Lesson Four

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THE POWER OF THE WIND

TEP BRIGHT STUDENTS: THE CONSERVATION GENERATION

Grade level appropriateness: Grades 6-8

Lesson Length: 1 ½ full class periods (~90 minutes)

Additional documents:

- Student Lab Sheet: Windmills and Work
- Teacher's Guide to Windmill Experiments
- Template: Making a Windmill

Tucson Electric Power

LESSON 4

Intro

Introduction/Overview

THE POWER OF THE WIND

After a general opening discussion, students work in small teams to create pinwheel windmills from a provided template. With "wind" from a blow dryer, they demonstrate that the kinetic energy of wind can be used to do work, raising pennies from floor to table height. Each student team uses a provided lab sheet, makes a prediction, and collects data on the number of pennies their windmill can lift. Then they average and graph their data to illustrate the relationship between the work performed (weight lifted) and time required. Throughout the lesson, windmills and wind turbines and the students' experiments are framed in terms of essential science concepts related to forms of energy, energy transformation, and work.

Core Concepts

Core Concepts

Harvesting wind energy involves capturing the motion energy of the wind using wind turbines. Wind turbines may be used individually or placed in large arrays called wind farms. Wind energy can be used in mechanical applications, such as pumping water, or the mechanical energy may be used to rotate a turbine to activate a generator to produce electricity. Generating wind energy does not produce solid waste, hazardous waste, water pollution, air pollution, or greenhouse gases.

Learning Objectives

TIME NEEDED

Part One – 45 minutes

Part Two – 45 minutes

After completing this lesson, students will be able to do the following:

- Explain why it is important in an experiment to keep all variables constant other than the variable being studied
- Discuss the value of using averages and the value of presenting data graphically
- Discuss examples of factors that may influence the results or validity of an experiment
- Give the scientific definition of work and of energy and explain the relationship between energy and work.
- Explain the forms of energy and energy transformations involved in using wind to perform mechanical work and to generate electricity
- Describe a process of collecting, recording, graphing, and interpreting experimental data
- Explain how their own experiments demonstrate use of the scientific method

Preparation

Advance Preparation

MATERIALS NEEDED

- Template: Making a Windmill – photocopy one per three-person team, preferably on heavy paper or cover stock
- Student Lab Sheet: Windmills and Work – photocopy one per student
- Stopwatches, watches, or wall clock displaying seconds – one per team
- 1 inch brass paper fasteners – one per team
- Large-diameter straws – one per team
- Standard-diameter straws – one per team
- 1 or 1.5 liter plastic bottles (empty) – one per team
- Material to weight the plastic bottles (water, sand, or fine gravel)–enough to fill bottles 1/3 to 1/2
- Lightweight string – approximately 5 feet per team
- Large paper clips – one per team
- Standard paper clips – 10 per team
- Pennies – 10 per team
- Yard sticks – one per team
- Scissors – one per team
- Tape – several inches per team
- "Tool" with which to puncture paper (compass, fine-tip pen, etc.) – one per team
- Blow dryers (hair dryers) – ideally one per team
- Optional: ring stands – one per blow dryer, if available

GENERAL PREP

- Make a pinwheel windmill in advance. This will provide a model for students to examine as well as prepare you to answer their questions.
- When collecting materials, be aware that large-diameter straws are available at certain fast-food outlets (e.g., McDonald's, Starbucks).
- Ask students to bring in plastic water bottles, pennies, and blow dryers well in advance.
- Review the one-page write-up about Wind Power within the student reading Electricity for You and Me and decide if you want to provide it to your class as background reading for this lesson

Procedure

Suggested Procedure

Part 1: Making Windmills

1. Open by inquiring what students know about windmills and the purposes for which windmills are used (E.g. to pump water for agriculture, to generate electricity; also – historically – to grind grain). Summarize these examples as all related to doing work. Define energy as the capacity to do work.
2. Ask if a volunteer can explain in scientific terms – that is, in terms of energy transformations – how a windmill functions: It captures the motion energy (kinetic energy) of wind to make it useful to humans. In the case of grinding or pumping, the kinetic energy of wind is converted to mechanical energy or kinetic energy in a machine. In the case of a modern wind turbine, or a windmill with a turbine generator, the kinetic energy is transformed to electric energy by the turbine.
3. Tell students that they will now build pinwheel windmills and test them to see if they can perform work. Define the scientific term work: Work is done when a force acts upon an object and the object moves from one place to another. State that when work is done on an object, the object gains energy – that is, it will have gained the capacity to do work. Demonstrate by raising an object up and noting that it has gained gravitational or potential energy
4. Group students in three-person (or four-person) teams and give each team a copy of the template "Making a Windmill." Show students the sample windmill you made in advance and point out the materials available. Explain as needed and then circulate among teams as they build windmills.

Suggested Procedure *(Continued)*

Part 2: Testing Our Windmills

5. When the windmills are complete and students are ready to test them, set up a windmill and blow dryer as an example. Explain that teams will be testing how much work their windmills can do (how many pennies they can lift). Demonstrate how to time the lifting of a penny.
6. Discuss the distinction between a question, prediction, and testable hypothesis, emphasizing the role of the latter in scientific inquiry. Ask for suggestions for a hypothesis in the context of our windmills doing the work of lifting pennies. (As we increase the number of pennies being lifted, the time required to lift them will also increase.)
7. Ask what the variables are in this experiment. Remind students that our hypothesis is a prediction about the relationship between these two variables; and if we want a good test of our hypothesis, we need to keep other variables constant. This is critical in any science experiment. Ask students to identify variables that should be kept constant. List ideas on the board where they will be visible throughout the lesson:
   - Speed of blow-dryers – use the lowest speed
   - Distance of blow dryers from windmill – measure to 18 inches
   - Angle of windmill – keep it facing blow-dryer straight on
   - Angle of blow-dryer – aim at center of windmill blades
   - Friction on thread – keep it clear of the table edge
   - Any other variables the class may identify
8. Give each student a copy of the student lab sheet Windmills and Work. Show teams the blow dryers (and ring stands if available) and provide any guidelines about use or sharing of equipment as well as safety in terms of securing electric cords.
9. Circulate and provide assistance as teams proceed. Give special attention to monitoring whether students keep extraneous variables constant and offer reminders as needed.

Suggested Procedure *(Continued)*

10. When students are finished, focus as a class to review the scientific inquiry process and discuss the experiments and results, touching on such areas as:
    - Whether the results support their hypothesis
    - Their conclusion and their confidence in its validity and reliability
    - Their level of success at controlling extraneous variables
    - Other potential sources of investigational error (inaccurate measurements, incorrect calculation of averages, etc.)
    - The advantage of using multiple trials and averages and
    - The value of presenting their data graphically
11. Also discuss:
    - Similarities and differences between our windmills and wind turbines and
    - The scientific definition of work and its relationship to energy
12. If time allows and if you have a U.S. map available, inquire whether anyone knows the location of any wind farms. Locate any that students may have seen (for example, along Interstate 8 en route to San Diego or Interstate 10 en route to Los Angeles). Discuss that people scattered around Arizona may use wind turbines to power their homes, but power companies only build wind farms in areas that are very windy all year. Only a few areas in Arizona may be windy enough to support wind generation on a commercial scale. Some power companies are experimenting here. Texas and the Dakotas are the states with the greatest potential for commercial wind generation. As with solar, hydro, biomass, and other renewable energy sources, the available resources and potential for power production vary from place to place.

Assessment Ideas

Students' completion of the lab sheets and participation in the discussion might serve as an assessment. Before beginning the lesson, you could create a rubric in relation to their participation and successful completion of the lesson. Or for a formal written assessment, reframe the bulleted discussion items from step 10 above as questions and ask students to write a paragraph or two on each of these subjects.

Extension Ideas

Using our windmills to make electricity: Present a demonstration or let students experiment to see if their windmills can create an electric current (enough current to make a compass needle deflect, or enough to register on a voltmeter sensitive to very low voltages). Use a fan for this, not a blow dryer. Props might include a small DC motor, approximately 1.5+ volt capacity; wire leads (connecting wires with clips or exposed wire on each end); a compass; miniature fan and/or buzzer and/or other device able to run on 1 to 5 volts DC; and a DC voltmeter or multi-meter able to display readings of 1 to 5 volts.