

## LESSON: Flood Barriers (Grades 3-4, 7)

### + OVERVIEW



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In this design challenge, students will learn about downstream flooding as a problem in communities. Students will be presented with the following problem: “Your home has been flooding. The city is unable to provide direct assistance, so you must design a solution to deal with this incoming water during a flood.” Students will put on their engineering hats to design flood barriers from various natural materials to determine what works best at diverting water away from their homes. Students will engage in a STEM challenge to design solutions to help their community and limit the amount of water seeping into their property.

### + 2021 Science TEKS covered in this design challenge

Grade 3 TEKS: 3.1.B, 3.1.E, 3.1.G, 3.2.D, 3.10.C, 3.11.A

Grade 4 TEKS: 4.1.B, 4.1.E, 4.1.G, 4.2.D, 4.10.B

Grade 7 TEKS: 7.1.B, 7.1.E, 7.1.G, 7.2.D, 7.11.A

### + Math TEKS covered in this design challenge

Grade 3 TEKS: 3.4.A, 3.4.G

Grade 4 TEKS: 4.4.B, 4.8.C

Grade 7 TEKS: 7.3.A, 7.3.B

### + Social Studies TEKS covered in this design challenge

Grade 3 TEKS: 3.3.B

Grade 7 TEKS: 7.8.C, 7.9.A

## **+ 2022 Technology Applications TEKS covered in this design challenge**

Grade 3 TEKS: 3.3.A, 3.3.B

Grade 4 TEKS: 4.3.A, 4.3.B

### **+ The students will be able to:**

- > Explore mixtures and recognize that a mixture is created when two materials are combined
- > Model and describe rapid changes in Earth's surface, such as volcanic eruptions, earthquakes, and landslides
- > Explore and explain how humans use natural resources such as in construction, agriculture, transportation, to make products
- > Model and describe slow changes to Earth's surface caused by weathering, erosion, and deposition from water, wind, and ice
- > Model the effects of human activity on surface water in a watershed
- > Add and subtract up to 100
- > Multiply a two-digit number by a one-digit number
- > Identify and compare how people in different communities adapt to or modify the physical environment in which they live, such as deserts, mountains, wetlands, and plains
- > Analyze the effects of physical and human factors such as climate, weather, landforms, irrigation, transportation, and communication on major events in Texas
- > Identify ways in which Texans have adapted to and modified the environment and explain the positive and negative consequences of the modifications

### **+ Students will use the following STEM fluency skills:**

- > Communication
- > Collaboration
- > Creativity
- > Critical Thinking
- > Resilience
- > Time/Resource Management
- > Innovation
- > Adaptability

**+ Materials needed for this design challenge:**

|                                  | <b>Grades 3-4</b> | <b>Grade 7</b>      |
|----------------------------------|-------------------|---------------------|
| Plastic container (9" x 9" x 2") | No cost           | No cost             |
| Gloves                           | No cost           | No cost             |
| Mini Toy House                   | No cost           | No cost             |
| Humus Soil                       | \$10 per half cup | \$10 per half cup   |
| Top Soil                         | \$15 per half cup | \$25 per half cup   |
| Sand                             | \$20 per half cup | \$20 per half cup   |
| Water                            | \$5 per half cup  | \$15 per half cup   |
| Cotton Balls                     |                   | \$1 per ball        |
| Popsicle Sticks                  |                   | \$1 per stick       |
| Chenille Sticks                  |                   | \$1 per stick       |
| Mesh Net (Mosquito Net)          |                   | \$7 per square inch |
| Tape                             |                   | \$5 per roll        |
| Scissors                         |                   | \$5 per pair        |

**+ Materials needed by the facilitator:**

- > Projector and computer
- > Slide deck for the lesson
- > Copies of the scorecard per group
- > Timing device
- > Gloves
- > Measuring cup (1/2 cup)
- > Plastic 16 oz cups
- > Plastic Rain Gutter (12-15")
- > 4 buckets
  - Each earth material will go into a separate bucket. The 4<sup>th</sup> bucket is the disposal bucket for students.
- > For grade 7 only
  - Blue or yellow dish soap (to be added to water mixture to act as a pollutant)
  - Kool-Aid or other colored powdered drink mix (to be added to water mixture to act as a pollutant)

\* After the competition of this activity, the earth material can be returned to the schoolyard or disposed of according to the local waste management guidelines.

**+ FACILITATION GUIDE**

| SECTION      | PROCEDURE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| INTRODUCTION | <p><b>Slide 1: Flood Barriers</b></p> <ul style="list-style-type: none"> <li>&gt; Introduce today's lesson on flood barriers.</li> </ul> <p><b>Slide 2: Flooding 1</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students the following questions about flooding:           <ul style="list-style-type: none"> <li>▪ What is a flood?               <ul style="list-style-type: none"> <li>• An overflow of water that submerges land that is usually dry.</li> </ul> </li> <li>▪ What is happening in the picture?               <ul style="list-style-type: none"> <li>• The house is completely flooded with water all around it.</li> </ul> </li> <li>▪ How did this home try to deal with flooding?               <ul style="list-style-type: none"> <li>• There are large piles of material surrounding the house.</li> </ul> </li> <li>▪ What went wrong?               <ul style="list-style-type: none"> <li>• Either the materials were not water-resistant or repellent, or, based on the geography, water was able to get in through the gap in the materials (what looks like it could be a driveway).</li> </ul> </li> </ul> </li> </ul> <p><b>Slide 3: Engineering Design 1</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students the question: What is engineering?           <ul style="list-style-type: none"> <li>▪ Explain to students that engineering is when engineers take what they know and apply it to solve problems by designing a product or process.</li> <li>▪ For example, phones could only be used at home or in specific locations. Why is this a problem? (Needing to make a call outside the home). What solution did engineers design to fix that problem? (Cell phones).               <ul style="list-style-type: none"> <li>• <i>Teacher's Note: Any example can be used here, but focus on examples that students are familiar with.</i></li> </ul> </li> </ul> </li> </ul> <p><b>Slide 4: Engineering Design 2</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students the question: What are some examples of engineering jobs?           <ul style="list-style-type: none"> <li>▪ <i>Teacher's Note: If students have trouble giving examples, ask students who they think makes the</i></li> </ul> </li> </ul> |

*things they use. Who makes refrigerators, cars, helmets, cell phones, and sneakers?*

**Slides 5-6: STEM Careers**

- > Show students pictures related to careers connected to the challenge.
- > City and Urban Planning
  - Ask students what they see in the pictures.
  - The people who work to plan out where things go in the city are city and urban planners. They help plan cities to address local concerns while also keeping the environment and the people who live there in mind.
- > Materials Engineering
  - Ask students what they see in the pictures.
  - The people who study different types of materials that can be used for products are called materials engineers.
  - Explain that materials engineers study different materials and how they perform under conditions such as water, heat, pressure, and wear. They help create products and structures that are strong, durable, and suited for specific jobs.
  - Explain that materials engineers would test different natural materials to determine which ones are best at blocking or redirecting water. In this design challenge, this role will help design flood barriers by selecting materials that absorb less water, stay strong during flooding, and protect homes and property from damage.

**Slides 7-8 Try the Trade**

- > Construction and Building Inspectors
  - Ask students what they see in the pictures.
  - Explain that construction and building inspectors check buildings, roads, bridges, and other structures to make sure they are safe and built correctly. They inspect materials, test designs, and look for problems that could affect safety or performance.
  - Explain that construction inspectors help evaluate flood-control structures to make sure they can withstand water and protect homes from damage. In this design challenge, this role will inspect the team's flood barrier design and test whether the

barriers successfully divert water and reduce flooding on the property.

> Masonry

- Ask students what they see in the pictures.
- Explain that masons build structures using materials such as brick, stone, concrete, and blocks. They help create strong walls, foundations, and barriers that can withstand weather and protect people and property.
- Explain that masons help build flood-control structures such as retaining walls, levees, and barriers that keep water away from homes and buildings. In this design challenge, this role will build a flood barrier to redirect water and reduce flooding on a property.

**Slide 9: Engineering Design 3**

- > Ask students the question, "Who can be an engineer?"
  - Anyone!

**Slide 10: Engineering Design Process**

- > Ask students if they think all engineers solve their problems in one try. Explain to students that it takes many tries to get something correct in engineering. In engineering, there is no such thing as a mistake, only opportunities to learn. It is okay to fail. Just find the mistake and correct it. In engineering, there is never one correct solution. There are always many solutions to a problem and always improvements that can be made. The steps that engineers take to find these solutions are called the *engineering design process*.
- > Ask students to read the first big step (Identify).
  - What does identify mean? (To point out or find). Engineers design solutions: what do they need to know first to find the answer? (The problem)
  - How do people know when they have found the correct answer? In engineering, there are no correct answers, just better ones. Explain to students that there are expectations that engineers must meet, called *criteria*. For example, when engineering a football, what does a football need to do? (Bounce, look a certain way, have laces, have air inside, etc.). Those things are all called criteria. By comparing the design to the criteria, an engineer knows a solution will work. Is a child-sized football the same as an adult football? The criteria for both footballs include leather, white laces for the fingers, and shape.

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|  | <p>However, the two footballs would have different size criteria. The footballs are similar but differ in certain criteria.</p> <ul style="list-style-type: none"> <li>▪ Once the criteria are understood for the design challenge, what could make it difficult for an engineer to design their solution? (Money, time, materials, etc.) Explain to students that these rules are called <i>constraints</i> or rules that engineers must follow. Engineers are given constraints they must follow when solving a problem. Think about football again. What are college and professional footballs made from? (Leather). What if, instead, the rule (or constraint) was not to use leather? Could another type of football be made instead? Many of the footballs for sale are made of rubber because the engineer had different constraints.</li> </ul> <p>&gt; Ask students to read the next step (Imagine).</p> <ul style="list-style-type: none"> <li>▪ Ask students what imagine, or imagination, means. Are these things real or tangible? They may not be real, but they help us imagine what things could be. In this step, see what materials are available, then brainstorm possible ideas and solutions to the problems.</li> </ul> <p>&gt; Explain to students that there are no right answers in engineering. Start with as many ideas as possible.</p> <p>&gt; Ask students to read the next step (Plan).</p> <ul style="list-style-type: none"> <li>▪ The third big step of the engineering design process is to plan out the idea. Make sure that what is designed can be repeated. A plan will help an engineer identify where mistakes happen so they can be fixed.</li> <li>▪ When planning, begin with the brainstorming phase. Each team member will contribute their ideas, and then the team will combine the different ideas!</li> <li>▪ Once ideas are combined into a single group idea, determine what materials will be used for the solution and make sure the design meets the criteria and constraints of the project.</li> </ul> <p>&gt; Ask students to read the next step (Create).</p> <ul style="list-style-type: none"> <li>▪ The fourth step is to create! Since this is the very first creation, it is called a <i>prototype</i>. A prototype is a first or preliminary model of something from which other forms are developed or copied. A prototype is created to test the engineer's idea or concept. Engineers ask themselves, "Did the idea work the</li> </ul> |
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|                 | <p>way we wanted it to?" After testing the idea, the engineer will make improvements to the prototype.</p> <ul style="list-style-type: none"> <li>&gt; Ask students to read the last step (Improve).             <ul style="list-style-type: none"> <li>▪ Finally, the last step is to improve. How does an engineer know if the prototype did well on the test? It must meet certain expectations and follow some rules. But how do engineers determine how well it met expectations and followed the rules? In school, how do you know if you mastered something? (Grades). The prototypes made today will be scored using a scorecard or rubric. By looking at the score, each team will determine if the design could be better. If improvements are needed, the team will revisit the plan and decide how to improve the score. Remember, there are no correct answers in engineering, just better solutions.</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>IDENTIFY</b> | <p><b>Slide 11-12: Identify – Problem</b></p> <ul style="list-style-type: none"> <li>&gt; Have students read the bolded section.             <ul style="list-style-type: none"> <li>▪ Ask students to <i>identify the problem</i>.</li> </ul> </li> <li>&gt; Explain to students that they will put on their engineering hats to design flood barriers that protect homes.</li> </ul> <p><b>Slides 13-14: Identify – Criteria (Desired Outcomes)</b><br/> <b>*DELETE OTHER GRADE SLIDE*</b></p> <ul style="list-style-type: none"> <li>&gt; Ask students what criteria or desired outcomes mean.             <ul style="list-style-type: none"> <li>▪ Explain to students that criteria are what engineers use to determine if they have successfully solved the engineering problem.</li> </ul> </li> <li>&gt; Ask students what determines if the solution is successful today.             <ul style="list-style-type: none"> <li>▪ A successful flood barrier must include the following:                 <ul style="list-style-type: none"> <li>• Protect the property (13cm x 13cm") from flooding                     <ul style="list-style-type: none"> <li>○ <i>Teacher's Note: Students may use the back portion of the container as one of their barrier walls.</i></li> </ul> </li> <li>• Be at least 2.5cm high</li> <li>• Maintain structural integrity                     <ul style="list-style-type: none"> <li>○ Explain to students that this means their barrier must not fall apart during testing.</li> </ul> </li> <li>• Prevent pollutants from entering the container                     <ul style="list-style-type: none"> <li>○ <i>Teacher's Note: This is only a grade 7 criterion.</i></li> </ul> </li> </ul> </li> </ul> </li> </ul> |

Bonus points will be awarded if the property is protected by a flood barrier on all four sides (Students cannot use the back of the flood container).

**Slides 15-18: Identify** – Constraints (Limitations)

*\*DELETE OTHER GRADE SLIDES\**

- > Ask students what constraints or limitations mean.
  - Explain to students that constraints are rules the engineers must follow.
- > Explain the constraints for this engineering design activity:
  - Time Limit: Students will have 25 minutes to build their flood barriers.
  - Materials: Students can only use the materials available.
  - Budget: Students will have \$100 to complete this challenge.
    - *Teacher's Note: Fake money can be given to each group to represent their budget. Students would then go to the supply table and hand the teacher the money to "buy" their materials.*
    - *Teacher's Note: For grade 7, students will have a budget of \$100,000.*
  - Collaboration: One design element from each team member must be used in the final design. Explain to students that a design element is taking one part of someone's idea and adding it to another.
  - Redesign: Each team can test their prototype as many times as needed during the 25-minute design phase. Remind students what a prototype is. It is the first creation of our design.
    - *Teacher's Note: When a team is ready to test their design, they should raise their hand, and the teacher should assist the team with their score. If the team receives a low score on any part of the design, the team should redesign if they still have time.*

**IMAGINE**

**Slide 19-20: Imagine** – Explore Materials

*\*DELETE OTHER GRADE SLIDE\**

- > Students will be presented with the materials needed to create their flood barrier and may mix the soils if they wish.
  - *Teacher's Note: To begin building, students will have to request the materials they wish to use from the teacher. Students will order in half-cup increments, and the teacher will put that amount of*

soil into a 16 oz plastic cup and give it to the students. Students may request water if they wish to saturate their soils. It can also be purchased in half-cup increments.

**Slide 21: Imagine** – Brainstorm

- > Give students one (1) minute to individually design and draw a plan of what they think the flood barriers should look like. Emphasize that students should not talk during this minute or share ideas with each other. Remind students that their ideas will be used as design elements for the final design.
- > After a minute, give students five (5) minutes to present and share their ideas with their group. Let students know that, when sharing, they should focus on the key aspects of their idea they like and want to use as design elements in the final design.
  - *Teacher's Note: If students are struggling with an idea for their design, provide ideas without giving the solution. For example, "This is a design that I tried earlier, but it failed. What could I do to improve it?" Emphasize that the design failed to reinforce that it is okay to fail and to let students know they cannot copy the design and expect success.*

**PLAN**

**Slides 22-23: Plan** – Gather Materials

*\*DELETE OTHER GRADE SLIDE\**

- > Hand out the scorecard that will be used during the design challenge. Review the testing criteria with the class and answer questions. The testing criteria will inform their design decisions.
- > Have students collaborate to come up with a final design. Let students know they must include at least one element from each team member for their final design.
- > Ask students again what the design criteria are:
  - A successful flood barrier must include the following:
    - Protect the property (13cm x 13cm") from flooding
    - Be at least 2.5cm high
    - Maintain structural integrity
    - Prevent pollutants from entering the container
      - *Teacher's Note: This is only a grade 7 criterion.*

Bonus points will be awarded if the property is protected by a flood barrier on all four sides (Students cannot use the back of the flood container).
- > Students will need to select the materials to be used for the design and develop a budget for the project. Students will have

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|                      | <p>\$100 to “purchase” materials for their build at the classroom supply table. The values used in this challenge can be found in the materials list. Students will raise their hands when they are ready to purchase materials. The teacher will ensure that the appropriate amount of money is used to purchase each material, but will not guide students in managing their budgets. Students can go over the allotted budget if they really want to, but remind them that they will lose points on their scorecard.</p> <p><b>Slide 24: Plan</b> – Team Member Responsibilities (Career Role-Playing)</p> <ul style="list-style-type: none"> <li>&gt; Assign each student a career role within their team. As students complete the challenge, they should make decisions and contribute from the perspective of their assigned career. This activity models how STEM and skilled trade professionals collaborate in the real world to design, build, test, and improve their prototype.             <ul style="list-style-type: none"> <li>▪ <u>City and Urban Planner</u>: Draws the team's plan for the flood barrier and helps decide where the flood barrier should be placed.</li> <li>▪ <u>Construction Inspector</u>: Tests the flood barrier's ability to keep the property safe and works with the team to make improvements, if needed</li> <li>▪ <u>Mason</u>: Builds the flood barrier with assistance from the group</li> <li>▪ <u>Materials Engineer</u>: Tests that materials are working as planned and keeps track of the building materials and budget</li> </ul> </li> </ul> |
| <p><b>CREATE</b></p> | <p><b>Slide 25: Create</b> – Design Your Flood Barrier</p> <ul style="list-style-type: none"> <li>&gt; Let students know to have fun, be creative with their designs, and work together.</li> <li>&gt; Remind students that being an engineer is not about getting the solution on the first try. There is no right answer, just better solutions.</li> </ul> <p><b>Slides 26-27: Identify</b> – Criteria<br/>*DELETE OTHER GRADE SLIDE*</p> <ul style="list-style-type: none"> <li>&gt; Display reminder slides for students to look at while working.</li> </ul> <p><b>Slides 28-31: Create</b> – Test<br/>*DELETE OTHER GRADE SLIDES*</p> <ul style="list-style-type: none"> <li>&gt; When students are ready to test, they will raise their hands and then bring their property containers to the testing station, where the teacher will place the rain gutter, which will serve as a ramp, into the container's entrance. They will pour water down the rain gutter to see if the flood barriers are successful. If students wish to re-test, they will reshape the contents of their container if</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

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|                       | <p>possible. If they need to start over, they will dump the contents of the container into the waste-soil bucket and redesign.</p> <ul style="list-style-type: none"> <li>&gt; Students will calculate their scores when testing in front of the teacher. The teacher will go through each category on the scorecard with the students. The students will mark their scores and calculate the total.</li> <li>&gt; The teacher will recap the point total with the students and how many points the team received for each category to make sure it matches what the students recorded.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <p><b>IMPROVE</b></p> | <p><b>Slide 32: Improve</b> – Redesign: Discussion</p> <ul style="list-style-type: none"> <li>&gt; Students will reflect on their scores and discuss:             <ul style="list-style-type: none"> <li>▪ What worked?                 <ul style="list-style-type: none"> <li>• <i>Teacher's Note: Focus on the materials being used and ask students why they think those materials were helpful. What mixtures did students make, and how did it help? What were the beneficial properties of the mixture?</i></li> </ul> </li> <li>▪ What did not work?                 <ul style="list-style-type: none"> <li>• <i>Teacher's Note: Focus on the materials being used and ask students why they think those materials did not work as well. What mixtures did they make, and how did it not help? What were the negative properties of the mixtures?</i></li> </ul> </li> <li>▪ What do you want to improve?                 <ul style="list-style-type: none"> <li>• <i>Teacher's Note: Focus on engineering aspects with students. Ask students why they were designing flood barriers. Ask students if they found a solution, or just part of one. Reinforce that it is okay to not succeed on the first try, and that engineering is about making improvements over time. Ask students how they would design their flood barriers differently if they had no rules, how? Ask students if working together was difficult. Learning to work together is very important and it is easier to find a solution with many ideas rather than just one idea.</i></li> </ul> </li> </ul> </li> </ul> |