CLEAN ENERGY BRIGHT FUTURES
A Program of BEF

LESSON PLAN

Solar Updraft Towers: Innovations in Renewable Energy

Lesson 3: Wind Power—A Hands On Experience

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DESCRIPTION
This lesson challenges students to work in teams to design successful turbine blades for the "KidWind Firefly". The firefly has an LED light that lights up when the students have designed turbine blades that spin effectively. This lesson provides students with hands on experience in designing turbines blades. This will scaffold them nicely into Lesson 4 when they design their own paper turbine for a Solar Updraft Tower toy.

GRADE LEVEL(S)
3, 4, 5, 6, 7, 8

SUBJECT AREA(S)
Wind energy, engineering design, energy transformations

ACTIVITY LENGTH
2 hours

LEARNING GOAL(S)

1. Students will understand that wind energy can be converted into other forms of energy.
2. Students will determine different methods to increase the effectiveness of a wind turbine blade at harnessing and converting the mechanical energy of the wind.

STANDARDS REMINDERS

- While students work on turbine blades, it is important that they understand that the motion of the turbine is a result of air molecules colliding with the blade itself and passing around it in the process. This will tie into later designs and investigations involving rising air in solar updraft towers.

- Ensure that students identify the energy conversions taking place within their turbine system and discuss how this energy conversion can be completed in a more efficient manner.

CONTENT BACKGROUND

STUDENT BACKGROUND

Students participating in this lesson should be familiar with the following:

- A basic understanding of wind turbines and how they work, perhaps from their or a classmate's energy report (Lesson 1).
- A basic understanding of an electrical circuit.

EDUCATOR BACKGROUND

Educators leading this lesson should be familiar with the following:

- A basic knowledge of wind turbines and how they work.
- A basic knowledge of wind turbine blade design. It might be a good idea for the teacher to participate in the turbine blade designing challenge. He or she will, most likely, learn something about the most successful design, from the students. There is no set wrong or right way to design turbine blades. There is only experimental improvement with trial and error, learning from one another.

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Worksheet 4-KWL Water Wind Heat
- Worksheet 5-Phenomena Chart

CLASSROOM SUPPLIES

- Pencils for drawing designs and writing explanations
- Box fan for testing turbine designs

ACTIVITY SUPPLIES (BREAK CLASS INTO 10 GROUPS)

- Recharge Labs Firefly Classroom Pack (RL-FIREFX, includes 10 firefly models with motors and lights)
- 10 unsharpened pencils to be used as handles for the "Fireflies"

Figure 1. REcharge Labs Firefly Models, http://www.rechargelabs.org/firefly

LESSON PROGRESSION

PLANNING AND PREP

PURCHASE

- Purchase a “REChargeLabs” firefly Class Pack for this activity.

BUILD

- Build one first to test it yourself.
- Do not share your design with the students. Let them test their own through trial and error. The motors have a tendency to fall out of the housing. I recommend that you tape or glue the motor into the housing unit for future use. If you have access to a soldering iron, I highly suggest soldering the connection wires to the motor before taping or gluing the motors into the units.

CUT

- Several 4x4” pieces of cardstock for turbine blade design.

The firefly kit comes with 5 different pattern templates for the turbines, however, the students will have a much better opportunity for engineering design if they are given blank squares of paper.

LESSON SEQUENCE

1. Light the Swedish Candle Spinner and have a review discussion with the students about what makes the turbine blade spin (heat from the candle is causing the heated air to rise up and move through the bends of the turbine blade, which causes it to spin).
2. Show the students the box fan, turn it on and conduct a class discussion about what makes the turbine blade in the fan turn and how it creates wind in the classroom.
3. Compare and contrast the box fan to the Swedish Candle spinner. How are they alike and how are they different? Creating a chart on the whiteboard is helpful.
4. Inform the students that they will be working in pairs or groups of 3, depending on your class size, to design and test their own turbine blade.
5. Hold up a piece of 4x4 paper and explain to the students that they will use this paper for their turbine designs. They will need to plan a design, cut it out and test it.
6. Show the students a firefly. Keep one firefly unassembled and show the students the different components of the device, or draw a model of the

turbine rod, motor and the electrical circuit that is connected to the little red light bulb. Demonstrate the firefly.

7. Inform the students that the "spirit of the problem" is to use a piece of 4 x 4 paper to plan, design, create and test a turbine blade by connecting to the firefly, holding it in front of the fan. Success is achieved if the red light on the firefly lights up. Let the students come up with their own blade designs from scratch, on their own.
8. If the design lights up, students will sketch their design and write a description discussing what they think makes it successful. They will then be asked to create other designs, changing one variable at a time such as number of blades, fold of the blades, size of the turbine. This will necessitate a discussion of the importance of isolating one variable, possibly tracking examples of these specific variables on a poster on the wall as a result of group discussion.
9. If the design doesn't cause the firefly to spin fast enough to light it up, students will sketch their turbine, and document one change they will make to the design at a time in order to hopefully improve how successful the device is.
10. Students will keep a chart of sketches of their designs and written explanations of variables that were changed one at a time.
11. Stop the action occasionally, and ask students do discuss, analyze, investigatenelements of design that they have found to be successful. This is a fantastic exercise for helping students to learn and understand that successful engineers are not in competition with one another, but rather made stronger and more successful by sharing successes and failures with one another.
12. If you did not explicitly cover the engineering design cycle with students during this activity, having them note each step, this is a good opportunity to introduce or reiterate concepts from this cycle. Create a chart that lays out each step of the design cycle with room next to each stage (Ask, Imagine, Plan, Create, Improve). Have students give specific examples of what they did during this activity for each stage, noting that many of these were done multiple times.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

This activity can last one to several days. Students will create turbines until they are able to light the firefly when held up to the fan. Students will take turns demonstrating their successful turbine design and giving a brief explanation of their design journey. Students will also be assessed on their design and test chart they created throughout the activity.

LESSON EXTENSIONS

Check out the MacGyver Kit at REcharge Labs, in which students design an entire windmill from found items instead of just the turbine blades.

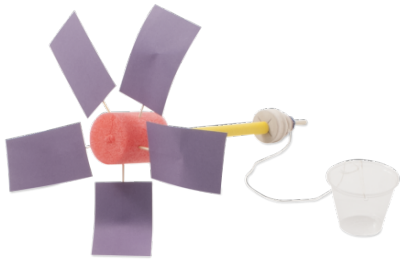

Figure 2. REcharge Labs MacGyver Windmill, http://www.rechargelabs.org/macgyver-windmill-class-pack