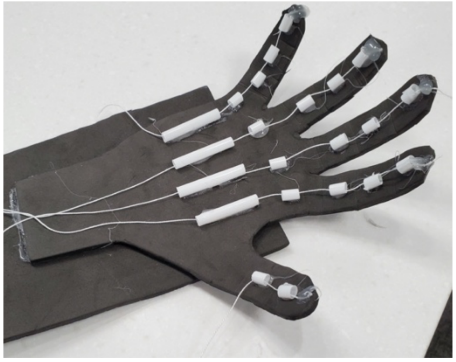
LESSON: Biomimicry (Grades 5, 7)

+ OVERVIEW



In this design challenge, students will receive a challenge to develop a prosthesis for John who lost his arm while operating machinery. Students will learn about biomimicry and get a basic understanding of how we, as humans, have looked to nature as a source of inspiration for designing solutions. The students will be presented with the following problem: “John recently got into an accident while operating machinery. Fortunately, he will recover but he had to have his right arm amputated. With advances in technology, prostheses can now be made with 3D printers. However, John is not sure how to create one and needs your help in designing a prosthesis that will allow him to complete certain tasks.” Students will engage in a STEM challenge to design a prosthesis that can hold a water bottle, lift one up and move it, and have a firm enough grip to open the water bottle. Teams will receive bonus points if their prosthesis can be tested using only one hand.

+ 2021 Science TEKS covered in this design challenge

Grade 5 TEKS: 5.1.B, 5.1.E, 5.1.G, 5.2.D, 5.13.A

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

+ Math TEKS covered in this design challenge

Grade 5 TEKS: 5.10.F

Grade 7 TEKS: 7.3.A

+ ELAR TEKS covered in this design challenge

Grade 5 TEKS: 5.1.D, 5.7.F

Grade 7 TEKS: 7.1.D, 7.6.F

+ 2022 Technology Applications TEKS covered in this design challenge

Grade 5 TEKS: 5.3.A, 5.3.B

Grade 7 TEKS: 7.3.A, 7.3.B, 7.3.C

+ The students will be able to:

> Compare the structures and functions of different species to identify how organisms survive in the same environment
> Solve a problem using the engineering design process
> Balance a simple budget
> Respond using newly acquired vocabulary
> Work collaboratively with others to develop a plan of shared responsibilities

+ 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:

> Scissors	$5 per pair
> Cardboard	$10 per sheet
> Thick Foam Sheet (6 mm)	$10 per sheet
> Hot Glue Gun	$20 per gun
> Hot Glue Stick	$1 per stick
> String	$3 per foot
> Straws	$2 per unit
> Zip Tie	$2 per tie
> Tape	$5 per roll

+ Materials needed by the facilitator:

- Projector and computer
- Internet access or downloaded video
- Slide deck for the lesson
- Copies of the scorecard for each group
- Timing device
- Water bottle (500mL)
- Sample of prosthesis mechanism

+ FACILITATION GUIDE

SECTION	PROCEDURE
INTRODUCTION	**Slide 1: Biomimicry** **Slide 2: Biomimicry (YouTube Slide)** > Ask students if they have heard the word biomimicry or have any ideas about what it could mean. Break the word apart into bio and mimic to help with understanding. Can they think of any biomimicry examples? > Explain to students that biomimicry is the imitation of nature to solve human problems. As engineers think about how to improve society, nature is a source of inspiration. This video (stop at 5:05) will explain some examples of how nature has helped engineers improve designs. ▪ *Teacher's Note: The video has eight examples. Teachers should have discretion on how many examples to show students based on time available.* ▪ *Teacher's Note: The video can be played directly from the slide if the computer is connected to the internet. If internet access is unavailable, download the video directly to the computer.* **Slide 3: 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 4: 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 5-7: Engineering Jobs 1-3 > Show students pictures related to engineering jobs connected to the challenge. > Architecture ▪ Ask students what they see in the pictures. ▪ Explain to students that the process of building these buildings is called architecture, which is the combination of art and science to design and construct buildings. ▪ Ask students how these buildings connect to nature. > Biomedical Engineering ▪ Ask students what they see in the picture. ▪ Explain to students that engineers who study the human body to design solutions are called biomedical engineers. They use science to help solve human body problems! Some of the work they do can help create a functional limb for a person who has lost a hand, arm, leg, or foot. > Materials Engineer ▪ 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 8: Engineering Design 3** > Ask students the question. Who can be an engineer? ▪ Anyone! **Slide 9: 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 10-11: Identify –** Problem > Have students read the bolded section. ▪ Ask students to *identify the problem*. > Explain to students that they will put on their engineering hats to design a prosthesis to complete daily tasks involving a water bottle. > Ask if students have heard the word prosthetic or prosthesis. Explain to students that prosthetics is the field of research, while prosthesis is the artificial device that is worn. **Slide 12: Identify –** Criteria (Desired Outcomes) > 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 prosthesis should include the following: • Uses nature as inspiration for design • Holds a water bottle for 30 seconds • Can lift and put down a water bottle without tipping it over

	- Holds a water bottle firmly enough to have it opened - *Teacher's Note: The student will hold the water bottle with the prosthesis while another student or teacher attempts to remove the cap with one hand.* Bonus points will be awarded if the prosthesis can be tested with one hand. **Slides 13-14: Identify –** Constraints (Limitations) > 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 30 minutes to build the prosthesis. • *Teacher's Note: The teacher will time the design challenge and give the students time checks periodically to assist the teams with their time management.* ▪ <u>Materials</u>: Students can only use the materials available. ▪ <u>Budget</u>: 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.* ▪ <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 prototype as many times as needed during the 30-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 15: Identify –** Explore Materials > Students will be presented with the materials needed to create a prosthesis. The teacher or facilitator will hold up a working example of how to get a foam sheet to bend using straws and strings. By pulling the string that is laid through the straw it allows the foam

	sheet to curl. Students will then use this mechanism as the basis for their design. **Slide 16: Imagine –** Brainstorm Ideas > Give students one minute to individually design and draw a plan of what they think their prosthesis should look like. Emphasize that students should not talk during this minute or share ideas. Remind students 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 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	**Slide 17: 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. > Review the design criteria: ▪ A successful prosthesis design should include the following: • Uses nature as inspiration for design • Holds a water bottle for 30 seconds • Can lift and put down a water bottle without tipping it over • Holds a water bottle firmly enough to have it opened Bonus points will be awarded if the prosthesis can be tested with one hand. ▪ *Teacher's Note: Students will not be expected to rank themselves or calculate their scores, but the teacher should explain how they will earn points. The testing criteria will inform their design decisions.* > 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. **Slide 18: Plan –** Team Member Responsibilities > Each team member must be given responsibility, such as materials
CREATE	**Slide 19: Create –** Design Your Prosthesis > 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 20: Identify –** Criteria > Display the reminder slide for students to look at while working. **Slide 21-22: Create –** Test > Students will test their prosthesis by coming up to the testing station and having one team member operate the prosthesis. An empty plastic water bottle will be used, and students will be required to go through each of the tests. For the bottle opening test, an additional student may help out with operating the prosthesis while the teacher attempts to take off the bottle cap. > 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 with what the students recorded.
IMPROVE	**Slide 23: Improve – Redesign: Discussion** > Students will reflect on their score and discuss the following: ▪ What worked? • *Teacher's Note: Focus on the materials being used and ask why they think those materials were helpful. Ask students what they pulled from nature for their design. Have students compare how their design operates to how their inspiration operates in nature. What similarities*

	exist between the two for it to work well on the prosthesis? ▪ 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 they pulled from nature for their design. Have students compare how their design operates to how their inspiration operates in nature. What differences exist between the two for it not work as well on the prosthesis?* ▪ What do you want to improve? • *Teacher's Note: Focus 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.*