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Appendix

STEM challenges are not recipes to follow, step-by-step instructions that guide students in creating identical projects, or processes that lead them to the same outcome. STEM is about allowing students to apply their content knowledge, creativity, critical thinking, and other skills as they work to solve a problem and create a solution.

STEM challenges will take time, so plan accordingly. Squeezing it in or treating STEM practices as "extra" may communicate that the skills and practices are not valuable. Our attitudes and beliefs are important as teachers; who we are informs who our students become. According to Hoffer, "If we model optimism, confidence, and courage about STEM in our classroom each day, students will absorb those" (2016, p. 3).

It is our hope that the STEM challenges included in this book will help you teach 21st century skills and STEM thinking, that these practices become a natural part of your classroom, and that STEM becomes a way of thinking and planning for you.

STEMulating
Design Challenges in Science

Grade 5

Challenge 3: The Disappearing Beach

Key Question

How can we slow down coastal erosion?

Problem

Sandy beaches along the coast are popular recreational areas for coastal residents and visitors. Beachgoers enjoy playing in the sand, surfing, and splashing in the waves. Coastal grasses and vegetation are home for many animals. Sandy beaches are used as nesting grounds by sea turtles and other small organisms. However, the beaches need our help! Extensive man-made construction and development and weather phenomena, such as storm surges and erosion, are causing our coastline to disappear ("Coastal Erosion," 2016). According to the Texas General Land Office, the average erosion rate for the 367 miles of Texas coast is 4.1 feet per year ("Coastal Erosion," n.d.). The beach is part of our world, and it needs your help now!

Design Challenge

As a group of scientists and coastal engineers, develop a plan and build a system that can slow down the process of coastal erosion caused by wind and water. The system should also preserve the natural beach landscape, animal and plant habitats, and man-made construction.

Teacher Notes

Students begin observing, describing, and sorting rocks in kindergarten (TEKS K.7A) and compare them in second grade (TEKS 2.7A). Students learn about soil characteristics in first grade (TEKS 1.7A) and are introduced to weathering, erosion, and deposition in fourth grade (TEKS 4.7B).

In this challenge, students will create a plan and build a system that can be used to slow down coastal erosion.

Through research, students should find that there are many ways engineers and scientists work together to protect and preserve our coastlines. Coastal engineers develop structures to protect beaches and coastlines from the damaging effects of weather-related phenomena, such as weathering and erosion, while scientists work to ensure that coastal communities and ecosystems are protected.

Students may discover that some of the current engineering solutions to control coastal erosion or to protect man-made structures include the use of natural barriers, such as dunes and vegetation, or a mix of natural and man-made systems, like geotextile tubes. Other solutions depend strictly on man-made structures such as seawalls, levees, and jetties. Students may initially believe that a seawall will protect the beach and its community, but in reality, a seawall might do more damage to the area by isolating the ocean from the land and increasing the rate of erosion.

Vocabulary

beach	deposition	weathering
coast	erosion	
coastline	sediment	

Materials

For the teacher

- 1 shoe-box size clear plastic container
- 1/2 gallon of sand
- small rocks/gravel
- dominoes or small plastic building blocks, to simulate buildings
- 1 small container lid, to simulate waves
- grass, twigs, or toothpicks, to simulate beach vegetation
- 1 L water
- one 500 mL beaker
- 1 ruler
- 1 timing device

For the class

- foam cups, plates, or pieces
- cardstock
- fabric
- craft sticks
- plastic cups, plates, or pieces
- gravel
- yarn
- cotton balls
- rubber bands
- foam egg carton tops
- paper towels
- masking tape
- camera

For each team

- 1 shoe-box size clear plastic container
- 1/2 gallon of sand
- small rocks/gravel
- dominoes or small plastic building blocks, to simulate buildings
- 1 small container lid, to simulate waves
- grass, twigs, or toothpicks, to simulate beach vegetation
- 1 L water
- 1 ruler
- 1 timing device
- 2 sheets of graph paper

Advance Preparation

- Prepare one beach model for each team's beach/coastline.
  1. Pour sand into the clear container, make it wet, and pack it on one end.
  2. Ocean: Pour 500 mL of water on the side of the container with no sand.
  3. Vegetation: Stick grass, twigs, or toothpicks into the sand and along the beach/coastline.
  4. Buildings/development: Press domino pieces and small rocks into the sand and along the beach.
- Using the materials from the *For the teacher* section, prepare a beach model to demonstrate what happens to the coastline as a result of rapid sea-level rise (storm surge) and erosion by water and wind.
- See page 147 for model example.

Suggested Time Frame

- Ask, Imagine, and Plan: 1–2 hours; may be broken down over a few days
  - research **(not more than 60 minutes)**
  - explore the materials **(about 5 minutes)**
  - sketch and plan independently **(about 10 minutes)**
  - reach team consensus on final design **(about 10–15 minutes)**
- Create, Test, and Improve: **45 minutes**
- Evaluate: **3–5 minutes** to present and test

The amount of time needed for this challenge may vary depending on your students' research skills and findings.

Texas Essential Knowledge and Skills (TEKS) for Science Connections

Science Concepts

5(7) Earth and space. The student knows Earth's surface is constantly changing and consists of useful resources.

(B) The student is expected to recognize how landforms such as deltas, canyons, and sand dunes are the result of changes to Earth's surface by wind, water, or ice.

Science Process Skills

5(1) Scientific investigation and reasoning. The student conducts classroom and outdoor investigations following home and school safety procedures and environmentally appropriate and ethical practices.

(B) The student is expected to make informed choices in the conservation, disposal, and recycling of materials.

5(3) Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions.

(B) The student is expected to draw or develop a model that represents how something that cannot be seen such as the Sun, Earth, and Moon system and formation of sedimentary rock works or looks.

English Language Proficiency Standards (ELPS)

1(C) Cross-curricular second language acquisition/speaking. The student is expected to use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary.

TEACHER GUIDE

ENGAGE

- Present or introduce the problem using an image, book, article, or video about coastal erosion and relate that to the teacher demonstration.
- Teacher demonstration: Follow the steps under the **EVALUATE** section of the challenge. Use the class beach model to demonstrate what happens to the coastline when it experiences erosion due to wind, water, and storm surges. Be sure to measure and record the height of the sand before and after each simulation.

FACILITATION QUESTIONS:

- What is coastal erosion and what causes it?
- What is the result of coastal erosion?
- What is happening to our beaches? Why?

ENGINEERING DESIGN PROCESS (EDP)

ASK

- Divide the class into teams of 3–4 students.
- Assign each team a place to work.
- Distribute a design challenge card to each team.
- Facilitate the creation of a "Know/Need to Know" T-chart, and ensure students understand the challenge.

FACILITATION QUESTIONS:

- How can we slow down coastal erosion?
- Why is it important to preserve our beaches?
- How are plant and animal habitats affected by coastal erosion? How are people affected?

SENTENCE STEMS:

- The problem is . . .
- The challenge is . . .
- To meet the criteria, the design needs to . . .
- The constraints are . . .
- To solve this problem, I need to know or learn more about . . .
- Others have tried . . .
- I would solve the problem by . . .

TEACHER GUIDE | ENGINEERING DESIGN PROCESS (EDP)

IMAGINE

- Provide research materials (access to the Internet and experts, artifacts, books, magazines, etc.).
- When necessary, define vocabulary and model techniques for research and note-taking.
- Observe teams to assess and provide feedback on their collaboration, creativity, critical thinking, and communication skills.
- Allow students to observe and explore the materials available for building.

Note: Do not give materials to teams at this time.

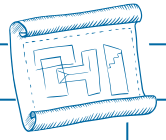
SUGGESTED RESEARCH TOPICS:

- coastal engineering
- beach loss
- beach/coastal/coastline erosion

FACILITATION QUESTIONS:

- What causes coastal erosion by wind and water?
- What weather phenomena contribute to beach loss?
- What are some solutions that have already been engineered to prevent coastal erosion?

PLAN



Independent Planning

- After they have finished their research, instruct students to create a sketch of their individual ideas. Remind students to include details such as labels, measurements, and explanations of how each part functions.
- Instruct students to think about one of the sentence stems below and complete the sentence.
  - I think my team could solve this problem by . . .
  - My idea for solving this problem . . .
  - Based on my research and understanding, I think we should . . .

Team Planning

- Facilitate consensus building and planning, encourage engagement, and support detailed sketching.
- Provide a clean sheet of paper for each team to record their final plan.
- Provide feedback to student teams on their final design and plan.
- Assist teams in managing roles and help team members understand their responsibilities within the challenge.
- Allow Materials Managers to collect the materials for their team.
- Observe teams to assess and provide feedback on their collaboration, creativity, critical thinking, and communication skills.

SUGGESTED ROLES:

- Project Manager
- Quality Control Manager
- Construction Manager
- Materials Manager
- Creative Design Manager

FACILITATION QUESTIONS:

- What kinds of materials will work best to prevent coastal erosion?
- How will your coastal erosion prevention system work?

SENTENCE STEMS:

- Our plan for solving this problem is . . .
- We will need the following materials . . .
- The steps we will take are . . .
- Our role assignments are . . .

TEACHER GUIDE | ENGINEERING DESIGN PROCESS (EDP)

CREATE/TEST/IMPROVE

- Manage materials and ensure students follow safety guidelines.
- Allow teams to work together to create, test, redesign, and retest their products.
- Remember not to take over the design process.
- Observe teams to assess and provide feedback on their collaboration, creativity, critical thinking, communication skills, and application of content knowledge.
- Encourage students to plan their presentations using the following sentence stems.
  - Our coastal erosion prevention system works because . . .
  - The steps we followed were . . .
  - The materials we used were . . .
  - First we tried _____, then we _____ . . .

EVALUATE

- Facilitate the presentation and testing process.
- Test each prototype using the same process each time.
- Accept and expect failure; failure is an opportunity to learn and improve.
- Ask questions to help students think critically about the successes and failures of their designs.
- Facilitate student reflection on their design process.
- Allow time for students to ask questions of each other, reflect, note, and communicate their observations. Facilitate the use of the rubric.

TEST PROCESS:

Prior to testing, students draw a sketch or picture of their beach model. The Project Manager should measure and record the height of the sand before conducting the simulations. As the teacher follows the steps below to simulate erosion by water and wind and storm surge, students will observe and record what happens to the coastline.

1. Instruct the Project Manager to measure the height of the sand.
2. Place the plastic lid into the water.
3. Move the plastic lid back and forth to simulate waves for 30 seconds, increasing the intensity of the waves every 10 seconds.
4. Instruct the team to observe and record any changes to the beach, including a sketch or photo.
5. Instruct the Construction Manager to measure and pour 500 mL of water into the ocean to simulate the storm surge.
6. Instruct the Quality Control Manager to measure the height of the sand. Remind the team to observe and record any changes to the beach, including a sketch or photo.

Each student should have before and after sketches or photos of their beach model after conducting each simulation.

FACILITATION QUESTIONS:

- What materials did your team choose?
- Did your coastal erosion system protect the beach as intended?
- Based on your measurements and observations (height of the sand and the before and after drawings or photos), how did the beach change due to erosion?
- What worked well?
- What could be improved or done differently?

SENTENCE STEMS:

- I observed . . .
- The part(s) that work(s) is/are . . .
- The part(s) that did not work is/are . . .
- When we tested, we learned . . .
- We know we were successful because . . .
- We know our design met the criteria because . . .
- When we observed other presentations, we learned . . .
- To make our coastal erosion prevention system better, we can . . .

The Disappearing Beach

Key Question

How can we slow down coastal erosion?

Problem

Sandy beaches along the coast are popular recreational areas for coastal residents and visitors. Beachgoers enjoy playing in the sand, surfing, and splashing in the waves. Coastal grasses and vegetation are home for many animals. Sandy beaches are used as nesting grounds by sea turtles and other small organisms. However, the beaches need our help! Extensive man-made construction and development and weather phenomena, such as storm surges and erosion, are causing our coastline to disappear ("Coastal Erosion," 2016). According to The Texas General Land Office, the average erosion rate for the 367 miles of Texas coast is 4.1 feet per year ("Coastal Erosion," n.d.). The beach is part of our world, and it needs your help now!

Design Challenge

As a group of scientists and coastal engineers, develop a plan and build a system that can slow down the process of coastal erosion caused by wind and water, while preserving the natural beach landscape, animal and plant habitats, and man-made construction.

Criteria:

- ❑ The coastal erosion prevention system should be able to sustain simulated waves that will increase in intensity over 30 seconds.
- ❑ The coastal erosion prevention system should protect the beach landscape, plant and animal habitats, and man-made construction along the beach/coastline during a storm surge.

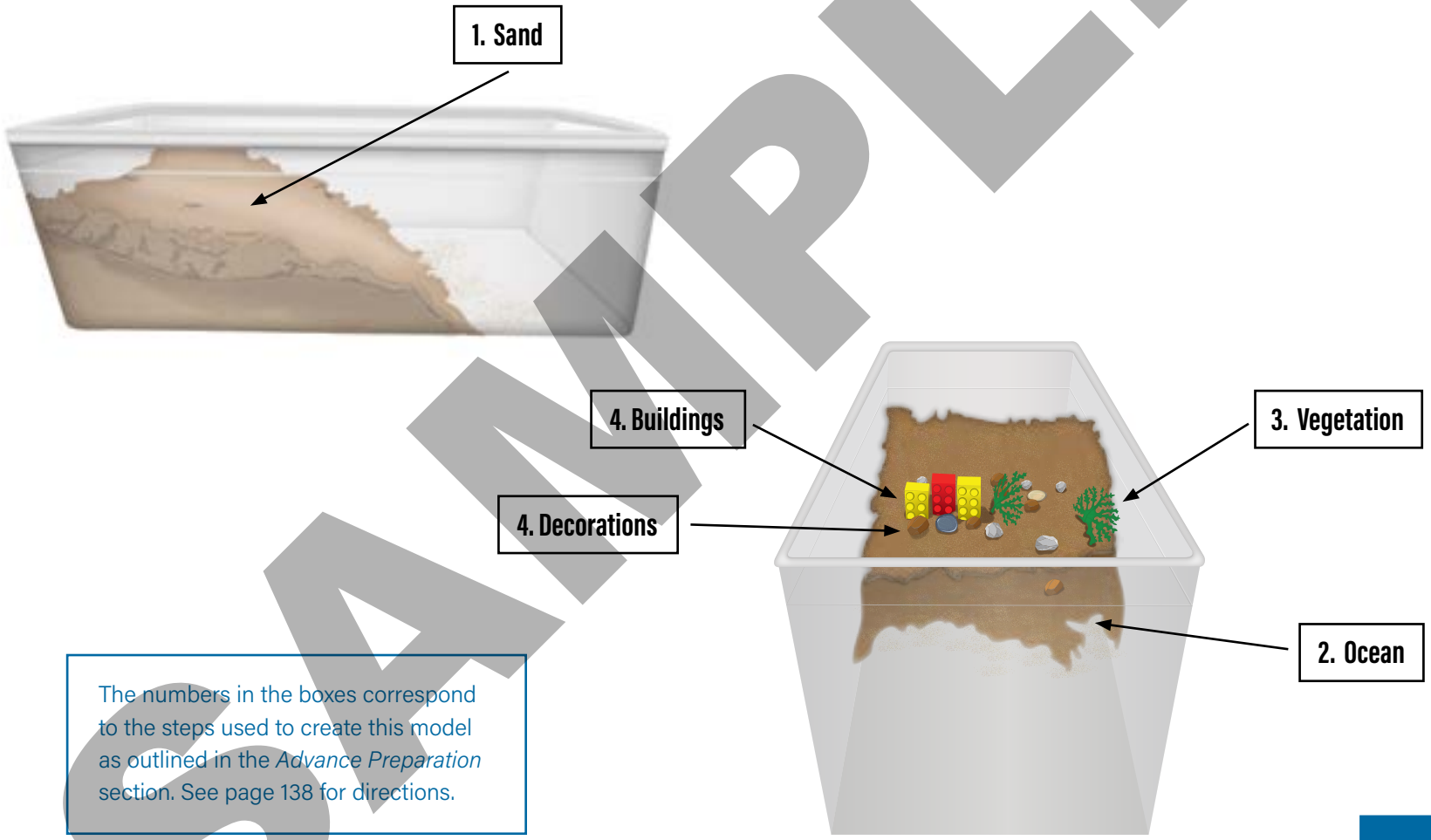
Constraints:

- ❑ Teams may choose no more than three different materials (not including tape) to build the system.
- ❑ Teams will have 45 minutes to build the coastal erosion prevention system.
- ❑ Each team will have 3–5 minutes to present and test their creations.

Grade 5

Challenge 3: The Disappearing Beach

Coastal Erosion Model



The numbers in the boxes correspond to the steps used to create this model as outlined in the *Advance Preparation* section. See page 138 for directions.