Lessons 12–17
Reducing Damage from Erosion

Prepare

In previous lessons, students developed an understanding of weathering and erosion. In Lessons 12–16, students apply that knowledge to solve a problem in an engineering challenge. Students are introduced to the engineering design process through the work of the Wright brothers by reading excerpts from the book *Who Were the Wright Brothers?* by James Buckley Jr. (2014). They then are tasked with developing a way to reduce damage related to erosion caused by different amounts of rainfall. Students use the engineering design process to develop solutions and test them under multiple conditions. Groups view their peers' designs and suggest improvements based on established criteria. The design process should take approximately three days but may vary as materials, redesign, and time allotted can affect the timeline for completion. Finally, in Lesson 17, students present their solutions to their peers.

Application of Concepts

Task

Engineering Challenge

Phenomenon Question

How can people reduce damage related to erosion?

Student Learning

Knowledge Statement

Designed solutions can reduce the impact of Earth's processes on humans.

Objective

- Lessons 12–17: Apply the engineering design process to design a structure to reduce damage related to erosion.

Texas Essential Knowledge and Skills Addressed

4.2A **Plan and implement descriptive investigations, including asking well defined questions,** making inferences, and **selecting and using appropriate equipment or technology to answer his/her questions.** (Addressed)

4.2C **Construct simple tables, charts,** bar graphs, and maps using tools and current technology to organize, **examine, and evaluate data.** (Introduced)

4.2D **Analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.** (Addressed)

4.2F **Communicate valid oral and written results supported by data.** (Addressed)

4.7B **Observe and identify slow changes to Earth's surface caused by** weathering, **erosion,** and deposition **from water,** wind, and ice. (Addressed)

English Language Proficiency Standards Addressed

2E Use visual, contextual, and linguistic support to enhance and confirm understanding of increasingly complex and elaborated spoken language.

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.

5F Write using a variety of grade-appropriate sentence lengths, patterns, and connecting words to combine phrases, clauses, and sentences in increasingly accurate ways as more English is acquired.

Materials

		Lesson 12	Lesson 13	Lesson 14	Lesson 15	Lesson 16	Lesson 17
Student	Science Logbook (Lesson 12 Activity Guide)	●	●	●	●	●	●
	Science Logbook (Lesson 13 Activity Guide)		●	●	●	●	●
	Engineering Challenge (1 per group); materials will vary but may include the following: 1 stream table from Lesson 8; 1 ball bearing catch from the Energy Module kit (or small plastic house); 1 9-ounce clear plastic cup with 1 hole; 1 9-ounce clear plastic cup with 2 holes; 1 9-ounce clear plastic cup with 3 holes; pebbles, rocks, grass, and bucket (or other plastic container) from Lesson 9; water; supplies students bring from home (e.g., plastic or paper plates; cardboard boxes; paper towel rolls; string; straws; plastic, polystyrene, or paper cups; wooden skewers; masking tape; craft sticks; building blocks; clay)		●	●	●	●	●
	Science Logbook (Lesson 16 Activity Guide)					●	●
Teacher	*Who Were the Wright Brothers?* by James Buckley Jr. (2014)	●					
	Engineering Design Process (Lesson 12 Resource A) (optional)	●	●				
	Blank Engineering Design Process Chart (Lesson 12 Resource B) (optional)	●					
	Engineering Challenge Scenario (Lesson 12 Resource C)	●	●				
	Anchor chart, anchor model		●				
Preparation	Prepare classroom materials for the engineering challenge and determine how students will retrieve materials. Either line up all materials by item on a counter for students to access when needed or gather each group's set of materials beforehand.			●			

Lesson 13

Objective: Apply the engineering design process to design a structure to reduce damage related to erosion.

Agenda

Launch (3 minutes)

Learn (40 minutes)

- Ask about an Engineering Problem (10 minutes)
- Imagine a Design Solution (10 minutes)
- Plan a Design Solution (20 minutes)

Land (2 minutes)

Launch 3 minutes

On the first day of this engineering challenge, review the lesson's Phenomenon Question: **How can people reduce damage related to erosion?** Then ask students to recap key ideas from the previous lesson about how landslides might damage homes. Tell students they will follow the footsteps of the Wright brothers to imagine, plan, and create a prototype that works under different conditions.

Teacher Note

Throughout the Engineering Challenge, encourage students to identify and demonstrate ways to reuse and conserve materials, such as reusing cardboard boxes or plastic cups (4.1B).

Differentiation

Students are asked several times to test a prototype under different *conditions* in this lesson. Sharing the Spanish cognate *condición* may be useful (4A).

Learn 40 minutes

Ask about an Engineering Problem 10 minutes

Display the photograph of a house destroyed by a landslide (Lesson 12 Resource C). Tell students to imagine the engineering challenge scenario described.

▶ You live in an area affected by landslides, which are related to erosion. Many people build homes on or near hills, like the home in the photograph. Design a system to protect the homes built on or near hills from erosion. Building homes away from the hills is not an option.

Have students summarize the problem and record it in the Ask section of their Science Logbooks (Lesson 13 Activity Guide).

Sample problem summary:

- *Erosion damages houses on the hill.*

Discuss the criteria and constraints that their solutions to the problem must meet, and have students record these in the Ask section of their Science Logbooks (Lesson 13 Activity Guide).

English Language Development

The words *criteria* and *constraints* are used repeatedly in this module. Introduce these terms explicitly. Sharing the Spanish cognate for *criteria* (*criterios*) may be useful (4A).

To help students determine criteria for their solutions, ask the following questions:

▶ What is an acceptable rate of erosion for the land a house and its yard is built on?

- *There shouldn't be any erosion around the house. Any erosion could damage the house.*

▶ How will you know whether erosion is happening? What might you see?

- *Dirt would move up the sides of the house or move the house.*
- *The house might fall down.*

To help students determine the constraints, ask the following questions:

▶ When designing your solution, what constraints should you consider?

- *We can't test this on a real house, so it should fit in the stream table. That is how we will model the scenario and test for erosion.*
- *We can only use materials from the classroom or home.*

Teacher Note

If necessary, review the meanings of the terms *criteria* and *constraints* that were introduced to students in Lesson 12.

Criteria: what is needed; what are the requirements

Constraints: what is possible; what are the limitations

Differentiation

As students discuss and record the criteria and constraints, consider providing sentence frames to support English learners and striving writers (5F).

- The house must _____.
- The solution must _____.

▶ What other issues should you consider when designing your solution?

- *The house should still be accessible; the people living there need to get in and out.*

Sample criteria and constraints:

Criteria	Constraints
▪ *The house must remain in its starting position through different amounts of rainfall.* ▪ *The land around the house cannot be eroded.*	▪ *The solution must fit inside the stream table.* ▪ *The solution must allow the house to remain accessible before and after the rainfall.* ▪ *The solution must be constructed using only a combination of materials from class and materials from home.*

To help students determine different conditions (various amounts of rainfall) under which to test their solutions, ask the following question:

▶ How can we mimic different amounts of rainfall to make sure our solution works in all conditions?

- *We could use cups with different numbers of holes in the bottom. One hole would be a little amount of rain, and more holes would be more rain.*

Imagine a Design Solution 10 minutes

Review class expectations for group work and assign student groups for the engineering challenge.

Draw students' attention to the anchor chart and anchor model from earlier in the module. Encourage groups to use their knowledge of erosion from previous lessons as they brainstorm solutions. Ask groups to record their thoughts in the Imagine section of their Science Logbooks (Lesson 13 Activity Guide). Then have students revisit the engineering problem, criteria, and constraints, and select a solution to design and test.

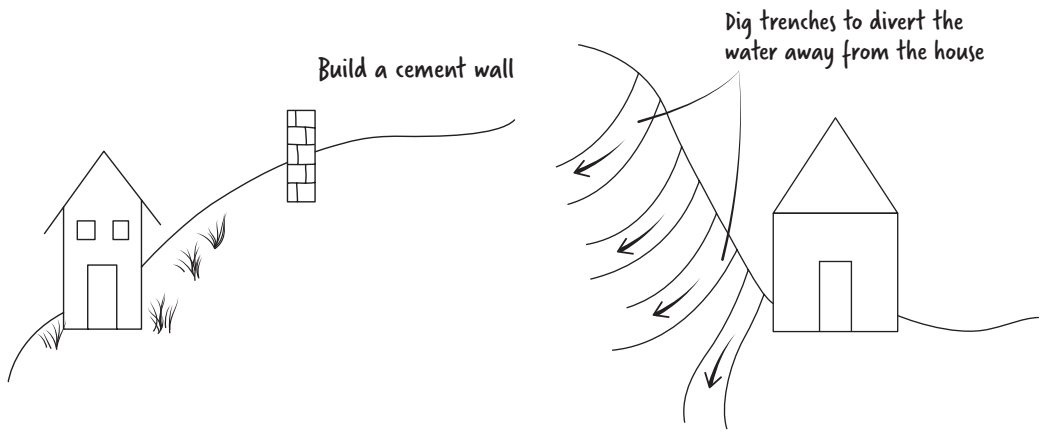
Teacher Note

Consider using the same groups used in Lesson 10 so students may use the rate of erosion testing plan developed in that lesson (if applicable).

Plan a Design Solution 20 minutes

After groups select an idea, have them create a diagram and a list of needed materials in the Plan section of their Science Logbooks (Lesson 13 Activity Guide). Responses will vary by group.

Sample diagrams:



Lesson 13 Activity Guide question and sample student responses:

What materials will you need to build your design?

- *We could use clay to model building a wall behind the house.*
- *We need some building blocks because we chose to build a wall of bricks behind the house.*
- *We need grass, leaves, and small plants because we chose to add in more plants behind the house.*

Land 2 minutes

Allow students time to regroup and discuss what common, inexpensive, and reusable materials each group member must bring from home to begin building their prototypes in the next lesson.

Teacher Note

Students may generate ideas for unrealistic solutions. Press students to consider practical designs. Use questions such as these to guide them toward realistic solutions: How much would it cost? Could we actually build this? How would that work?

English Language Development

Understanding the term *prototype* (noun) is required to participate fully in the engineering challenge. Sharing the Spanish cognate *prototipo* may be useful (4A).

Lesson 14

Objective: Apply the engineering design process to design a structure to reduce damage related to erosion.

Agenda

Launch (3 minutes)

Learn (40 minutes)

- Create a Design Solution (40 minutes)

Land (2 minutes)

Launch 3 minutes

Ask students to get into their engineering challenge groups and discuss where they are in the engineering design process. Remind students that the process is flexible and that they may need to go back to a previous stage as they continue to work.

Learn 40 minutes

Create a Design Solution 40 minutes

Tell groups to begin building their prototypes. After their prototype is built, they should refer to the conditions they discussed in Lesson 13 and choose one initial condition to test (e.g., using a one-hole cup to simulate slow rainfall). As they complete their first test, they should respond to the questions in the Create section of their Science Logbooks (Lesson 13 Activity Guide). Responses will vary by group.

Lesson 13 Activity Guide questions and sample student responses:

What works well?

- *The wall blocks a lot of the sediment from getting to the house.*

What needs improvement?

- *The wall prevents access to the house.*
- *The house still moved because not all of the sediment was blocked.*

After testing the initial condition chosen by the group, students should test two other conditions discussed in Lesson 13 (e.g., using a two-hole cup and a three-hole cup to simulate increasingly faster rainfall) and record their results in their Science Logbooks (Lesson 13 Activity Guide). As needed, ask follow-up questions such as these: Does your solution work in each tested condition? Did the house move at all? Is the house always accessible? If students finish testing their solutions under each condition, encourage them to begin brainstorming improvements. Remind students that the engineering design process is iterative, and they may need to revisit another stage of the process.

Land 2 minutes

Allow students to brainstorm what materials they might need to bring from home to make improvements to their prototypes. Students should plan to bring any new materials for the next lesson.

English Language Development

The following line of questioning involves the word *improvement*. English learners may benefit from additional scaffolding in the form of sentence frames. Consider using sentence frames like the ones below to scaffold this conversation.

- We can improve our house by _____.
- Our _____ needs improvement.
- _____ isn't working. We can improve it by _____.

Lesson 15

Objective: Apply the engineering design process to design a structure to reduce damage related to erosion.

Agenda

Launch (3 minutes)

Learn (40 minutes)

- Provide Peer Feedback (10 minutes)
- Improve a Design Solution (30 minutes)

Land (2 minutes)

Launch 3 minutes

Ask students to form their groups and set up their prototypes to share with their peers. Explain that students will participate in a Gallery Walk for groups to share ideas.

Differentiation

Use a Chalk Talk instead of a Gallery Walk if students would benefit from more individual processing time. In a Chalk Talk, students silently view other groups' designs and leave written comments on chart paper next to each design. Students can annotate and respond to each other's comments on the chart paper, engaging in a silent conversation.

Learn 40 minutes

Provide Peer Feedback 10 minutes

Have students circulate to view and try other groups' prototypes under different conditions, leaving any relevant feedback on sticky notes. Remind students to leave the prototypes as they found them. Students should discuss the following questions as they circulate.

- How well does this design meet the criteria and constraints?
- How is this design similar to and different from our design?
- What suggestions can we leave for this team to make improvements?
- Does this design give us ideas for improving our design?

Differentiation

Consider providing sentence frames to support English learners and striving writers as they give feedback. For example, "To help fix _____, try _____ (5F)."

Check for Understanding

Observe the feedback students provide.

Evidence

Look for evidence that all students

- include suggestions on how to make the house more accessible or protected, and
- understand the effects of erosion and how to improve their designs.

Next Steps

If students have difficulty giving feedback that includes a suggestion, provide the following sentence frame: The design could be improved by _____.

If students do not make the connection to the effects of erosion, remind them of the investigations on erosion they did in Lessons 9 and 10 or refer them to the Frayer model they completed in Lesson 9.

As students move into improving their solution, consider pairing groups that have difficulty using feedback with students who suggested helpful feedback or who have already implemented similar changes successfully.

Improve a Design Solution 30 minutes

Next, groups should move back to their own prototypes, review their peer feedback, and begin the Improve section of their Science Logbooks (Lesson 13 Activity Guide). Responses will vary by group.

Lesson 13 Activity Guide question and sample student response:

What will you change? How do you predict those changes will affect your prototype?

- *Our design works, but water still moves toward the house. If we add a channel for the water to go somewhere else, then it may prevent the water from moving toward the house.*

Throughout this process, groups should discuss improvements, adjust their designs, create new versions of their prototypes, and retest under the chosen range of conditions. Have students document their improvements and findings by using the tables in their Science Logbooks (Lesson 13 Activity Guide). Continue reminding students that the engineering design process is iterative. Encourage students to revisit the Plan, Create, and Improve stages of the process until they are satisfied with their design.

Content Area Connection: Mathematics

Consider providing students with measurement tools, such as beakers, scales, meter sticks, rulers, and protractors. Students may use these tools to precisely measure capacity, weight, length, or angles of features in each prototype. Other groups may improve their designs with precision based on these measurements.

Land 2 minutes

Allow students to brainstorm what materials they might need to bring from home to make further improvements to their prototypes. Students should plan to bring any new materials for the next lesson.

Lesson 16

Objective: Apply the engineering design process to design a structure to reduce damage related to erosion.

Agenda

Launch (5 minutes)

Learn (35 minutes)

- Improve a Design Solution (15 minutes)
- Prepare to Share a Design Solution (20 minutes)

Land (5 minutes)

Launch 5 minutes

Begin the class by asking students to briefly discuss their responses to the questions below.

- ▶ Where are you in the engineering design process?
- ▶ What is going well in your group's process?
- ▶ What can improve your group's process?

Explain that groups will continue to optimize their designs and that each group will then have time to plan a presentation for sharing their final prototype with the class in the next lesson.

Differentiation

If students need support reflecting on the engineering design process, review the Lesson 12 Activity Guide. Ask students to identify the part of the visual that describes their current tasks. Then ask students to identify the stages they have completed and consider what has gone well and what needs improvement within those stages (2E).

Learn 35 minutes

Improve a Design Solution 15 minutes

Groups should continue to make improvements to their designs, create new versions of their prototypes, and retest. Have students document their improvements and findings by using the tables

in their Science Logbooks (Lesson 13 Activity Guide). Encourage students to revisit the Plan, Create, and Improve stages of the process until they are satisfied with their design.

Prepare to Share a Design Solution 20 minutes

Explain that scientists and engineers present their work in a variety of ways, including speeches, visual presentations, videos, websites, and published articles. Work with students to determine which methods of presentation will work best considering the time and resources available in the classroom.

Introduce students to the engineering challenge rubric in their Science Logbooks (Lesson 16 Activity Guide) and discuss student questions about the criteria. Give groups time to plan their presentations, create their final diagrams, and record this information in the Share section of their Science Logbooks (Lesson 13 Activity Guide).

Land 5 minutes

Remind students that during the next lesson, their teams will present their designs to the class. Ask students to determine how each team member will contribute to the presentation.

Lesson 17

Objective: Apply the engineering design process to design a structure to reduce damage related to erosion.

Agenda

Launch (2 minutes)

Learn (38 minutes)

- Share a Design Solution (38 minutes)

Land (5 minutes)

Launch 2 minutes

Allow students a few minutes to prepare for their presentations.

Learn 38 minutes

Share a Design Solution 38 minutes

Gather the class to listen to each group's presentation. Tell students to consider the rubric criteria in their Science Logbooks (Lesson 16 Activity Guide) as they listen.

After each presentation, students should write feedback on sticky notes or half sheets of paper for the group, responding to this prompt:

▶ **Considering the rubric criteria, identify one strength and one idea for improvement for this group's presentation.**

Teacher Note

Allow groups to demonstrate their prototypes in the stream tables during their presentations.

Each time students respond to the prompt, collect feedback from the class before the next group presents. After all groups have presented, distribute the compiled feedback to each group. Give students time to review the feedback and ask questions before turning it in.

Land 5 minutes

Revisit the Phenomenon Question **How can people reduce damage related to erosion?**
Discuss students' reflections on this process. Ask the following questions to guide the discussion:

- ▶ How did you apply your knowledge of erosion to solve the problem?
  - *We know that large amounts of water make erosion occur at a faster rate. If we channeled the water away from the house, it would reduce the amount of water that could cause erosion near the house.*
- ▶ What knowledge of erosion was most useful in designing your solution?
  - *We know that smaller sediment is easier to move with erosion than larger sediment or rocks. We used this idea to add larger sediment or rocks by the house to prevent some erosion.*
- ▶ What other natural processes cause hazards? What solutions could engineers design to reduce the impact of those hazards?
  - *I saw floods on the news. There was water in people's houses. Engineers could design ways to pump water out of people's houses or build houses higher off the ground.*
  - *Sometimes there are earthquakes near our school. They're usually little, but big earthquakes can cause buildings to crack and fall. Earthquakes can also knock down objects that might hurt people. Engineers might be able to design buildings with materials that don't break as easily.*

Build on student responses to explain that humans cannot eliminate hazards from natural processes, but they can reduce hazards' negative impacts through engineering and other processes. Explain that in the next lesson, students will begin to identify patterns in natural features and some of the processes that form those features.

Extension

As students reflect on ways to reduce erosion in the context of the engineering challenge, encourage them to think about how these concepts apply on a larger scale. Ask students to research human activities, such as farming or deforestation, that might influence erosion rates and to consider how erosion can be reduced in those cases.

Spotlight on Knowledge and Skills

Help students reflect on the relationship between science, engineering, and technology. Engineers apply relevant scientific knowledge to improve or develop technologies that solve problems in society.