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 see how downstream water can cause flooding through the aid of an Augmented Reality (AR) Sandbox. They will then 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 made from different natural materials to determine what works best in 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

TEXAS MOBILE STEM LABS

+ 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:

	Grades 3-4	Grade 7
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	$10,000 per half cup
Top Soil	$15 per half cup	$15,000 per half cup
Sand	$20 per half cup	$20,000 per half cup
Water	$5 per half cup	$5,000 per half cup
Spray Bottle	$10 per bottle	$10,000 per bottle
Cotton Balls		$1,000 per ball
Popsicle Sticks		$1,000 per stick
Chenille Sticks		$1,500 per stick
Mesh Net (Mosquito Net)		$7,500 per square inch
Tape		$5,000 per roll
Scissors		$5,000 per pair

+ Materials needed by the facilitator:

- Projector and computer
- AR Sandbox
- 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 4th 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
INTRODUCTION	**Slide 1: Flood Barriers** > Introduce today's lesson on flood barriers. **Slide 2: Flooding 1** > Ask students the following questions about flooding: ▪ What is a flood? • An overflow of water that submerges land that is usually dry. ▪ What is happening in the picture? • The house is completely flooded with water all around it. ▪ How did this home try to deal with flooding? • There are large piles of material surrounding the house. ▪ What went wrong? • Either the materials were not water resistant or repellant, 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). **Slide 3: Flooding 2** > AR Sandbox Demonstration ▪ Demonstrate a watershed with a designated area marked by LEDs to represent housing property. Make it precipitate and demonstrate how water runoff flows through a watershed and can lead to flooding. ▪ Create a landslide in the watershed and show students how the water runoff changes in real time. There should be additional runoff as the water now has additional pathways created from the landslide. ▪ Ask students what they think will happen to the landscape of the watershed during a catastrophic event, like a tornado or hurricane, and demonstrate those changes to see the impact. ▪ Ask students what they think happens to land when humans build structures on it. Make those changes so that students can see the impact on the watershed in real time. Building structures requires flat land. As a result, the water has more difficulty moving through that portion of the watershed.

Slide 4: Engineering Design 1

- Ask students the question: what is engineering?
  - Explain to students that engineering is when engineers take what they know and apply it to solve problems by designing a product or process.
  - 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).
    - *Teacher's Note: Any example can be used here but focus on examples that students are familiar with.*

Slide 5: Engineering Design 2

- Ask students the question: What are some examples of engineering jobs?
  - *Teacher's Note: If students have trouble giving examples, ask students who they think makes the things they use. Who makes refrigerators, cars, helmets, cell phones, and sneakers?*

Slides 6-8: Engineering Jobs 1-3

- Show students pictures related to engineering jobs connected to the challenge.
- City/Urban planners
  - 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 out cities to address city concerns while also keeping in mind the environment and the people who live in the city.
- Civil Engineers
  - Ask students what they see in the pictures.
  - The people who work and build for the city are civil engineers. They help get water and electricity to buildings but also build bridges and roads. In case of flooding, they are the ones in charge of building dams and barriers to protect the city.
- 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.
  - Ask students what materials were used on feet throughout history.

- Explain to students that just like sneakers, materials engineers are always thinking of ways to help find solutions by exploring different types of materials, like what is the best material to design prosthetic legs that are light and strong enough to run at an Olympic level.

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 before they can 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, the white laces for fingers, and the shape. However, the two footballs would have different criteria for the size. The footballs are similar but different because of different criteria.
  - 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 *constraints* or rules that engineers must follow. Engineers are given constraints they must follow when finding the solution to 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.

- Ask students to read the next step (Imagine).
  - Ask students what imagine, or imagination, means. Are these things real or tangible? They may not be real, but they help give us ideas about what things could be. In this step, see what materials are available, then brainstorm or think about possible ideas/solutions to the problems.
- Explain to students that there are no right answers in engineering. Start with as many ideas as possible.
- Ask students to read the next step (Plan).
  - 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.
  - When planning, begin with the brainstorming phase. Each team member will contribute their ideas, and then the team combines the different ideas!
  - Once ideas are combined into a single group idea, determine what materials will be used for the solution and make sure the design has met the criteria and constraints of the project.
- Ask students to read the next step (Create).
  - The fourth step is to create! Since this is the very first creation, it is called a *prototype*. 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 way we wanted it to?" After testing the idea, the engineer will make improvements to the prototype.
- Ask students to read the last step (Improve).
  - 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 the expectations and how well it 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 should be made, then the team will revisit the plan and decide what to do to improve the score.

	Remember, there are no correct answers in engineering, just better solutions.
IDENTIFY	**Slide 11-12: Identify** – Problem > Have students read the bolded section. ▪ Ask students to *identify the problem*. > Explain to students that they will put on their engineering hat to design flood barriers that protect homes. **Slides 13-14: Identify** – Criteria (Desired Outcomes) **DELETE OTHER GRADE SLIDE** > Ask students what criteria or desired outcomes mean. ▪ Explain to students that criteria are what engineers use to determine if they have successfully solved the engineering problem. > Ask students what determines if the solution is successful today. ▪ A successful flood barrier must include the following: • Protect the property (13cm x 13cm") from flooding ○ *Teacher's Note: Students may use the back portion of the container as one of their barrier walls.* • Be at least 2.5cm high • Maintain structural integrity ○ Explain to students that this means their barrier must not fall apart during testing. • 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). **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 are: ▪ 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 teacher for the materials they wish to use. Students will order in increments of half-cups, and the teacher will put that amount of soil into a plastic 16 oz cup and give the plastic cup to the students. Students may request water if they wish to saturate their soils. It can also be purchased in increments of half-cups.* **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 they should focus on key aspects of their idea that they like and want to be used as design elements for the final design when sharing. ▪ *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 $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 hand when they are ready to purchase materials. The teacher will make sure that the appropriate money is used to purchase each material but will not guide students in managing their budget. Students can go over the allotted budget if they really want to, but remind them that they will lose points on their scorecard. **Slide 24: Plan –** Team Member Responsibilities > Each team member must be given a responsibility, such as materials manager, banker, head engineer, and quality control manager.

CREATE	**Slide 25: Create** – Design Your Flood Barrier > Let students know to have fun, be creative with their designs, and work together. > Remind students that being an engineer is not about getting the solution on the first try. There is no right answer, just better solutions. **Slides 26-27: Identify** – Criteria **DELETE OTHER GRADE SLIDE** > Display reminder slides for students to look at while working**.** **Slides 28-31: Create** – Test **DELETE OTHER GRADE SLIDES** > When students are ready to test, they will raise their hand and then bring their property container 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 possible. If they need to start over, they will dump the content of the container into the waste soil bucket and start re-designing. > Students will calculate their scores when testing in front of the teacher. The teacher will go through each of the categories on the scorecard with the students. The students will mark their scores and calculate the total. > 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.
IMPROVE	**Slide 32: Improve** - Redesign: Discussion > Students will reflect on their scores and discuss: ▪ What worked? • *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?* ▪ What did not work? • *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?* ▪ What do you want to improve? • *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.*