PTRA: Bringing Physics to Life Through Literature

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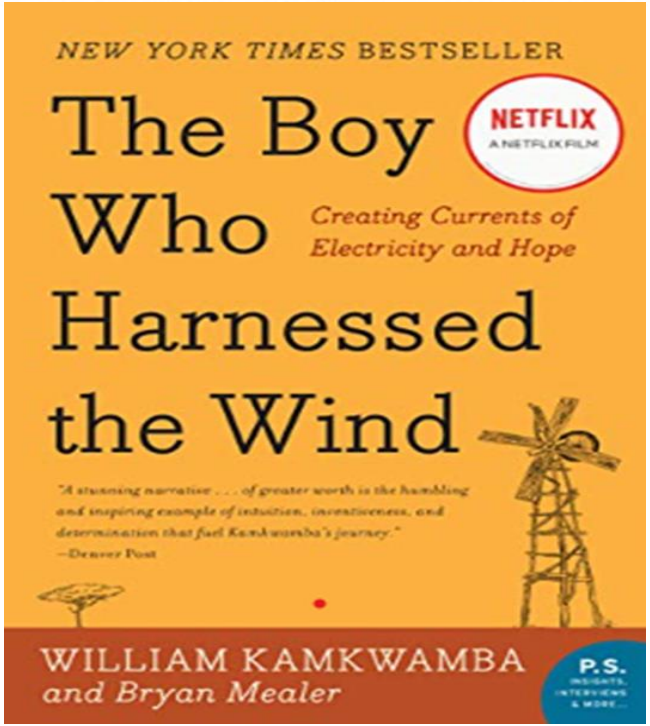
The Boy Who Harnessed The Wind
Introduction

Windmills are the ancient ancestors of modern wind turbines. To understand how wind turbines work, one must first understand a basic windmill. This lesson will help students understand how a windmill captures the energy of the wind and converts it into usable mechanical energy, which is the basis for understanding modern wind turbines. Students will use the engineering design process and the scientific method to design, build, test, and improve their models.

Standards Aligned with the Learning Cycle
NGSS
3 PS3 A – D Definition of Energy, Conservation of Energy, Energy Transfer and Processes.
4 PS 2 and 4 Energy
5-ESS3: Earth and Human Activity
ELA/Literacy SL. 11-12.5
Mathematics
MP.2
MP.4
HSN.Q.A.1-3

The Boy Who Harnessed The Wind

Engage

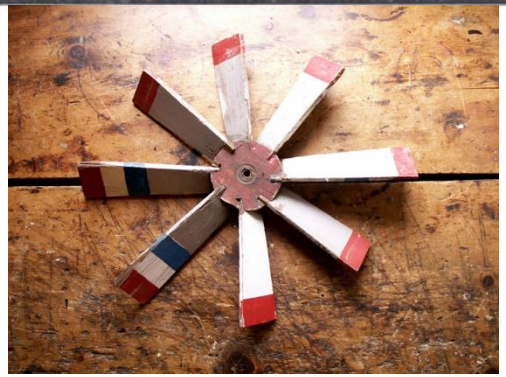


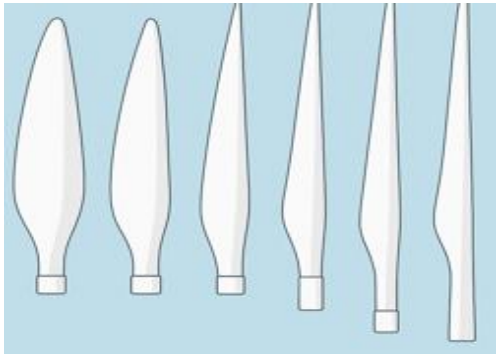
- https://youtu.be/G8yKFVPOD6o

https://1drv.ms/w/c/670cf41058257ff9/IQD6Zc5HMPD2RL4cMB5a8FBIAX5uy9uIw1bqOzGfmSIGcjQ?e=7h1d4M
Link to Lesson Plan

The Boy Who Harnessed The Wind
Explore

Construct a Pinwheel and test pre-made blades to determine which blade design produces the most voltage. Students will design and build blades to generate electricity.





The Boy Who Harnessed The Wind
Explain

Ask Students the Following Questions:
Who has seen a real windmill (mechanical or electrical)?
What are the parts and features of a windmill?
What are windmills used for?
How does the wind cause the windmill to rotate?

As the students' design, test and redesign a wind turbine they will develop and utilize the math skills of ratios and proportional reasoning to solve real-world and mathematical problems. Students will determine which shape and how many blades on a hub produce the greatest amount of electrical energy through the lighting of LED bulbs and the pumping of water.

Which Blades are the Best and How Do I Design Better Blades?

Variables to be tested may include:

- blade length
- number of blades
- weight/distribution of weight on blade
- blade pitch/angle
- blade shape
- blade material
- blade twist

Students will test their design with respect to the number of volts each design produced and as a whole the class will answer:

- What variable has the greatest impact on power output?
- What type of blades worked best at low speeds? High speeds?
- What number of blades worked best?
- What shapes worked best?
- What length worked best?
- What problems did you encounter?
- Did longer blades bend backward in the wind?
- Was this a problem?
- What happened when the diameter of the turbine rotor was bigger than the diameter of the fan?

The Boy Who Harnessed The Wind
Evaluate

Building a Wind Farm Students will use their windmills to build a wind farm with a minimum of 4 windmills and light bulbs and pump water. Or Lift a mass using a mechanical windmill

Power Up Challenge:

Your turbine system will compete in the following categories:

- voltage produced/mass
- voltage produced/Cross sectional area or diameter
- voltage produced/ Number of blades
- Power of the system Power(P) = $\frac{Work\ (W)}{Time\ (t)} = \frac{force\ x\ distance}{time}$ Where the force is the weight lifted aka number of washers and distance is the height through which the bucket moves.
- Following the above combine your wind turbines to maximize voltage produced, light bulbs and pump water.
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Power Production Old Maid

Object: Students try to complete power production chains from the generation plant to the end user. This is accomplished by matching colors in the top left corner of the cards

Basic Rules: Power production chains (for this activity) consist of six steps. To assist students who may not be familiar with all the various processes, matching cards have been color coded. A matching process consists of six cards with the same color square in the upper left corner of the card. White squares should be considered as blank and do not count as a match. When students have six cards with matching color squares they may put the entire set of six down on the table in front of them. Sets of less than six cards may not be played but, must be held in the hand until they are completed.

Sample of Cards: