LESSON PLAN

Rescue and Design (Grades 6-8)

+ OVERVIEW

In this design challenge, students will be tasked with designing a prosthetic limb for injured animals to restore their mobility. They will apply the engineering design process to develop solutions tailored to the unique needs of the animals. Students will be presented with the following scenario:

"An animal rescue center has taken in several animals with injuries that affect their ability to move. Today, you will take on the role of engineers to design and create a prototype for a prosthesis that will help these animals regain mobility and thrive."

Students will practice their problem-solving and teamwork skills as they diagnose the injury and design functional prostheses. By engaging in this STEM challenge, students will address the challenge of designing effective and sustainable solutions, fostering an understanding of structure and function in organisms.

+ 2021 Science TEKS Covered

Grade 6 TEKS: 6.13.C, 6.1.B, 6.1.E, 6.1.G, 6.2.A, 6.2.D, 6.5.A, 6.5.C, 6.5.D, 6.5.F

Grade 7 TEKS: 7.13.D, 7.1.B, 7.1.E, 7.1.G, 7.2.A, 7.2.D, 7.5.A, 7.5.C, 7.5.D

Grade 8 TEKS: 8.13.C, 8.1.B, 8.1.D, 8.1.E, 8.1.G, 8.2.A, 8.2.D, 8.5.A, 8.5.C, 8.5.D

+ The students will be able to:

> Solve a problem using the engineering design process.

> Analyze the structure and function of body parts in organisms to determine how they contribute to survival, movement, and interactions within their environment.

> Evaluate how injuries or physical impairments impact the ability of an organism to perform essential life functions, such as movement, feeding, or escape from predators.

> Design and create a prosthetic solution that restores or mimics the function of a missing or damaged body part in an animal.

Commented [KD1]: I would include 1.b, 1.e, and 1.g 2.a, 2.d and 5.a, 5.c, and 5.d for each grade level

Commented [MOU2]: What do you think about 6.1.G develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

Commented [KD3]: We'd like to have at least one content standard with each grade level (everything 1-5 is more skill based).

If the activity is mainly focused on structure/function or adaptations to an environment I would add these: 6.13.C, 7.13.D, 8.13.C

Commented [MOU4]: what do you think about 7.5.C?

(C) analyze how differences in scale, proportion, or quantity affect a system's structure or performance;

Commented [MOU5]: What about 8.1.G?

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems

and 8.5.C

(C) analyze how differences in scale, proportion, or quantity affect a system's structure or performance;

- Use evidence from provided diagnostic materials (e.g., diagnostic charts, observable traits) to identify problems and develop targeted solutions.
- Compare and contrast structural adaptations of animals in an aquatic environment, demonstrating an understanding of how environments shape biological structures.
- Communicate their findings and solutions effectively using diagrams, treatment plans, and structured presentations.
- Reflect on how engineered solutions can support conservation efforts and improve the survival of injured or endangered species.

+ 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

> Testing Tanks	Free
> Wind-up Marine Toys with one fin or tail removed	Free
> Scissors	$5 per pair
> Cork	$10 per cork
> Adhesive Velcro	$5 per Velcro strip
> String	$3 per ft
> Toothpicks	$2 per toothpick
> Chenille Sticks	$2 per stick
> Popsicle Sticks	$2 per stick
> Rubber Bands	$5 per rubber band
> Modeling Clay	$30 per bag

Commented [KD6]: How big does the tank need to be? Does it need to be a certain depth?

Commented [JA7R6]: They can be smaller storage containers found ate Walmart. Depth needs to be at least 2-3 inches of water

Commented [KD8]: Adhesive or non adhesive?

Commented [KD9]: You should include the cost for each material in the activity (how much money for how many chenille sticks when students want to "purchase"?)

+ FACILITATION GUIDE

SECTION	PROCEDURE
INTRODUCTION	**Slide 1: Rescue and Design: Engineering for Wildlife** > Introduce today's lesson on designing prostheses for injured animals. > Explain that students will address real-world challenges faced by animals in the wild and be tasked with designing a prosthetic limb for injured animals to restore their mobility. **Slide 2-3: Structure and Function 1-2** > Discuss the concept of structure and function in organisms. > The structure of an animal's body part is closely related to its function, or how it helps the animal survive. > Introduce key idea that an animal's survival often depends on the functionality of its limbs or fins. ▪ Example: Fins and flippers allow marine animals like dolphins and turtles to swim, steer, and escape predators. > Highlight how injuries to these structures can impact an animal's ability to move, hunt, or evade predators. > Injuries to these structures can significantly hinder an animal's ability to move efficiently, making it harder to catch food, avoid predators, or migrate. ▪ Example: A missing fin might cause a turtle to swim in circles while a damaged tail could prevent an animal from propelling itself forward. **Slide 4-5: Engineering and Biology Connection 1-2** > Play video showing an example of real-life prosthesis designed for animals. > Ask "What challenges do you think engineers face when designing prostheses?" **Slide 6: 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 7: 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?* **Slide 8-10: Engineering Jobs 1-3** > Show students pictures related to engineering jobs connected to biotechnology. ▪ **Biomedical Engineer -** Biomedical engineers use engineering principles combined with biological knowledge to design medical devices, prostheses, and healthcare equipment. They often create artificial limbs, implants, or supportive devices to help people or animals regain mobility and improve their quality of life. ▪ **Environmental Bioengineer -** Environmental bioengineers focus on developing sustainable solutions for environmental challenges, like pollution or habitat loss. They create systems to restore ecosystems, design habitats to protect endangered species, and use living organisms, such as plants or algae, to clean water and air. ▪ **Biomechanical Engineer -** Biomechanical engineers apply mechanics and biology to understand how organisms move and function. They design devices and solutions that mimic or enhance the natural movements of animals or humans. Examples include

	creating robotic limbs, improving sports equipment, or designing animal prostheses to assist wildlife rehabilitation. **Slide 11: Engineering Design 3** > Ask students the question. Who can be an engineer? ▪ Anyone! **Slide 12: 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; 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	**Slide 13-14: Identify - The Challenge** > Present the problem to the class: > An animal rescue center has taken in several animals with injuries that affect their ability to move. Today, you will take on the role of engineers to create a prototype for a prosthesis that will help these animals regain mobility and thrive. > Ask students: "What challenges might an animal face if it loses a limb or fin? How might this impact its ability to survive? > Explain that students will need to diagnose the injury using observable traits and fill out the animal chart and then design a functional prosthesis to help the animal regain mobility. > Explain to students that they will put on their engineering hats to design a prosthesis for marine animals. **Slide 15: Identify - Criteria (Desired Outcomes)** > Ask students what criteria or desired outcomes mean. ▪ Explain to students that criteria are the goals engineers use to determine if their solution is successful. > Ask students how we will know if we are successful engineers today. ▪ A successfully designed prosthesis will do the following: • Restore the animal's ability to swim in a straight line. • Maintain durability during repeated use by testing each design three times. • Attach in a way that avoids damage to the animal (e.g., no glue, staples, or tape). ▪ Bonus Points: Creating an ecofriendly design that incorporates recycled materials.

Commented [MOU10]: If you do change this on the other place don't forget to change it here

Commented [KD11]: I would put a teachers note here: how many tests do they have to run to measure this? 3 times? 5 times?

I'd also update the rubric to be more specific as well

Commented [KD12]: I saw in the rubric this meant recycled materials- but which of the materials provided are recycled?

	Slide 16-17: Identify - Constraints (Limitations) > Ask students what constraints or limitations mean. ▪ Explain to students those constraints are rules the engineers must follow. > Explain the constraints for this biomedical engineering design activity: ▪ Time Limit: Students have 25 minutes to complete their prosthesis design. ▪ Materials: Students can only use the provided materials. ▪ Budget: Each team will have $100 to purchase materials for their design. • 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. ▪ 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: Teams can test and revise their prototypes as many times as needed within the time limit. > 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 18: Imagine - Explore Materials** > Present students with the materials available for designing their prosthesis. **Slide 19: Imagine - Brainstorm** > Provide each group with the diagnostic chart for their assigned animal. > Give students three minutes to individually analyze the animal and fill out the diagnostic chart, then brainstorm and sketch their design for the prosthesis.

	> Emphasize that students should not talk during these minutes or share ideas. Remind students their ideas will be used as design elements for the final design. > After three minutes, give students two minutes to present and discuss their ideas within their group. ▪ Encourage the group to identify and incorporate at least one design element from each team member's sketch into 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?" > Remind students that failure is part of the engineering process. Reinforce that it is okay to fail and to let students know they cannot copy the design and expect success, they need to adapt and innovate.
PLAN	**Slide 20: 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 prosthesis will do the following: • Restore the animal's ability to swim in a straight line. • Maintain durability during repeated use by testing each design three times. • Attach in a way that avoids damage to the animal (e.g., no glue, staples, or tape). ▪ Bonus Points: Creating an ecofriendly design that incorporates recycled materials. > 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 prices 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 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 budget if they want to but remind them that they will lose points on their scorecard. > Answer any questions regarding the rubric and emphasize how the criteria will guide their design decisions. **Slide 21: Team Member Responsibilities** > Each team member must be given responsibility such as: ▪ Materials Manager: Responsible for collecting, organizing, and returning materials. ▪ Budget Analyst: Tracks spending and ensure the team stays within budget. ▪ Head Engineer: Leads the construction process and ensures the design aligns with the criteria. ▪ Quality Control Specialist: Checks the prosthesis for durability, fit, and functionality during testing.
CREATE	**Slide 22: Create - Design the Prosthesis** > Encourage students to have fun, be creative, and collaborate effectively while constructing their prosthesis. > Highlight the process: ▪ Remind students that real-world engineering often requires multiple attempts to find the best solution. There is no single "right" answer only opportunities to improve and innovate. **Slide 23: Identify - Criteria** > Display a reminder slide with the design criteria and constraints for students to reference during the building phase: • Restore the animal's ability to swim in a straight line. • Maintain durability during repeated use by testing each design three times. • Attach in a way that avoids damage to the animal (e.g., no glue, staples, or tape). ▪ Bonus Points: Creating an ecofriendly design that incorporates recycled materials.

	Slides 24-25: Create - Testing > Students will calculate their scores when testing in front of the teacher or facilitator: 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 with what the students recorded.
IMPROVE	**Slide 26: Improve – Redesign: Discussion** > Students will reflect on their score and discuss: ▪ What worked? • Teacher's Note: Focus in on the materials being used and ask why they think those materials were helpful. Ask students what specific materials contributed to the success of their prosthesis design and how their design choices helped achieve their goals. Ask students if they can identify any techniques or strategies that were effective. ▪ What did not work? • Teacher's Note: Focus in on the materials being used and ask why they think those materials did not work as well. Ask students what materials or design choices proved to be less effective, and why. Ask if what challenges they faced with the stability or movement of their animal. Ask how they handled any setbacks or failures during the design process and if they could redesign their prosthesis, what changes would they make to improve its performance. ▪ What do you want to improve? • Teacher's Note: Focus in on engineering aspects with students. Ask students why they were designing a prosthesis. 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 if

	they would design their prosthesis 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. > Reinforce that engineering is an iterative process, and improvement is part of the journey. > Discuss how collaboration contributed to their success and how teamwork could be refined for future projects. > Emphasize the importance of learning from failure ▪ Every engineer improves through trial and error. Mistakes help us grow, innovate, and succeed. > Close by asking students to share things they learned during the activity that could apply to real-world challenges.