engineering 4 us all

HANDS-ON ACTIVITY

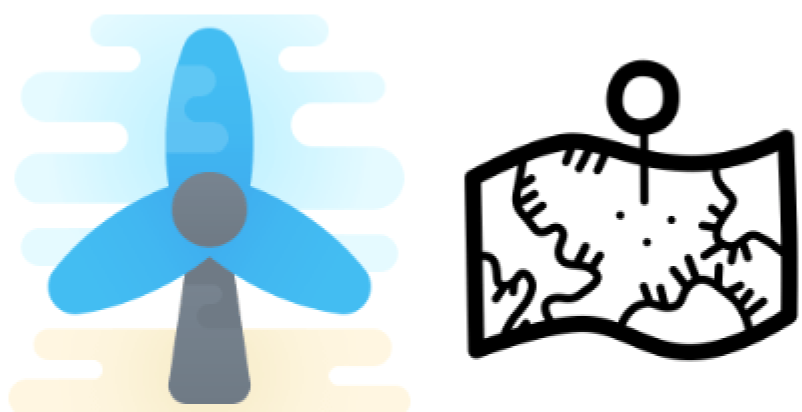
2.4.1 Improvised Wind Turbine Problem

Quick Look

e4usa+ Making

Grade Level: 9 (9-12)
Expendable Cost/Group: US $0.00
Activity Dependency: None
NGSS Performance Expectations:

HS-ETS1-2



Defining the problem is an important part of the design process.

Educational Standards

- NGSS: Next Generation Science Standards - Science
- International Technology and Engineering Educators Association - Technology

Materials and Cost

- **Materials**
  - computers with internet access for research purposes
  - sticky notes (if using them for voting)
- **Cost**

- $5

Worksheets and Attachments

Lesson 2.4 Problem Definition Slide Deck
e4usa Team Performance Rubric

Visit [www.teachengineering.org/activities/view/e4usa-unit2b-wind-lesson4-1-improvised-wind-turbine-problem] to print or download.

Introduction/Motivation

Engineers follow a design process when solving a problem. A crucial part of this process is to define the problem. This lesson and activity combo focuses on clearly defining the problem in a design challenge, while considering design criteria, specifications, and constraints as a whole class.

Procedure

Before Class

- Set up the room for teamwork
- Ensure that students have access to a computer (desktop or laptop).
- Prepare a way to vote for parameters that will be addressed (such as with physical or electronic sticky notes)
- Decide how you will have students complete the e4usa Team Performance Rubric. (You may wish to create an electronic form, such as a Google Form, so that the rubric can be completed electronically.)

Procedure

1. [2 min] Students are given a short problem prompt, related to earlier lessons on wind energy:

> *A fierce storm ravaged your community's power supply equipment. You have alerted the local government about the damaged power infrastructure. To stay in touch with the rescue teams, your phone needs electricity. Luckily, local residents, including you, have improvised wind power generators at home, which can charge household batteries as emergency backup and then charge your phone. How would you design a household wind turbine that maximizes electricity production to charge your household batteries? (Notes: If power was sufficient, it could even provide additional activities like nighttime illumination.)*

Note: teachers may modify and contextualize the example above based on classroom and school context.

2. [30 minutes] Team-based problem definition and research .
    a. Hand out copies to students or give access to the Supplemental Document for Problem Definition and Testing.
    b. Inform student teams that they will research the problem. Let them know that being able to identify and prioritize the possible problems will be key to developing a more specific problem statement and deciding on the criteria and constraints. Ask students to consider the following questions:
        - What are possible things that could be wrong with the wind turbines?
        - Which problems would be most important to fix? For example, does the number of blades matter the most?
3. These research and design specification ideas will allow the team to contribute to a whole-class discussion to finalize the problem's specifications and requirements.
4. [60 minutes] In a whole class discussion, develop a more specific problem statement and a list of prioritized criteria and constraints.
    - On a classroom board (virtual or physical), set up a column for each of the following possible measurable parameters about the device that are listed below. Note that parameters will be both about the device itself as well as how it can improve the efficiency of wind turbines. Be sure to save an empty column or two for additional parameters that the students might suggest based on their team research. Discuss with students why something like "the length of the blades" needs careful consideration. (The length of the blades would affect the impact of air drag.)
        - Possible requirements or parameters for the device:
        - The efficiency of the improvised wind turbine, time of charging, etc.
        - Dimensions of the device, weight of the device, how long it takes to manufacture
    - Have teams report out from their research on why each parameter is important. Ask them, "What goes wrong when that parameter isn't considered?" Teams can report ideas in each column as they apply.
    - Conduct a vote with students to determine which prioritized parameters (which may be criteria or constraints) they will tackle in this design problem. Of course, all parameters are likely important, but for this introductory design challenge, we want to minimize its complexity a bit. You (and your students) may set the cut off for how many parameters will be addressed, but about five parameters is a good number for this challenge.
        - Give each student team seven votes (perhaps sticky notes if doing this in person) and let them vote on the most important parameters. Let

them know that they can vote for a particular parameter more than once if they think it is particularly important.

- Work with students to do the following for the selected parameters:
    - Make them each specific and measurable. For example:
        - If students select output *power* or *efficiency* as one of their measurable criteria, they need to add specifics so that they can measure whether or not they are successful.
            - They could specify that the design's output power should surpass a defined threshold. For instance, they might state, "The output power must exceed 1W." They could use a multimeter to test the output Power.
            - They could specify that the design's efficiency should surpass a defined threshold, which is a percentage representing the amount of input power converted by the wind turbines. For instance, they might state,
            - “The efficiency of energy conversion exceeds 5%."
            - They could also use a multimeter to test the output Power and calculate the power coefficient (Cp). The equation for this is Cp = output power/input power. Output power may be calculated by multiplying the measured current times the measured voltage. These equations may be found in this equation document.
        - Another constraint should be around the limited availability of materials and tools in their house. Perhaps they might say, “The tools used for making improvised wind turbines should not require electricity as the case is when there is a power outage.”
    - Outline the specifications. Design criteria should be measurable and will be used to test the prototypes later in the unit.
        - Be sure to post this final problem statement and its design criteria and constraints in a place where students can see it and refer to it throughout this unit.
    - Record the tables created through this lesson; the research recorded here may be helpful later.

5. [15 min] Introduce and use the e4usa Team Performance Rubric.

    a. Explain that the CATME rating scale is used to evaluate and provide feedback to individuals about their individual teamwork skills and contributions.
    b. Explain that effective teams are much more than the sum of their parts. Effective teams establish good team norms and develop habits that improve the team’s functioning.
    c. The e4usa Team Performance Rubric is a tool to evaluate how well a team is performing as a whole with respect to team norms and habits.

d. Prompt teams to read through the rubric, discuss how they are doing, and come up with strategies for improvement.
    - [Individually] Use the e4usa Team Performance Rubric to take stock of your team's current habits. Take particular note of your team's strongest and weakest habits.
    - [In teams] Each team member shares out the team's strongest and weakest habits.
    - [In teams] Discuss and write down strategies that the team can use to help develop strong team habits.

Assessment

None

Engineering Design Process Portfolio

While students are not yet creating portfolios, the work done here would contribute to Element A.

Supplemental Resources

- KidWind Wind Turbine Basics for All Levels (Vernier Science Education)
- Designing the Perfect Wind Turbine (Museum of Science)
- How do Wind Turbines work? (Lesics)
- Types of Wind Turbines: 3 Main Types with Details (Linquip)
- Windwise Education (Kidwind)
- Learn Wind (Kidwind)
- Advanced Blade Design (Kidwind)
- Advanced Kidwind Experiment Kit (Kidwind)

Supporting Program

Engineering for US All (e4usa)

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