in the natural world.** (Addressed)
- 1.2B **Plan and conduct simple descriptive investigations.** (Addressed)
- 1.2C **Collect data and make observations using simple tools.** (Addressed)
- 1.2E **Communicate observations and provide reasons for explanations using student-generated data from simple descriptive investigations.** (Addressed)
- 1.3A **Identify and explain a problem and propose a solution.** (Introduced)
- 1.3C **Describe what scientists do.** (Introduced)
- 1.5A **Classify objects by observable properties such as larger and smaller**, heavier and lighter, **shape**, color, and texture. (Addressed)
- 1.5B **Predict and identify changes in materials caused by heating** and cooling. (Mastered)
- 1.6A **Identify and discuss how different forms of energy such as light, thermal**, and sound are important to everyday life. (Addressed)

## English Language Proficiency Standards Addressed

- 1C Use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary.
- 2F Listen to and derive meaning from a variety of media such as audio tape, video, DVD, and CD ROM to build and reinforce concept and language attainment.
- 2I Demonstrate listening comprehension of increasingly complex spoken English by following directions, retelling or summarizing spoken messages, responding to questions



and requests, collaborating with peers, and taking notes commensurate with content and grade-level needs.

- 4A Learn relationships between sounds and letters of the English language and decode (sound out) words using a combination of skills such as recognizing sound-letter relationships and identifying cognates, affixes, roots, and base words.

### Materials

		Lesson 12	Lesson 13	Lesson 14	Lesson 15	Lesson 16
<b>Student</b>	Science Logbook (Lesson 6 Activity Guide B)	•				
	Science Logbook (Lesson 12 Activity Guide)	•	•	•		•
	Roof materials exploration (1 set per student pair): prepared roof materials (1 of each material), safety goggles (2), tape		•			
	Flashlight (1 per group of 4 students)		•		•	
	Shelter building (1 set per student pair): copy of Mesa Verde dig site template from Lesson 12 Resource B (1), painter’s tape, access to prepared roof materials, safety goggles (2), prepared shelter frame (1), wooden dolls (3)				•	•
<b>Teacher</b>	Engineering Challenge Rubric (Lesson 12 Resource A)	•	•	•	•	•
	Engineering Design Process Visual (Lesson 6 Resource B)	•	•	•	•	•
	Sticky note or magnet (1)	•	•	•	•	•
	Anchor model Mesa Verde dig site: anchor model, copy of Mesa Verde dig site template from Lesson 12 Resource B (1), small rocks ( $\frac{1}{2}$ cup), wooden dolls from Lesson 2 (3)	•	•	•	•	
	Flashlight (1)	•	•		•	
	Shelter frame preparation for anchor model and student pairs: building straws (12 per shelter frame), connectors (8 per shelter frame)		•	•	•	

	Roof materials preparation: 3" × 5" index cards (70), aluminum foil (1 roll), jumbo craft sticks (120), plastic mesh (6 square feet), lace (6 square feet), ruler (1), screen (6 square feet)		•	•	•	
	Casa Batlló Photographs (Lesson 16 Resource)					•
<b>Preparation</b>	Cue "Native American Ruins Near Durango" video ( <i>Durango Herald</i> 2019): <a href="http://phdsci.link/1520">http://phdsci.link/1520</a> .	•				
	Prepare a copy of Lesson 12 Resource B and place it on top of the anchor model. Then use the template as a guide to construct a model dig site. Make three rings of small rocks on the circles to represent dig sites, and position three wooden dolls on the crosshairs to represent archaeologists.	•				
	Prepare shelter frames. (See Lesson 13 Resource.)		•			
	Prepare roof materials for student exploration and shelter building. Cut the aluminum foil, plastic mesh, lace, and screen into 3" × 5" pieces. Cut enough of the materials to create 70 pieces of aluminum foil and 40 pieces each of plastic mesh, lace, and screen. Also gather 120 jumbo craft sticks and 70 index cards. Then determine how students will retrieve roof materials during lesson activities. Either line up all materials by item on a counter or table for students to access when needed or gather a set of materials for each student pair in a box or bag beforehand for ease of distribution and cleanup.		•			
	Prepare to distribute a copy of Lesson 12 Resource B to each student pair.			•		

# Lesson 13

**Objective:** Apply the engineering design process to create a shelter that helps archaeologists feel cooler when they are working in the sunlight.

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## Launch 5 minutes

Draw students' attention to the class problem and solution chart, and work with students to summarize what they know so far about the Engineering Challenge.

- What problem are we trying to solve?
  - *The archaeologists working at a dig site are hot.*
  - *We want to keep the sunlight off the archaeologists so that they feel cooler.*
- How can we solve the problem?
  - *We'll make a shelter.*
  - *We need to make a shelter for shade.*
- How will you know if your solution works?
  - *We'll test it.*
  - *We will shine a flashlight on our shelter and see if the archaeologists are in the shade.*

Display the engineering design process visual (Lesson 6 Resource B), and move the sticky note or magnet next to the Imagine stage. Remind students that during the Imagine stage, engineers explore materials and brainstorm ideas for their solution. Tell students that in this lesson, they will focus on the Imagine stage as they consider which materials they will use to make their shelter.

## Agenda

Launch (5 minutes)

Learn (27 minutes)

- Imagine a Shelter (20 minutes)
- Plan a Shelter (7 minutes)

Land (3 minutes)

## Learn 27 minutes

### Imagine a Shelter (20 minutes)

Show students the model dig site that is on top of the anchor model. Add a prepared shelter frame (Lesson 13 Resource) to the top of the anchor model. Position the frame so that all the wooden dolls are within it.



Explain that students will receive a shelter frame and that they will need to make their shelter by taping a roof to the frame. Display and introduce the materials students can use to make the roof of their shelter: index cards, aluminum foil, craft sticks, plastic mesh, lace, and screen. 📄 Have students Think–Pair–Share in response to the following question:

- How can we test these materials?
  - *We can look at the materials and see if they have holes that light could shine through.*
  - *We can hold them under a flashlight and see if they block the light.*

Select one roof material available for students to test (e.g., an index card), and demonstrate how students can shine a flashlight on the material to figure out how much shade the material creates underneath it.



#### Teacher Note

Consider listing the material names on a sheet of chart paper. Next to the name of each material, tape a small piece of that material to the chart. If students need support identifying or describing materials during the Engineering Challenge, encourage them to refer to this chart.

**Safety Note**

This exploration poses potential hazards. To minimize the risk, review these safety measures and look for evidence that students are following them (1.1A):

- Wear safety goggles throughout the activity.
- Never point a flashlight toward yourself or others.

**Teacher Note**

Invite students to identify ways to reuse and conserve the materials during and after this investigation (1.1B).

Place students in pairs, and distribute a set of roof materials to each pair. Then have student pairs form groups of four, and give each group a flashlight.  Explain that students will work with their partner to test the materials but that each group of four will share a flashlight. Dim the classroom lights so that students can clearly discern how the different materials block the light of the flashlight.

Provide time for students to test the materials. Circulate to support students as they work. Encourage students to try layering different materials or changing the materials by bending, crumpling, or stretching them.

After students finish testing, ask student pairs to discuss the materials that they think provide the most shade. Then tell students to gather their materials, and bring the class together.

Have students Think–Pair–Share in response to the following questions.

- Which materials do you think would make the best shelter? Why do you think so?
  - *We think foil and index cards will work best because they make a lot of shade.*
  - *We think craft sticks would work if we put a bunch together because they block the light.*

Bring students' attention to the materials that have holes (lace, screen, plastic mesh).

- How could you use these materials to make a shelter?
  - *You could fold the lace so that there wouldn't be as many holes for the light to get through.*
  - *You could use more than one material to block more light.*

Encourage students to demonstrate with the materials as they explain their ideas.

**Differentiation**

Consider also providing each group with a wooden doll to represent an archaeologist. Students can place the doll under materials as they test the materials.

## Plan a Shelter (7 minutes)

Tell students that after engineers imagine a possible solution, they are ready to move to the Plan stage. Return to the engineering design process visual (Lesson 6 Resource B), and move the sticky note or magnet next to the Plan stage. Remind students that during the Plan stage, engineers create a detailed drawing of their idea and decide which materials to use.

Allow student pairs time to discuss and decide on the materials they will use for their shelter. Clarify that students may use any combination of materials. Then have students turn to the Plan section in their Science Logbooks (Lesson 12 Activity Guide). Demonstrate how to tape their selected materials to the page.  As students work, circulate to provide support. Make sure that student pairs select materials and tape them into their Science Logbooks.

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## Land 3 minutes

Draw students' attention to the Imagine and Plan stages on the engineering design process visual (Lesson 6 Resource B). Remind students that during the Imagine stage, engineers explore materials and brainstorm ideas for their solution and that during the Plan stage, engineers decide which materials they will use and create a detailed drawing of their solution. Have students Think–Pair–Share about the work they did for these stages during the lesson.

- What did you do during the lesson to complete the Imagine stage?
  - *We used a flashlight to see if materials make shade.*
  - *We tested materials to see how we could make shade with them.*
- What did you do today that helped you plan your shelter?
  - *We picked the materials we want to use for our shelter.*

Tell students that in the next lesson, they will continue to plan how they will create their shelter.

## Optional Homework

Students use a flashlight at home to test how other materials make shade. Students then show a family member how various materials can be used to make shade.



### Teacher Note

Consider providing an additional set of materials for each student pair so that both students can tape materials to the page in their Science Logbooks.

# Lesson 14

**Objective:** Apply the engineering design process to create a shelter that helps archaeologists feel cooler when they are working in the sunlight.

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## Launch 2 minutes

Display the engineering design process visual (Lesson 6 Resource B). Remind students that they began the Plan stage during the previous lesson. Also remind students that during the Plan stage, engineers decide which materials they will use and create a detailed drawing of their solution. Tell students that in this lesson, they will create a drawing of their shelter.

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## Learn 30 minutes

### Plan a Shelter (12 minutes)

Show students the model dig site and prepared shelter frame (Lesson 13 Resource) on top of the anchor model. 

### Agenda

Launch (2 minutes)

Learn (30 minutes)

- Plan a Shelter (12 minutes)
- Create a Shelter (18 minutes)

Land (3 minutes)



### Content Area Connection: Mathematics

Working with a three-dimensional representation of a shelter supports students' awareness of geometric forms in their environment. Students may recognize that the shelter frame is a cube. When students add to the shelter frame to create their shelters, they model other basic shapes.



Remind students that they will make their shelter by taping a roof to a shelter frame. Show students the dig site template (Lesson 12 Resource B) as well as the wooden dolls they will use to represent archaeologists. Demonstrate how to use the dig site template as a guide to position one doll at each crosshair.

Next, display one piece of material available for students to use (e.g., an index card), and show students that it is too small to shade all the archaeologists at the dig site.

- How can you create shade for all the archaeologists?
  - *We can use more than one material.*
  - *We can tape pieces together to make a bigger roof.*

Agree that students will need to use multiple pieces of materials to make their shelter. Allow student pairs time to discuss and decide on a final plan for their shelter.  Then instruct students to draw their idea in the Plan section of their Science Logbooks (Lesson 12 Activity Guide). Remind students to refer to the materials they selected during the previous lesson as they draw.

## Create a Shelter (18 minutes)

Return students' attention to the engineering design process visual (Lesson 6 Resource B), and move the sticky note or magnet next to the Create stage. Tell students that during the Create stage, engineers work together to build their solution.

Explain that students will now build their shelters. Have student pairs gather three wooden dolls, a copy of the dig site template (Lesson 12 Resource B), a prepared shelter frame, painter's tape, and several pieces of the roof materials they selected during the previous lesson.  Instruct students to use the dig



### Differentiation

Students may need support articulating their opinions and coming to a consensus on a final plan for their shelter. Consider posting the following sentence frames:

- I think we should \_\_\_\_ because \_\_\_\_.
- What if we try \_\_\_\_?
- I agree/disagree because \_\_\_\_.



### Teacher Note

Withholding flashlights during this lesson encourages students to use their Plan pages (Lesson 12 Activity Guide) and their understanding of materials to build their shelters. In the next lesson, students will use flashlights to test their shelters as they work to improve them.

site template and wooden dolls to set up their dig site. Then tell them to place their prepared shelter frame over the dig site and begin building.  Guide students to refer to the Ask and Plan sections of their Science Logbooks (Lesson 12 Activity Guide) as needed.

As students work, check in on their thinking by asking questions such as these:

- Why did you choose this material?
- Do you think your shelter will shade all the archaeologists? Why or why not?

Once students have built their shelter, prompt them to clean up their workspace. 



### Teacher Note

In upcoming lessons, students improve their shelters and share them with the class. Between lessons, store students' shelters in a place that is out of the way. Consider labeling each shelter with a sticky note with students' names or assigning student pairs a number with which to label their shelter.

Bring the class together. Tell students to imagine a shelter that archaeologists might use at a real dig site at Mesa Verde. Ask students to compare the shelter they are picturing with the model shelter they built during this lesson. Use a response technique, such as equity sticks, to select the students who share their ideas.

- How might your model shelter be different from a shelter an archaeologist would use at Mesa Verde? 
  - *Our shelter is much smaller.*
  - *I think the materials are different. I've never seen shelters made of foil.*
  - *The pieces we used are a lot smaller than the ones they would use to cover real archaeologists.*

Confirm that students' shelters differ from an actual shelter because students' shelters are models.



### Teacher Note

As students build and test their shelters over the next few lessons, be sure they always place their shelter frames so that all the wooden dolls are within it.



### Teacher Note

If necessary, provide time at the beginning of the next lesson for students to finish building their shelters.



### Differentiation

Some students may need support comparing their model shelter to a shelter that archaeologists could use. Highlight differences in the model and an actual shelter by asking if any materials from the Engineering Challenge could form the roof of a shelter that shades actual archaeologists. Alternatively, show students the video "Native American Ruins Near Durango" (*The Durango Herald* 2019) (<http://phdsci.link/1520>) again, and compare the size of the area where the archaeologists are working to the sizes of students' models and materials (2F).

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## Land 3 minutes

Draw students' attention to the Create stage on the engineering design process visual (Lesson 6 Resource B), and review that in the Create stage, engineers work together and use their plans to build their solution. Have students Think–Pair–Share about what they did during the lesson as they worked through the Create stage.

*Sample student responses:*

- *We built a roof for our shelter.*
- *We used the materials we picked to make our shelter.*

Tell students that in the next lesson they will test their shelters to see if they work.

# Lesson 15

**Objective:** Apply the engineering design process to create a shelter that helps archaeologists feel cooler when they are working in the sunlight.

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## Launch 5 minutes

Display the engineering design process visual (Lesson 6 Resource B), and tell students that after engineers build their solution, they test the solution to find out whether it works. Then revisit the class problem and solution chart. Review each column with students and explain that in this lesson, students will find out whether their shelters work.

- How can we test our shelters to see whether they work?
  - *Let's turn a flashlight on over the roof and see if the light shines through or not.*
  - *We can hold a flashlight over our shelter and see if the archaeologists are in the shade.*

Use the anchor model to demonstrate how students should test their shelters. Dim the classroom lights. Hold one piece of material available for students to use (e.g., an index card) at an angle above the shelter frame, and explain that the material represents the shelter's roof. Hold the flashlight about two feet above the roof. Position the flashlight so that it shines straight down onto the top of the shelter. Invite students to look at how much of the dig site is shaded.

- Do you think this shelter helps all the archaeologists feel cooler? Why or why not?
  - *I think it only helps some of the archaeologists, because it makes shade for some of them.*
  - *No, because there is still a part of the dig site that is not in the shade.*

## Agenda

Launch (5 minutes)

Learn (25 minutes)

- Test and Improve a Shelter (25 minutes)

Land (5 minutes)

► How could we change the shape of the roof to get more shade?

- *We could use more index cards to make sure it is the same size and shape as the frame.*
- *I think a flat roof would make more shade.*

Tell students that they will use this approach to test whether their shelters solve the archaeologists' problem.

## Learn 25 minutes

### Test and Improve a Shelter (25 minutes)

Ask student pairs to gather their shelter, dig site template, and wooden dolls from the previous lesson. Have each student pair sit with another pair.

#### Safety Note

This activity poses potential hazards. To minimize the risk, review these safety measures and look for evidence that students are following them (1.1A):

- Wear safety goggles throughout the activity.
- Never point a flashlight toward yourself or others.

Distribute one flashlight to each group of four. Instruct student pairs in each group to take turns using the flashlight to test their shelter. 

After all students have tested their shelter, have students pause their work. Return students' attention to the engineering design process visual (Lesson 6 Resource B), and move the sticky note or magnet next to the Improve stage. Explain to students that during the Improve stage, engineers make changes to try to make their solution better. 



#### Spotlight on Knowledge and Skills

As students test their shelters, they should notice that the shape of the roof is related to the function of the shelter because the roof's shape partly determines the amount of shade that the roof creates.



#### Extension

As an extension, test students' shelters outside or under a heat lamp (with adult supervision) by placing a cup of water under the completed shelter and a cup of water outside of the completed shelter. Use the student thermometers from Lesson 5 to measure and compare the temperatures.



#### Differentiation

Some students may create a successful shelter on the first try. Consider providing these students with an extra challenge, such as

- designing and creating a second shelter from different materials,
- expanding their current shelter to shade a larger area, or
- moving the wooden dolls outside of the model shelter and creating an overhang to shade the archaeologists there.

Ask student pairs to discuss ways to make their shelter better. Tell students that they may use the flashlight to test their improvements and that they may use new or additional materials. Circulate to support students as they work. To help students think about how their shelter could be improved, ask questions such as these:

- What happened when you tested your shelter?
- Would changing your shelter help the archaeologists feel cooler? Why do you think so?
- What changes will you make?

Provide time and materials for students to improve and test their shelters.  Instruct students to clean up their workspace when they are done.

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## Land 5 minutes

Bring the class together. Remind students that during the Improve stage, engineers make changes to try to make their solution better. Ask students to consider the improvements they made to their shelters.

- What did you keep the same? What did you change?\*
- *We changed the material we used.*
- *We still used craft sticks, but we added more.*
- Did your shelter work better after you made changes? How do you know?
- *Yes. After we changed it, our shelter made more shade to cover all the archaeologists.*
- *Yes, it worked better because all the archaeologists were in the shade.*

Tell students that in the next lesson they will move to the final stage of the engineering design process, the Share stage.



### Differentiation

If students' model shelters do not provide shade for the archaeologists, ask student pairs to discuss ways that they can improve their shelter. The following sentence frames may provide scaffolds for the conversation (21).

- We can make our shelter better by changing \_\_\_\_\_.
- The \_\_\_\_\_ didn't work. Let's try using \_\_\_\_\_ instead.

# Lesson 16

**Objective:** Apply the engineering design process to create a shelter that helps archaeologists feel cooler when they are working in the sunlight.

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## Launch 3 minutes

Display the engineering design process visual (Lesson 6 Resource B), and move the sticky note or magnet next to the Share stage. Explain that in the Share stage, engineers present their work and learning to others.

- Who do you think we should share our model shelters with?
  - *I think we should share our shelters with archaeologists, so we can help them.*
  - *We could share them with anyone who is in the sun and needs shade.*

Tell students that in this lesson they will share with the class the shelter that they built.

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## Learn 25 minutes

### Share the Shelter (25 minutes)

Use a Whip Around routine to elicit responses to the following question:

- What advice would you give to someone who needs to create a shelter to provide shade?
  - *Pick materials that don't let sunlight through.*

### Agenda

Launch (3 minutes)

Learn (25 minutes)

- Share the Shelter (25 minutes)

Land (7 minutes)

- *Make sure to build a shelter that is big enough to cover you!*

Have student pairs display their completed shelter at their table or desk.  Review with students the classroom rules for a Gallery Walk, and then allow student pairs to move around the room together to view other students' shelters. Tell students that as they look at their classmates' shelters, they should think about the following questions:

- How would this shelter help archaeologists feel cooler?
- Does this shelter give you any new ideas for how to make a shelter for shade?

After the Gallery Walk, bring the class together to discuss the shelters.

- What is similar about our shelters?
  - *Every shelter has a roof that covers the dig site.*
  - *They all have materials that are good at making shade.*
- What new ideas did you get about how to build a shelter for shade?
  - *I had an idea about using a different material.*
  - *I got an idea about how to tape materials together to build a bigger roof that makes more shade.*

Review the Phenomenon Question **How can we help archaeologists feel cooler when they work?** Have students think about the shelters they built.

- How might a shelter like the model you created help archaeologists feel cooler when they work?
  - *It would make shade for the archaeologists so they feel cooler than they would in the sunlight.*
  - *The roof would block the sunlight and the archaeologists would stay cooler in the shade.*



### Teacher Note

If needed, provide students a few minutes to make final touchups or repairs to their shelters before sharing.



**Check for Understanding**

Students use observations to describe how their shelters could help archaeologists feel cooler.

Evidence	Next Steps
Students use observations to describe how their shelter would help archaeologists feel cooler by applying their understanding that people feel cooler in the shade than they do in the sunlight.	If students do not describe how their shelter would help the archaeologists feel cooler, return to the Imagine stage of the engineering design process. Display the materials students tested, and ask students to describe why they did or did not select each material to create their shelter.

Have students find the Share section in their Science Logbooks (Lesson 12 Activity Guide), and ask them to draw a picture that shows their shelter and how it would help archaeologists. 🧑🧑🧑 As students work, circulate to provide support. 🐙



**Teacher Note**

Since students created their shelter with a partner, they will not be able to take it home. Consider setting up an engineering display area for showcasing students’ shelters along with the Plan and Share pages of their Science Logbooks. If setting up a display area for the shelters is not an option, consider taking a photograph of each shelter and sending home a copy with students so that they can share their work with their families.



**Differentiation**

Students who are able to write may label their picture or write a short letter describing how their shelter would help the archaeologists feel cooler (2I).



**Extension**

Consider showing students photographs of archaeologists working at dig sites around the world.

**Land** 7 minutes

Invite students to share some examples of shelters from the module or from their daily lives. Add new ideas to the Related Phenomena section of the driving question board.

*Sample student responses:*

- *We made tents.*
- *The cliff dwellings are shelters.*

- *Our school is a shelter too.*
- *We made a model of a shelter for archaeologists.*

► How are these shelters alike?

- *They all have roofs.*
- *They are supposed to protect people from the weather.*

Next, display the photographs of the exterior and interior of Casa Batlló (Lesson 16 Resource), a building in Barcelona, Spain, designed by Antoni Gaudí. 📷 Prompt students to observe the photographs silently. Then explain that the photographs show the outside and inside of the same building.



► Do you think this is a shelter? Why or why not?

- *I don't know. It doesn't look like the shelters we learned about.*
- *Yes. It has windows, walls, and a roof, so it could protect people.*

Acknowledge that Casa Batlló is a shelter because it can help protect people from the weather and keep people safe and comfortable.

► Do you think this building was designed only to protect people from the weather? Why or why not? 🧑🧑🧑

- *I don't think so because it looks very fancy.*
- *No, because a shelter doesn't need walls and windows that look like that to protect people.*



### Teacher Note

Consider showing students the location of Casa Batlló on a map.



### Differentiation

If students need support to answer the question, consider asking them about buildings they are familiar with that not only protect people from the weather but were also built for another purpose, such as grocery stores, theaters, and museums.

Explain that while all shelters are built to protect people from the weather, some shelters are also designed to serve other purposes. Tell students that Casa Batlló is considered a work of art and that people can visit it like a museum.

### Optional Homework

Students explore their neighborhood to identify shelters that protect people from the weather but that also serve another purpose.