LESSON: Maintaining a Balance (Grades 3-8)

+ OVERVIEW

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In this design challenge, students will discuss ecosystems and take part in a species survival demonstration. This demonstration will challenge students to remove as many species from the environment as possible within one minute and discuss their results. The students will then be presented with the following problem: “Our ecosystem’s population balance has gone out of control. We need to fix our ecosystem to make sure there is equilibrium amongst the species.” The students will put on their engineering hats to assist in maintaining species populations within an ecosystem. The teams will have an opportunity to design a tool to remove the invasive species and restore balance to the ecosystem.

+ 2021 Science TEKS covered in this design challenge

Grade 3 TEKS: 3.1.B, 3.1.E, 3.1.G, 3.2.D, 3.12.B

Grade 4 TEKS: 4.1B, 4.1.E, 4.1.G, 4.2.D, 4.12.B

Grade 5 TEKS: 5.1B, 5.1.E, 5.1.G, 5.2.D, 5.12.A, 5.12.B

Grade 6 TEKS: 6.1.B, 6.1.E, 6.1.G, 6.2.D, 6.12.A, 6.12.B

Grade 7 TEKS: 7.1.B, 7.1.E, 7.1.G, 7.2.D, 7.12.B

Grade 8 TEKS: 8.1.B, 8.1.E, 8.1.G, 7.2.D, 8.12.A

+ Math TEKS covered in this design challenge

Grade 3 TEKS: 3.4.C

Grade 4 TEKS: 4.8.C

Grade 5 TEKS: 5.10.F

Grade 6 TEKS: 6.3.D

Grade 7 TEKS: 7.3.A, 7.3.B

+ The students will be able to:

- Identify and describe the flow of energy in a food chain and food web
- Predict how changes in a food chain affect the ecosystem
- Explain how organisms and populations in an ecosystem depend on and may compete for biotic and abiotic factors
- Describe and give examples of predatory and competitive relationships between animals
- Predict how changes and disruptions to the ecosystem affect the food chain or food web
- Add, subtract, multiply and divide integers numbers fluently
- Balance a simple budget
- Solve a problem using the engineering design process

+ 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:

Biodiversity Box	No cost
Artificial Turf	No cost
Turf Container	No cost
Tweezers	$400 per pair
Straws	$100 per straw
Scissors	$100 per pair
Tape	$100 per roll
Hand Rake	$400 per rake
Hand Shovel	$300 per shovel
Sieve	$300 per sieve
Comb	$300 per comb
Plastic Spoon	$150 per spoon
Plastic Fork	$150 per fork
Chenille Sticks	$100 per stick
Fan	$200 per fan
Flashlight	$200 per flashlight
String	$100 per 10 cm
Water	$200 per 1000 mL

Materials needed by the facilitator:

- Projector and computer
- Slide deck for the lesson
- Copies of the scorecard for each group
- Timing device
- Biodiversity box preset (large beads, medium beads, and lettuce seeds)

  - Lettuce seeds will represent the invasive species
  - May add a 4th species by including small beads

TEXAS MOBILE STEM LABS

+ FACILITATION GUIDE

SECTION	PROCEDURE
INTRODUCTION	**Slide 1: Maintaining a Balance** **Slide 2: Ecosystem** > Discuss food webs and the role of species within the food web. ▪ Ask students how species have adapted to survive in this food web/ecosystem. ▪ Why are hawks the apex predator? • Flying makes it so others can't target them and gives them an advantage over prey • Excellent vision • Sharp claws • Speed ▪ How do snakes, rabbits, and lizards survive from the hawk? • Hiding in the grass • Burrowing underneath the ground • Using camouflage ▪ How do mice and grasshoppers survive from snakes and lizards? • Hiding in small holes that snakes cannot fit inside • Quicker than their predator ▪ What will happen if we remove the grass? • Everything will eventually disappear because the herbivores will not have food, and the food web will be disrupted • Animals and insects would either die or move somewhere else > Ask students what happens when a species disappears from an ecosystem. ▪ Other species could go endangered or extinct ▪ The environment could be destroyed by overgrazing or overpopulation ▪ Negative impact on breeding grounds ▪ Food sources might become scarce ▪ Invasive species outcompete apex predators and has no natural predator > Ask students: How can we protect ecosystems? ▪ Protect the existing environment as sanctuaries or national parks ▪ Avoid or limit practices that destroy the environment like deforestation

	▪ Remove an invasive species by utilizing traps or other removal procedures **Slides 3-4: Predator vs. Prey** > This species survival demonstration will challenge students to remove as many species from the environment as possible within one minute and discuss their results. > Students will establish on their team who will be picking the invasive species out of the ecosystem. > Students will place their piece of turf onto the table with the grass side up and dump the contents of the biodiversity box onto the turf. > Using only one hand, the picker will collect as many of the species as possible within 30 seconds. They can only pick one species up at a time. > Once the 30 seconds is up, they will separate the species into the mini cups according to the color and size and then count how many were picked out of the ecosystem. > Ask students which species they picked the most and which were the least picked. > Ask students why they think that happened. ▪ The ones they picked the most were easier to see because they were bigger and brighter. > Ask students how they think their experience connects to an ecosystem's food web with predators and prey. ▪ Predators will target the easier-to-catch prey, leaving population imbalances. These imbalances put the health of an ecosystem at risk. If all the mice are gone, what happens to the snake? How does that impact the hawk? ▪ As the snake's food source decreases, they might starve or leave the ecosystem. ▪ If the snakes are gone, then fewer hawks would survive. ▪ Rabbit and lizard populations would increase, and their food sources would become scarce. **Slide 5: 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 6: 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 7-9: Engineering Jobs 1-3

- Show students pictures related to engineering jobs connected to the challenge.
- Environmental Engineering
    - Ask students what they see in the pictures.
    - Explain to students that engineers who study the planet and natural materials are called environmental engineers. They use science to help the Earth. Some of the work they do can help make plants grow bigger and healthier or understand why there are population imbalances in the ecosystem.
    - Ask students why they think population imbalances would happen in the ecosystem. Explain that the change in the climate results in different producers being grown, which impacts which consumers survive. Another explanation is when invasive species grow out of control and limit the growth of the native species. Devastation to the environment via natural causes or human construction could also force species to leave the area and then affect the food web.
- Civil Engineering
    - Ask students what they see in the pictures. Ask them: How does it look different from architecture?
    - Explain to students that what they are seeing in the pictures is called civil engineering. While architecture combines art and science to build buildings, civil engineers use math and a type of science called physics to construct buildings that help people. Architects and civil engineers are also different because while architects mainly focus on buildings, civil engineers will build many structures like bridges, highways, towers, and water systems!
- Chemical Engineering
    - Ask students what they see in the pictures.
    - Explain to students that this is called chemical engineering. This is when engineers specialize in working with things called chemicals. Chemicals are things that cannot be broken down without changing what they are. An example of a chemical is water, oxygen, or gold!
    - Ask students why would learning about chemicals be important for an ecosystem. Explain to students that chemical spills occur, and we need to understand the impacts of the damage

	they leave. We also can try to control invasive species through the use of chemicals. **Slide 10: Engineering Design 3** > Ask students the question: who can be an engineer? ▪ Anyone! **Slide 11: Engineering Design Process Steps** > 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; there are 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	**Slides 12-13: 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 today to fix our ecosystem by designing a process to eliminate invasive species.
	
	Slide 14: Identify – Criteria (Desired Outcomes)
	> Ask students what criteria or desired outcomes mean.
	    ▪ Explain to students that those criteria are what engineers use to determine if they have successfully solved the engineering problem.
	> Ask students how we will know if we are successful engineers today.
	    ▪ A successfully designed process will do the following in one minute:
	        • Remove invasive species (lettuce seeds)
	        • Protect the native species (beads)
	        • Limit environmental damage
	
	Slides 15-16: Identify – Constraints (Limitations)
	> 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:
	    ▪ <u>Time Limit</u>: Students will have 25 minutes to design their tools and practice their process.
	    ▪ <u>Materials</u>: Students can only use the available materials.
	    ▪ <u>Budget</u>: Students will have $1,000 to complete this challenge.
	        • *Teacher's Note: If play money is available, we recommend using it. Monetary values may feel too abstract for students, so providing something more tangible will help. The budget is set for $0,000 but can be lowered to $100 and divide material costs by 10 as well.*
	    ▪ <u>Collaboration</u>: 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.
	    ▪ <u>Redesign:</u> Each team can test their process and tools as many times as needed during the 25-minute design phase.
	        • *Teacher's Note: When a team is ready to test their design, they should raise their hand. The teacher will then ask them to come to the testing station and test*

	their design. If a team received a low score on any part of the design, the team should redesign if they still have time.
IMAGINE	**Slide 17: Imagine** – Explore Materials > Students will be designing a process to eliminate as many of the invasive species as possible. During the first trial, students experienced how an invasive species can cause damage to the balance of an ecosystem when there is no natural predator to control its population. As a result, they will be designing ways to specifically eliminate the invasive species from the environment. The design will include a step-by-step process using tools they have “purchased” from the supply table. For example, Step 1- Rake the environment. Step 2-Use a spoon to scoop out the species pulled from the rake. Modifications can be made to the tools to implement their process better if desired. > Depending on classroom size, each team’s process will be tested at a testing location. If space is not available, the teacher may go to each team station to test their process. **Slide 18: Imagine** – Brainstorm > Give students one minute to individually design and draw a plan of what they think their tools should look like and the order which they should be used. Emphasize that students should not talk or share ideas during this minute. Remind students that their ideas will be used as design elements for the final design. > After a minute, give students five minutes to present and share their ideas with the group. Let students know that they should focus on key aspects of their idea 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	**Slide 19: Plan** – Gather Materials > 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 successfully designed process will do the following in one minute: • Remove invasive species (lettuce seeds)

	• Leave native species unharmed (beads) • Limit environmental damage > Students will need to select the materials to be used for their design process and develop a budget for the project. Students will have $1,000 to “purchase” materials for their design at the classroom supply table. The prices 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 the appropriate amount of money is spent to purchase each material but will not guide students on following their budget. Students can go over the budget but remind them that they will lose points on their scorecard. **Slide 20: Plan** – Team Member Responsibilities > Each team member must be given responsibility, such as materials manager, banker, head engineer, and quality control manager.
CREATE	**Slide 21: Create** – Design Your Process > 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. **Slide 22: Identify** – Criteria > Display the reminder slide for students to look at while working. **Slides 23-24: Create** – Test > When students are ready to test, they will raise their hands, and the teacher will come to their station to observe the process. The teacher will time the process for one minute. > 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 25: Improve** - Redesign: Discussion > Students will reflect on their scores and discuss: ▪ What worked? • *Teacher's Note: Focus on the materials being used and ask why they think those materials were helpful. Ask students what characteristics of the environment allowed certain species to be supported. What aspects of their design process allowed the invasive species to become easier to remove?* ▪ What did not work?

	• *Teacher's Note: Focus on the materials being used and ask why they think those materials did not work as well. Ask students what characteristics of the environment made it difficult to remove the invasive species.* ▪ What do you want to improve? • *Teacher's Note: Focus on engineering aspects with students. Ask students why they were designing a process for the ecosystem. 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 process differently if they had no rules? 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.*