LESSON PLAN

Renewable Innovators (Grades 3-5)

+ OVERVIEW

In this design challenge, students will be tasked with designing a functional wind turbine that can harness wind energy to perform work by lifting a small weight. They will apply the engineering design process to develop solutions demonstrating energy transfer and mechanical function. Students will be presented with the following scenario:

“Texas leads the nation in wind energy production, with significant contributions from the Coastal Bend and Rio Grande Valley regions. Wind energy is a vital sustainable resource that powers homes and businesses across South Texas. Today, you will take on the role of engineer to design a wind turbine capable of harnessing wind power to perform work, such as lifting a weight.”

Students will practice problem-solving and collaboration skills as they design, build, and test their wind turbine prototypes. By engaging in this STEM challenge, students will explore the role of renewable energy in powering communities, learn about energy transfer and mechanical systems, and gain insight into the importance of sustainable energy solutions.

+ 2021 Science TEKS Covered

Grade 3 TEKS: 3.1.A, 3.1.B, 3.1.E, 3.1.G, 3.2.A, 3.2.D, 3.5.A, 3.5.C, 3.5.E, 3.7.A

Grade 4 TEKS: 4.1.A, 4.1.B, 4.1.E, 4.1.G, 4.2.A, 4.2.D, 4.5.A, 4.5.C, 4.5.E, 4.7.A

Grade 5 TEKS: 5.1.A, 5.1.B, 5.1.E, 5.1.G, 5.2.A, 5.2.C, 5.2.D, 5.5.A, 5.5.C, 5.5.E, 5.7.A

+ Math TEKS Covered

Grade 3 TEKS: 3.1.A, 3.4.A, 3.8.A

Grade 4 TEKS: 4.1.A

Grade 5 TEKS: 5.1.A

+ The students will be able to:

- Solve a problem using the engineering design process.
- Investigate how the components of a wind turbine work together to capture and utilize wind energy.
- Analyze how wind energy can perform tasks such as lifting objects or generating power.
- Design and construct a functional wind turbine model capable of lifting a small weight.
- Test their wind turbine design, identify areas for improvement, and refine their model for better performance.
- Compare the benefits and challenges of wind energy to other energy sources.
- Present their wind turbine designs and findings to classmates, explaining their design choices and results.
- Understand the role of renewable energy like wind power in protecting the environment and supporting sustainability in their community.

+ 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

- Weight - Free
- Scissors - $5 per pair
- Straws - $10 per straw
- Rubber Bands - $5 per rubber band
- Tape - $10 per roll
- Linking Cubes - $60 per box
- Toilet Paper Roll - $20 per tube
- String - $5 per foot
- Chenille Sticks - $5 per stick
- Toothpicks - $2 per toothpick
- Paper - $2 per sheet

+ FACILITATION GUIDE

SECTION	PROCEDURE
INTRODUCTION	**Slide 1: Energy in Action: Building Wind turbines** > Introduce today's lesson on creating wind turbine models to explore renewable energy. > Explain that students will learn how wind energy can be harnessed to perform work, such as lifting objects, and will be tasked with designing their own wind turbine model to lift a small weight. **Slide 2: Understanding Energy 1** > Discuss the concepts of kinetic energy and mechanical energy. ▪ Energy is the ability to do work or cause change. Two important types of energy that we will discuss are kinetic energy and mechanical energy. ▪ Kinetic energy is the energy of motion. If something is moving it has kinetic energy. ▪ Mechanical energy is the total energy of an object due to its motion (kinetic energy) and its stored energy (potential energy). It is the energy that allows objects to do work, such as lifting a weight or turning gears. **Slide 3: Understanding Energy 2** > Introduce the key idea that wind energy can be transformed into mechanical energy to perform tasks, like lifting objects. ▪ Wind is moving air, and that moving air has kinetic energy. We can capture that kinetic energy and convert it into another form of energy that we can use. ▪ For example, when wind hits the blades of a wind turbine, it causes them to spin. This spinning motion is a form of mechanical energy that can be used to perform tasks. **Slide 4: Other Types of Energy 1** > Discuss the different types of energy (potential, electrical, thermal).

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- Potential Energy: This is stored energy. It's energy that an object has because of its position or condition.

Slide 5: Other Types of Energy 2

- Electrical Energy: The energy produced by the movement of charged particles, like electrons, through a conductor.

Slide 6: Other Types of Energy 3

- Thermal Energy: The energy in an object or system that comes from the movement of its atoms and molecules. It is also known as heat energy.

Slide 7: Harnessing Energy

> Highlight real-world applications of wind energy, such as wind turbines used in South Texas to generate electricity and reduce reliance on nonrenewable resources.
  - Wind energy is a form of renewable energy, which means it won't run out like fossil fuels such as coal and oil.
  - In places like South Texas, wind turbines are used to generate electricity by capturing the wind's kinetic energy and converting it into electrical energy.
  - Using wind energy helps reduce our dependence on nonrenewable resources and it also provides a clean and sustainable way to generate power.

Slide 8: Harnessing Wind Energy in Action

> Play a video showcasing real-world wind turbines and their role in generating renewable energy.

Slide 9: Engineering Connection

> After the video, ask students, "What challenges do you think engineers faced when designing wind turbines?"
  - In the video we learned that wind turbines can be as tall as 60 m and that wind speeds for turbines can range from 11 km to 90 km. But how big and fast is that in terms we use every day in the U.S.?
  - Wind turbine is about 60 m tall.

- Conversion: 1 m is about 3.28 ft
- 60 m x 3.28 ft/m is 197 ft
- That is about the height of a 20-story building and taller than the Statue of Liberty (151 ft).

▪ Wind turbines need a minimum wind speed of 11 kph to work and can withstand wind speeds of up to 90 kph.

- Conversion: 1 km is about 0.621 mph
- 11 kph x 0.621 = 6.8 mph
- 90 kph x 0.621 = 55.9 mph

Slide 10: 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 11: 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 12-14: Engineering Jobs 1-3

> Show students pictures related to engineering jobs.

▪ Wind Energy Engineer: They design, test, and improve wind turbines to make them stronger, safer, and more efficient at producing electricity from the wind.

▪ Electrical Engineer: They work with the wiring and power systems of wind turbines. They

figure out how to send the electricity from the turbines to homes and businesses.
    - Environmental Engineer: Help design wind farms in eco-friendly ways. They study how wind turbines affect wildlife, land, and air quality, and find ways to make wind energy clean and safe for nature.

Slide 15: Engineering Design 3

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

Slide 16: 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 17-18: Identify - Problem** > Present the problem to the class: > Texas leads the nation in wind energy production, with significant contributions from the Coastal Bend and Rio Grande Valley regions. Wind energy is a vital sustainable resource used to power homes and businesses across South Texas. Today, you will take on the role of engineers to design a wind turbine capable of harnessing wind power to perform work, such as lifting a weight. > Ask students: ▪ Why is renewable energy like wind important for the environment and our community? > Explain that students will explore how wind energy works, analyze the materials provided, and design a wind turbine that can effectively lift a small weight.

Slide 19: 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 wind turbine will do the following:
    - Harness wind energy to lift a small weight 20 cm
    - Operate smoothly and efficiently without tipping or breaking
    - Build a wind turbine a minimum of 25 cm in height
  - Bonus Points: Incorporating ecofriendly materials in the wind turbine design.

Slide 20-21: 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 wind turbine 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 22: Imagine - Explore Materials** > Present students with the materials available for designing their wind turbine. **Slide 23: Imagine - Brainstorm** > Provide each group with an open space for brainstorming. > Give students three minutes to brainstorm and sketch their design for the wind turbine. > 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 24: 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 wind turbine will do the following:
    - Harness wind energy to lift a small weight 20 cm.
    - Operate smoothly and efficiently without tipping or breaking.
    - Build a wind turbine a minimum of 25 cm in height.
  - Bonus Points: Incorporating ecofriendly materials in the wind turbine design.
- 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 25: 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 wind turbine for durability and functionality during testing.
CREATE	**Slide 26: Create - Design the Wind Turbine** > Encourage students to have fun, be creative, and collaborate effectively while constructing their wind turbine. > 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 27: Identify - Criteria** > Display a reminder slide with the design criteria and constraints for students to reference during the building phase: • Harness wind energy to lift a small weight 8 inches. • Operate smoothly and efficiently without tipping or breaking. • Build a wind turbine a minimum of 10 inches in height. ▪ Bonus Points: Incorporating ecofriendly materials in the wind turbine design. **Slide 28-29: Create - Testing** > Teachers will establish a designated area where groups can test their wind turbines. ▪ Designate an area in the classroom with a fan to simulate wind for testing the wind turbines. ▪ Provide a standard weight (e.g., small washer or paperclip) to be attached to the wind turbine's string mechanism for lifting. ▪ Ensure the fan is positioned to direct consistent airflow at each wind turbine during the test. > 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 30: 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 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 wind turbine. Ask how they handled any setbacks or failures during the design process and if they could redesign their wind turbine, 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 wind turbine. 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 wind turbine 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.