GR. 5 STEM UNIT

Energy and Energy Transfer: Building a Wind Turbine

In this unit, students will engage in the processes of Science Inquiry and Engineering Design to explore concepts related to wind energy and energy transfer.

Unit Title: Energy and Energy Transfer: Building a Wind Turbine **Date Developed/Last Revised:** 07.8.13 **Unit Author(s):** L. Lum, R. Saito, K.Umeda, B. Jennings	**Grade Level:** 5 **Time Frame:** 15 45-minute periods **Primary Content Area:** Science, Engineering

UNIT DESCRIPTION:

Students will engage in the Scientific Inquiry Process (SIP) to investigate the concepts of energy and energy transfer. Through engagement in the Engineering Design Process (EDP) students will apply this scientific knowledge to engineer a wind turbine of their own design. Mathematics and technology is applied throughout these processes of this STEM unit.

Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit):

Students will discover and investigate the physical science concept of energy through engagement in the scientific inquiry process. More specifically, they will understand how energy can be transferred from one form to another, and how this knowledge is used to create renewable energy resources that are efficient and minimally impact the environment. Human endeavor is closely linked to the amount and kind of energy available. The transformation of wind (motion) energy to electrical energy is an excellent example of how people have invented ingenious ways to harness energy transformations that are useful to them (Atlas of Science Literacy, 2007, pg. 26). They will engage in an investigation that will demonstrate how models and simulations can be effectively used to understand features and processes in the real world.

While the Scientific Inquiry Process helps us to answers questions about the world, the Engineering Design Process (EDP) enables us to solve problems, create, and redesign products and systems. Through engagement in this process, students will engage in creating prototypes of ideas while applying their knowledge in science, math, and technology. They will also practice the GLOs and the STEM Competencies as they apply the cooperative skills needed to work in engineering design teams and optimize their product. In this unit, students will work in teams and apply their scientific knowledge of wind energy and wind turbines towards engineering turbines of their own design.

Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas):

- How do we conduct inquiry investigations?
- How can energy be transferred from one form to another?
- What is the role of models and simulations in the investigative process?
- How does the Engineering Design Process enable us to create and innovate?

	BENCHMARKS/STANDARDS/LEARNING GOALS *Note: The "L" codes at the end of each benchmark refer the Marzano's Taxonomic Level of Understanding*
Science (HCPS III)	• SC.5.1.1: Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments (L3) • SC.5.1.2: Formulate and defend conclusions based on evidence (L3) • SC.5.6.1: Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they can change and transfer energy from one form to another (L2)
Technology (HCPS III)	• SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world (L2/3)
Engineering (HCPS III)	• CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Mathematics (CCSS)	*Mathematics Standards* • CCSS.5.MD.A.1: Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step real world problems. *Mathematical Practices* • CCSS.Math.Practice.MP1: Make sense of problems and persevere in solving them. • CCSS.Math.Practice.MP2: Reason abstractly and quantitatively. • CCSS.Math.Practice.MP3: Construct viable arguments and critique the reasoning of others. • CCSS.Math.Practice.MP4: Model with mathematics. • CCSS.Math.Practice.MP5: Use appropriate tools strategically. • CCSS.Math.Practice.MP6: Attend to precision. • CCSS.Math.Practice.MP7: Look for and make use of structure. • CCSS.Math.Practice.MP8: Look for and express regularity in repeated reasoning.

English Language Arts and Literacy (CCSS)	*Language Arts Standards* • CCSS.ELA-Literacy.W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. • CCSS.ELA-Literacy.SL.5.4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace. • CCSS.ELA-Literacy.L.5.2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use punctuation to separate items in a series.* b. Use a comma to separate an introductory element from the rest of the sentence. c. Use a comma to set off the words yes and no (e.g., Yes, thank you), to set off a tag question from the rest of the sentence (e.g., It's true. isn't it?), and to indicate direct address (e.g., Is that you, Steve?). d. Use underlining, quotation marks, or italics to indicate titles of works. e. Spell grade-appropriate words correctly, consulting references as needed.
STEM Competencies	• Indicator 2.2: Collaborates with, helps and encourages others in group situations (in science and engineering teams) • Indicator 2.5: Demonstrates responsible and ethical behavior in decision making (while making choices for the team's implementation plans) • Indicator 6.4: Uses the appropriate technologies for communication, collaboration, research, creativity, and problem solving

LESSON SEQUENCE

	Lesson Title/Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame (45min/period)
1	Engagement Activity: Creating a Pinwheel Turbine	*Students will be able to:* • Create a pinwheel turbine and explore how energy can harnessed to do work. • Explain that energy is the ability to do work and work is done when a force moves an object (ScienceSaurus, 2005).	• Teacher Observations • Group Data Sheet • Student Journal: Pinwheel Turbine	1 class period
2	Structured Inquiry	*Students will be able to:* • Describe inquiry procedures and variables; use data to support conclusions. • Describe how wind (motion) energy can be transformed into electrical energy.	• Teacher Observations • Group Data Sheet • Student Journal: Data Collection and Analysis	2 class periods
3	Guided Inquiry (Optional. If preferred, concepts may be addressed in the EDP Performance Task)	*Students will be able to:* • Apply the steps of the Scientific Inquiry Process. • Use a model of a wind turbine to investigate the process of energy transfer from one form to another. • Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments. • Formulate and defend conclusions based on evidence. • Describe how wind (motion) energy can be transformed into electrical energy.	• Teacher Observations • Group Data Sheet • Student Journal: SIP Steps and Summary	4 - 6 class periods
4	Summative Assessment (Optional. Access to Discovery Education subscription services is required)	*Students will be able to:* • Conduct an investigation in a virtual lab to test and explain the effects of different variables on wind turbine performance. • Explain the importance of controlling variables in an investigation. • Formulate and defend conclusions based on evidence.	• Teacher Observations • Wow Windmills Virtual Lab • Teacher Assessment using the Task Specific Rubric included in this unit	1 class period

ENGINEERING DESIGN PROCESS: The six step EDP is usually conducted over a series of several sessions				
5	Engineering Design Process (EDP) Performance Task EDP Step 1: Ask EDP Step 2: Imagine EDP Step 3: Plan EDP Step 4: Create EDP Step 5: Experiment EDP Step 6: Improve Summary of EDP Task	*Students can follow the steps of the Engineering Design Process to:* • Identify the problem and requirements of the task (construction of model wind turbine). • Generate ideas, share and collaborate with team members to develop a plan for a specific prototype. • Follow the team plan and build the prototype; agree upon and record initial modifications to plan. • Test, record, and analyze data on the model wind turbine. • Repeat the engineering design process to make improvements to design of the wind turbine. • Share the results of their investigation and defend their conclusions based on evidence. • Describe how wind (motion) energy is transformed into electrical energy in their model wind turbines.	• Teacher Observations • Student Journal: EDP Steps; Summary of EDP Performance Task	4 - 6 class periods
6	Engineering Design Process Assessment	*Students will be able to:* • Describe the steps of the Engineering Design Process and reflect on their learning.	• EDP Assessment Sheet	1 class period

Notes:
Cover Image: https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcS-QUn-JWWHH0d9GPM3OWJAyZMPii8EVgnE-oR4W2C1gifcYRNn0Q

Unit Title: Energy and Energy Transfer: Building a Wind Turbine Lesson Title: Engagement Activity: Creating a Pinwheel Turbine Date Developed/Last Revised: 07.8.13 Unit Author(s): L. Lum, R. Saito, Karen Umeda, B. Jennings	Lesson #: 1 Grade Level: 5 Primary Content Area: Science Time Frame: 1 class period

DESCRIPTION

In this lesson, students explore concepts related to wind energy through construction and testing of a pinwheel turbine. They explain that energy is the ability to do work and generate questions about wind energy and energy transfer.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

Hawaii Content Performance Standards III: Science

- SC.5.6.1: Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they can change and transfer energy from one form to another (L2)
- SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world (L2/3)

Hawaii Content Performance Standards III: Career & Technical Education

- Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems.

Common Core State Standards: English Language Arts

- CCSS.ELA-Literacy.W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- CCSS.ELA-Literacy.SL.5.4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- CCSS.ELA-Literacy.L.5.2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
  a. Use punctuation to separate items in a series.*
  b. Use a comma to separate an introductory element from the rest of the sentence.
  c. Use a comma to set off the words yes and no (e.g., Yes, thank you), to set off a tag question from the rest of the sentence (e.g., It's true. isn't it?), and to indicate direct address (e.g., Is that you, Steve?).
  d. Use underlining, quotation marks, or italics to indicate titles of works.
  e. Spell grade-appropriate words correctly, consulting references as needed.

2A. Criteria- What Students Should Know and Be Able to Do:
Students can-

- Create a pinwheel turbine and explain how it demonstrates that energy is the ability to do work.
- Generate new questions related to wind turbines and energy.

2B. Assessment Tools/Evidence:
Formative:

- Teacher observations conducted during class discussions and as students conduct their inquiry investigations (CTE Standard 1; SC.5.2.1; SL.5.4).
- Individual Journal Entry: Pinwheel Turbine (SC.5.1.2; SC.5.6.1; W.5.8; L.5.2)

3. Learning Experiences (Lesson Plan)
Materials: Per Group

- Paper, cut to size (8.5" square)
- Straws
- String, narrow ribbon, or similar material
- Paper clips: Per group, 60+ "Jumbo" (1.75" long)
- Hole puncher
- Tape
- Fans (2-4 fans of the same make and model, if possible)

Handouts:

- How to Make a Pinwheel Turbine handout
  (*Note: Materials to build the turbine are listed in this document.)*
- Lesson 1: Exploring Pinwheel Turbines Group Data Sheet (1 per group)
- Individual Student Journals

Teacher Preparation:

- Fans should be set up such that the "wind" of each fan does not interfere with the others. The fan should be set at the highest level. There should be a masking tape marker about 12 inches from the face of the fan to control the distance variable.

Procedure:

- Review what variables are and why it is important to control the variables in any investigation.
- Pass out the How to Make a Pinwheel Turbine handout.
- Divide students in pairs and have them follow the directions to create their pinwheel turbine, emphasizing the importance of following the directions diligently.
- Pass out the Observations and Wonderings Recording Sheet.
- Instruct students to test their turbine with just the one clip attached and record their observations.
- Direct students to predict and record how many clips their turbine can lift.

• Have students to attach the predicted number of clips and test their turbine again. • Instruct students to discuss and record their observations and their wonderings. • Discuss their observations and wonderings as a class.   o Key question: How does this pinwheel turbine relate to real world technology? • Direct students to complete an entry in their journals: Describe how the investigation demonstrates that energy is the ability to do work; and generate new questions and wonderings related to wind turbines.
TEACHING & ASSESSMENT (Steps 4, 5, 6, & 7) **Completed by teacher after instruction has taken place**
4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

RUBRIC: Student Journal Entry – Lesson 1				
	4	**3**	**2**	**1**
Science and Writing SC.5.1.2 SC.5.6.1 W.5.8	Gives a detailed explanation of how energy from the wind is transferred to the pinwheel turbine and enables lifting a load (work). Generates 2 or more questions/ wonderings related to the inquiry.	Describes how energy from the wind is transferred to the pinwheel turbine and enables lifting a load (work). Generates at least 1 question/ wondering related to the inquiry.	Description of the activity and its relationship to energy or work is somewhat unclear. Question(s)/ wondering(s) are only marginally related to the inquiry.	Lack of clarity and/or completeness in the description of the investigation prevents the reader from determining student understanding of key concepts. Question(s)/ wondering(s) are missing or unrelated to the investigation.
Language Arts L.5.2	Accurately uses standard English conventions and grammar with no errors.	Accurately uses standard English conventions and grammar with no more than 1 error.	One or more errors in the use of standard English conventions and grammar, but meaning is clear.	Lack of clarity and/or completeness in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.

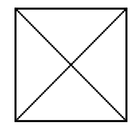
How to Make a Pinwheel Turbine

> *NOTE: To save time, teacher can complete steps 1 - 3 and provide prepared pinwheel to students for final assembly.*

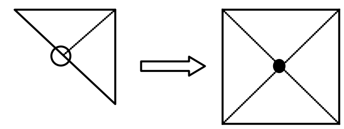
Materials:

8.5" Paper square - regular bond paper
1 Drinking straw
2 Pieces of lightweight string or ribbon, 30cm long
1 Box (60 count or more per box) "Jumbo" (1.75 long) paperclips
Tools: Ruler, tape, scissors, hole punch

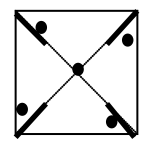
Procedure:



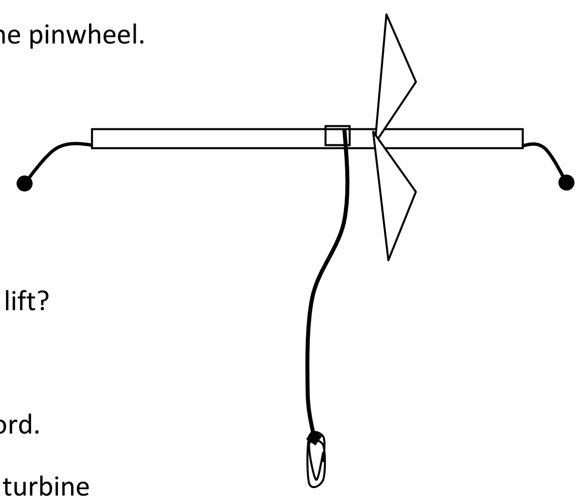
1. Draw diagonal lines between opposite corners of the paper square.



2. Pinch lightly (don't crease) in half to punch a center hole. Place puncher halfway onto the folded paper so that you will have 1 round hole at the center of the square when it is unfolded.



3. Punch holes in every other corner.
4. Cut from each corner halfway to the center of the square.
   Do not cut all the way to the center.
5. Put straw through center hole, then bend each corner to place the corner hole over the straw to make your pinwheel. Secure corners with tape as needed to keep them tight to the center of the square. Tape the pinwheel assembly securely to the straw so that it does not spin.
6. Thread string or ribbon through the center of the straw (you can suck it through if needed) and knot each end so that you can hold it easily.
7. Tape the second piece of string or ribbon about 2" behind the pinwheel. Tie a paper clip to the end.



8. Now- test your turbine! When you hold the two free ends of string and hold your turbine in front of a wind source, the spinning turbine will lift the paper clip as the string winds around it.
9. Make a prediction: How many paper clips can your turbine lift?
10. Test your prediction and record your data.
11. Based on your results, make a new prediction, test and record.
12. What might be changed about the design of your pinwheel turbine to increase its load capabilities? What variables could you test?

Lesson 1: Exploring Pinwheel Turbines Group Data Sheet

Observations of your turbine with one clip attached:

Prediction of how many clips your turbine can lift: ________

Observations of your turbine with many clips attached:

What are your wonderings based on your observations?

Unit Title: Energy and Energy Transfer: Building a Wind Turbine **Lesson Title:** Structured Inquiry **Date Developed/Last Revised:** 07.8.13 **Unit Author(s):** L. Lum, R. Saito, Karen Umeda, B. Jennings	**Lesson #:** 2 **Grade Level:** 5 **Primary Content Area:** Science **Time Frame:** 2 class periods

DESCRIPTION

In this lesson, students use a model of a wind turbine to explore how selected variables affect the amount of electrical energy produced. They investigate, measure, record data, and explain results of an investigation that demonstrates the transfer of energy from one form to another.

Note: While a Wind Experiment Kit is described for this investigation, the pinwheel turbine can effectively be used to investigate wind energy and energy transfer concepts. If students will engage in the Engineering Design Process to build a wind turbine, consider implementing only the structured inquiry rather than both the structured (Lesson 2) and guided (Lesson 3) inquiries.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

Hawaii Content Performance Standards III: Science

- SC.5.6.1: Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they can change and transfer energy from one form to another (L2)
- SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world (L2/3)

Hawaii Content Performance Standards III: Career & Technical Education

- Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems.

Common Core State Standards: English Language Arts

- CCSS.ELA-Literacy.W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- CCSS.ELA-Literacy.SL.5.4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- CCSS.ELA-Literacy.L.5.2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
  a. Use punctuation to separate items in a series.*
  b. Use a comma to separate an introductory element from the rest of the sentence.

c. Use a comma to set off the words yes and no (e.g., Yes, thank you), to set off a tag question from the rest of the sentence (e.g., It's true. isn't it?), and to indicate direct address (e.g., Is that you, Steve?).
d. Use underlining, quotation marks, or italics to indicate titles of works.
e. Spell grade-appropriate words correctly, consulting references as needed.

Common Core State Standards: Mathematics

- CCSS.Math.Practice.MP5: Use appropriate tools strategically.
- CCSS.Math.Practice.MP6: Attend to precision.
- CCSS.5.MD.A.1: (Supporting) Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step real world problems.

Note: It is assumed that the mathematics has already been introduced and the student is able to apply the concepts/skills needed to successfully complete these investigations.

2A. Criteria- What Students Should Know and Be Able to Do:
Students will be able to apply the scientific inquiry process as they-

- Describe data resulting from testing a variable.
- Formulate, share and defend conclusions based on evidence.
- Describe how wind (motion) energy can be transformed into electrical energy.

2B. Assessment Tools/Evidence:
Formative:

- Teacher observations conducted during class discussions and as students conduct their inquiry investigations (CTE Standard 1; SC.5.2.1; SL.5.4)
- Group Data Sheet
- Individual Journal Entry: Data Collection and Analysis (MP5; MP6; SC.5.1.1; SC.5.1.2; SC.5.6.1; W.5.8; L.5.2)

3. Learning Experiences (Lesson Plan)
Materials: Per group

- Wind Experiment Kit (Kid Wind)
- Fans
- Masking tape
- Multimeter

Handouts:

- Group Data Sheet (Copied from Lesson 2 section of Student Journal, 1 per group)
- Individual Student Journals

Teacher Preparation:

- Turbine and blades should be assembled ahead of time.

- To control variables, the fans should be set up such that it does not create a cross-breeze. Each fan should be turned on to its highest setting. A distance approximately 18 inches should be measured from the face of the fan and this distance should be marked on the floor with masking tape.

Procedure:

- Review what was learned from the previous lesson.
- Introduce the assembled wind turbine, and compare and contrast it to the pinwheel turbine to demonstrate how it can generate electricity.
- Group students into teams according to the number of students in your class and the number of turbines available. 2-3 students per team is recommended if materials permit.
- Provide a multimeter for each group of students and explain how it is used to measure electricity. Explain that the multimeter will allow them to select from different systems for measurement and provide time for students to compare these different systems, then direct students to use the lowest setting for measuring the low electrical voltage output that will be generated by the turbine.
- Explain that for any design, there are variables - or things about the design that could be changed. On this turbine, for example, one variable is the number of blades that are used.
- If desired, have students brainstorm other possible variables that could be considered, such as length or shape of blade.
- Explain that each variable must be tested separately to determine its effect apart from the other variables. In today's lesson, each team will test the number of blades as the variable and measure how much electricity the turbine will generate based on 2 different designs- one with 3 blades and one with 4 blades.
- Have students test the turbine voltage using 3 blades first, then 4 blades and record their data.
- Direct student groups to discuss and record their wonderings based on the data.
- Lead a whole class discussion about their data findings and wonderings.
- Direct students to respond to the Journal prompts for this lesson: Record data from their group investigation, compare the data and explain which design was most effective.

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:
Teacher Notes:

5. Analysis of Student Products/Performances - Formative:
Teacher Notes:

6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):
Teacher Notes:

7. Teacher Reflection: Replanning, Reteaching, Next Steps:
Teacher Notes:

RUBRIC: Student Journal Entry – Lesson 2				
	4	**3**	**2**	**1**
Math Practices MP5 MP6	Accurately records data and computes averages.	Accurately records data and computes averages with no more than 1 minor error.	Records data and computes averages with 2 or more minor errors.	Data is incomplete and/or very inaccurate, with numerous or significant errors.
Science and Writing SC.5.1.1 SC.5.1.2 SC.5.6.1 W.5.8	Uses data to explain in detail how varying the number of blades on a wind turbine effects energy transfer. Generates at least 1 new testable question/ wondering related to the inquiry.	Uses data to explain how varying the number of blades on a wind turbine effects energy transfer. Generates at least 1 new question/ wondering related to the inquiry.	Explains that varying the number of blades on a wind turbine effects energy transfer without reference to data. Question(s)/ wondering(s) are only marginally related to the inquiry.	Lack of clarity and/or completeness in the explanation of the investigation prevents the reader from determining student understanding of key concepts. Question(s)/ wondering(s) are missing or unrelated to the investigation.
Language Arts L.5.2	Accurately uses standard English conventions and grammar with no errors.	Accurately uses standard English conventions and grammar with no more than 1 error.	There are two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.

Unit Title: Energy and Energy Transfer: Building a Wind Turbine **Lesson Title:** Guided Inquiry **Date Developed/Last Revised:** 7.9.13 **Unit Author(s):** L. Lum, R. Saito, Karen Umeda, B. Jennings	**Lesson #:** 3 **Grade Level:** 5 **Primary Content Area:** Science **Time Frame:** 4-6 class periods

DESCRIPTION

In this lesson students apply the steps of the Scientific Inquiry Process as they use a model wind turbine to investigate the process of energy transfer from one form to another. In small groups, they will test a selected variable to determine its effect on energy transfer, measure and record data, and explain their findings. If pressed for time, some teachers may opt to omit this lesson and to focus on the Engineering Design Process (Lesson 5) where the same concepts will be addressed. *Note: If wind turbine kits are not available, students may also conduct this inquiry using the pinwheel turbines to explore variables such as the size or material used for blades, shape of blades, etc.*

PLANNING (Steps 1, 2, & 3)

1. <u>Standards/Benchmarks and Process Skills Assessed in this Lesson:</u>

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

Hawaii Content Performance Standards III: Science

- SC.5.1.1: Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments (L3)
- SC.5.1.2: Formulate and defend conclusions based on evidence (L3)
- SC.5.6.1: Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they can change and transfer energy from one form to another (L2)
- SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world (L2/3)

Hawaii Content Performance Standards III: Career & Technical Education

- Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems.

Common Core State Standards: English Language Arts

- CCSS.ELA-Literacy.W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
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- CCSS.ELA-Literacy.L.5.2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
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Common Core State Standards: Mathematics

- CCSS.Math.Practice.MP5: Use appropriate tools strategically.
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- CCSS.5.MD.A.1: (Supporting) Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step real world problems.
  Note: This assumes that the mathematics has already been introduced and the student is able to apply the concepts/skills needed to successfully complete these investigations.

2A. Criteria- What Students Should Know and Be Able to Do:

Students will be able to apply the scientific inquiry process as they-

- Identify the variables in scientific investigations and explain the importance of controlling variables in scientific experiments.
- Formulate, share and defend conclusions based on evidence.
- Describe how wind (motion) energy can be transformed into electrical energy.

2B. Assessment Tools/Evidence:

Formative:

- Teacher observations conducted as part of class discussions and as participants conduct their inquiry investigations (CTE Standard 1; SC.5.2.1; SL.5.4)
- Group Data Sheet
- Individual Journal Entry: SIP Steps and Summary (MP5; MP6: SC.5.1.1; SC.5.1.2; SC.5.6.1; W.5.8; L.5.2)

3. Learning Experiences (Lesson Plan)

Materials: Per group-

- Wind Experiment Kit
- Fans
- Multimeter

Handouts:

- Group Data Sheet (Copied from Lesson 3 section of Student Journal, 1 per group)
- Individual Student Journals

Teacher Preparation:

- Turbine and blades should be assembled ahead of time.
- To control variables, the fans should be set up such that it does not create a cross-breeze. Each fan should be turned on to its highest setting. A distance approximately 18 inches should be measured from the face of the fan and this distance should be marked on the floor with masking tape.

Procedure:

- Review what was learned in the learned in the previous lesson.
- Review the concepts of independent, dependent, and controlled variables that were discussed in the context of the structured inquiry.
- Assign students to groups and ask them to brainstorm and identify some of the additional variables that could be tested using the wind turbine (e.g., blade number, thickness, materials, design, pitch, length, angle of attack).
- Provide students with time to read selected resources such as the following to increase their background knowledge:
  - http://science.howstuffworks.com/environmental/green-science/wind-power.htm
  - http://www.eia.doe.gov/kids
- Direct each group to select one variable for their investigation. Based on their selection, assist them to identify the independent, dependent, and controlled variables (Step 1).
- Instruct student teams to develop a testable hypothesis (Step 2) and a procedure for their investigation (Step 3).
- If necessary, review data collection and organization process skills.
- Review use of the multimeter, including different measurement systems and settings, and remind students to use the lowest setting to measure the electrical voltage output from their turbines (see Lesson 2).
- Guide students to implement their investigation, record their observations, collect, and analyze their data.
- Have students formulate and record their conclusions as a group, then direct them to record the information in their individual journals.
- Enable teams to share the results of their investigations or have them share via a gallery walk. Students should be able to defend their conclusions based on evidence.
- Optional Discovery Education video segment to conclude the investigation: Deconstructed: Wind Turbines (04:51).

Adapted From: Island Energy Inquiry: Island Breezes Blowing Energy

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:

Teacher Notes:

5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

RUBRIC: Student Journal Entry – Lesson 3				
	4	**3**	**2**	**1**
Math Practices MP5 MP6	Accurately records data and computes averages.	Accurately records data and computes averages with no more than 1 minor error.	Records data and computes averages with 2 or more minor errors.	Data is incomplete and/or very inaccurate, with numerous or significant errors.
Scientific Inquiry Process (SIP) and Writing SC.5.1.1 SC.5.1.2 SC.5.6.1 W.5.8	Identifies tested variable and explains controls in detail. Clearly explains hypothesis and findings. Uses data to effectively explain and defend a conclusion regarding how the selected variable affected the transfer of energy.	Identifies tested variable and explains controls. Describes hypothesis and findings. Uses data to explain and defend a conclusion regarding how the selected variable affected the transfer of energy.	Identifies tested variable. Explanation of controls is unclear. Describes hypothesis and findings. Describes conclusion with little or no reference to data. Explanation regarding how the selected variable affected the transfer of energy is unclear.	Lack of clarity and completeness in descriptions of: - variables - hypothesis - findings - conclusion ...prevents the reader from determining student understanding of key concepts.
Language Arts L.5.2	Accurately uses standard English conventions and grammar with no errors.	Accurately uses standard English conventions and grammar with no more than 1 error.	There are two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.

Unit Title: Energy and Energy Transfer: Building a Wind Turbine Lesson Title: Summative Assessment Date Developed/Last Revised: 07.09.13 Unit Author(s): L. Lum, R. Saito, K. Umeda	Lesson #: 4 Grade Level: 5 Primary Content Area: Science Time Frame: 1 class period

DESCRIPTION

OPTIONAL ACTIVITY: In this lesson, students will use a web-based interactive to test variables that affect the performance of a virtual wind turbine and complete an assessment to demonstrate their understanding. The interactive activity is hosted on the Discovery Education website, and requires a subscription in order to be accessed.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

Hawaii Content Performance Standards III: Science

- SC.5.1.1: Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments (L3)
- SC.5.1.2: Formulate and defend conclusions based on evidence (L3)
- SC.5.6.1: Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they can change and transfer energy from one form to another (L2)
- SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world (L2/3)

Hawaii Content Performance Standards III: Career & Technical Education

- Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems.

Common Core State Standards: English Language Arts

- CCSS.ELA-Literacy.W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- CCSS.ELA-Literacy.SL.5.4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- CCSS.ELA-Literacy.L.5.2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
  a. Use punctuation to separate items in a series.*
  b. Use a comma to separate an introductory element from the rest of the sentence.

c. Use a comma to set off the words yes and no (e.g., Yes, thank you), to set off a tag question from the rest of the sentence (e.g., It's true. isn't it?), and to indicate direct address (e.g., Is that you, Steve?).
d. Use underlining, quotation marks, or italics to indicate titles of works.
e. Spell grade-appropriate words correctly, consulting references as needed.

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- Conduct and explain an investigation in a virtual lab that tests the effects of different variables on wind turbine performance.
- Explain the importance of controlling variables in an investigation.
- Formulate and defend conclusions based on evidence.

2B. Assessment Tools/Evidence:

Formative:

- Teacher observations conducted as part of class discussions and as participants conduct their inquiry investigations (CTE Standard 1; SC.5.2.1; SL.5.4)

Summative:

- Discovery Education Virtual Lab: Wow Windmills! Student Guide Worksheet Level 1 may be used as an assessment product (download from Discovery Education Virtual Lab: Wow Windmills! in "Materials")
- Individual Journal Entry (Lesson 4 Discovery Education "Wow Windmills!" Constructed Response Assessment):
    - What are your conclusions based on the data collected in the Wow Windmills virtual lab? (SC.5.1.2)
    - Why is it necessary to test one variable at a time in an investigation? (SC.5.1.1)
    - How does the wind turbine model help us to understand energy transfer? (SC.5.6.1)
    - What are some of the different energy transfers that can occur through wind turbine technology? (SC.5.6.1)

3. Learning Experiences (Lesson Plan)

Materials and Related Resources:

- Computers
- Discovery Education Wow Windmills! Virtual Lab

Handouts:

- Wow Windmills Student Guide Worksheet Level 1 (Download from Discovery Education Virtual Lab: Wow Windmills! in "Materials")
- Individual Student Journals

Procedure: • Guide students to the Wow Windmills Virtual Lab in the Discovery Education Website. • Demonstrate how to conduct the virtual lab. • Review the constructed response prompts related to the lab. • Review the task specific rubric with the students. • Allow students to conduct their virtual lab. • Record observations as students conduct their investigation. • Ask clarifying questions and record responses as necessary to further document evidence of student learning. • After completing the activity, debrief with students and direct them to respond to the prompt in their Student Journals.
TEACHING & ASSESSMENT (Steps 4, 5, 6, &7) **Completed by teacher after instruction has taken place**
4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

RUBRIC: Student Journal Entry – Lesson 4				
	4	**3**	**2**	**1**
Formulates conclusions based on the data SC.5.1.2 W.5.8	Writes the conclusion as a summary statement and supports it using trends and patterns in the data from the investigation.	Writes the conclusion as a summary statement and supports it using data from the investigation.	Writes the conclusion as a summary statement but needs assistance in supporting the conclusion with data.	Requires assistance to address or summarize the investigation.
Uses tested variables in an investigation SC.5.1.1	Explains why only one variable should be tested at a time and gives an example.	Explains why only one variable should be tested at a time.	Recognizes that testing only one variable at a time is important, but needs assistance to explain why.	Needs assistance identifying a variable and why it is important to test only one variable at a time.
Uses models to understand concepts and processes SC.5.2.1	Explains how a wind turbine model can be used to understand energy transfer and generalizes this understanding to why scientists use models in their investigations.	Explains how a wind turbine model can be used to understand energy transfer.	Recognizes that the wind turbine used in the investigation is a model, but needs assistance explaining how it can be used to understand energy transfer.	Needs assistance recognizing what a model is used for and how scientists use it to explain concepts and processes.
Identifies how energy can transfer from one form to another SC.5.6.1	Identifies multiple ways energy is transferred (i.e. motion > electrical > light or sound or heat.	Identifies that wind (motion) energy is transferred to electrical energy.	Recognizes that wind (motion) energy is transferred into electrical energy.	Needs much assistance in identifying that the wind turbine transfers motion energy into electrical energy.

Unit Title: Energy and Energy Transfer: Building a Wind Turbine Lesson Title: Engineering Design Process (EDP) Performance Task Date Developed/Last Revised: 07/10/13 Unit Author(s): L. Lum, R. Saito, K. Umeda, B. Jennings	Lesson #: 5 Grade Level: 5 Primary Content Area: Science, Engineering Time Frame: 4 - 6 class periods

DESCRIPTION

The Engineering Design Process (EDP) is comprised of a series of six steps that lead to the development of a product or solution to a given problem. In most cases the sequence of steps will take place over the course of several sessions and/or days during which students create, test, and redesign a product or solution for a specific purpose. In this design challenge, students design, construct, test, and improve a model wind turbine.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

Hawaii Content Performance Standards III: Science

- SC.5.1.1: Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments (L3)
- SC.5.1.2: Formulate and defend conclusions based on evidence (L3)
- SC.5.6.1: Identify different forms of energy (e.g., thermal, electrical, nuclear, light, sound) and how they can change and transfer energy from one form to another (L2)
- SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world (L2/3)

Hawaii Content Performance Standards III: Career & Technical Education

- Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems.

Common Core State Standards: Mathematics

- CCSS.Math.Practice.MP5: Use appropriate tools strategically.
- CCSS.Math.Practice.MP6: Attend to precision.
- CCSS.5.MD.A.1: (Supporting) Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step real world problems.

  Note: This assumes that the mathematics has already been introduced and the student is able to apply the concepts/skills needed to successfully complete these investigations.

Common Core State Standards: English Language Arts

- CCSS.ELA-Literacy.W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

- CCSS.ELA-Literacy.SL.5.4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- CCSS.ELA-Literacy.L.5.2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
  a. Use punctuation to separate items in a series.*
  b. Use a comma to separate an introductory element from the rest of the sentence.
  c. Use a comma to set off the words yes and no (e.g., Yes, thank you), to set off a tag question from the rest of the sentence (e.g., It's true. isn't it?), and to indicate direct address (e.g., Is that you, Steve?).
  d. Use underlining, quotation marks, or italics to indicate titles of works.
  e. Spell grade-appropriate words correctly, consulting references as needed.

2A. Criteria- What Students Should Know and Be Able to Do:

Students can follow the steps of the EDP to design, test, and improve a product and its function-

- Identify the problem and requirements of the task (construction of model wind turbine).
- Generate ideas, share and collaborate with team members to develop a plan for a specific prototype.
- Follow the team plan and build the prototype; agree upon and record initial modifications to plan.
- Test, record, and analyze data on the model wind turbine.
- Repeat the engineering design process to make improvements to design of the wind turbine.
- Share the results of their investigation and defend their conclusions based on evidence.
- Describe how wind (motion) energy is transformed into electrical energy in their model wind turbines.

2B. Assessment Tools/Evidence:

Formative and Summative:

- Teacher observations conducted as part of class discussions and as participants conduct their inquiry investigations (CTE Standard 1; SC.5.2.1; SL.5.4)
- Group EDP Step Sheets
- Individual Journal Entry: EDP Steps (Formative) and Summary (Summative) (MP5; MP6; SC.5.1.1; SC.5.1.2; SC.5.6.1; W.5.8; L.5.2)

3. Learning Experiences (Lesson Plan)

Materials:

Per Teacher:

- 1 wooden pencil
- 1 mechanical pencil
- Exacto blade (for teacher use only)
- Glue gun (for teacher use only)

- Fans (several, set up for student use)
- Supply table: Assorted recycled materials for students to use to create the turbine blades (i.e., cardstock, cardboard, plastic containers and cups)

Note: It is recommended that the teacher set up and man a glue gun and cutting station where the students can come to you for assistance with these tasks.

Per Team:

- 1 - 0.925 inch motors (For example: RadioShack Model: 273-223, Catalog #: 273-223) http://www.radioshack.com/product/index.jsp?productId=2102822#
- 1 - Digital multimeter
- 2 - Alligator clips
- 1 - Cork stoppers for hubs (1” x 1-1/4” size)
- 1 - Recycled 1 liter plastic beverage bottle (with caps still attached) to mount the turbine on
- Scissors
- Masking tape

Per Student:

- Safety goggles

Handouts:

- Group EDP Step Sheets (Copied from Lesson 5 section of Student Journal, 1 per group)
- Individual Student Journals: EDP Steps and Summary

Procedure:

Notes to the Teacher:

- The class will go through each step of the process together. Stop after each step to discuss the procedures and journal entries completed by the students. The teacher may refer to “Engineering Design Rubric” to help guide discussions. It is highly unlikely that the entire sequence of the EDP will be completed on a single school day. Prepare to “chunk” the following steps into sessions of 1 hour or more to complete the sequence over 3 – 4 days. For example: **Session 1:** Steps 1, 2, and 3; **Session 2:** Steps 4 & 5; **Session 3:** Step 6… and repeat steps to redesign/re-test.
- Do the amount of steps you feel your students can handle in the time allotted. It may take 1 day or many days to go through and understand these steps. Don’t worry… it’s the process that’s important. During each step, the teacher should prompt students’ thinking, and record observations to monitor student learning as part of the formative assessment process.
- Just as they would in the real world, assign students to work in teams.
- Note also that although students are part of a team, each student is responsible for completing each part of their own engineering design process journal. The team is there to help brainstorm, share ideas, and create 1 product, but each student must participate

and contribute their individual ideas to help the group.

Introduction/Student Engagement Activity: Teacher Demonstration

- Show students a pencil. Ask students…
  - What is an engineer? (A person who solves problems by creating technological tools/products by applying their scientific knowledge)
  - How is this pencil an example of engineering?
- Show students a mechanical pencil. Ask students…
  - How did an engineer come up with this new design?
  - What process did the engineer go through to redesign this pencil?
- Guide the discussion to show that their natural way of thinking of how to do things is similar to the Engineering Design Process that they will be experiencing.

Engineering Design Performance Task

Step 1: Ask

Read the following performance task to the students:

Look around our school and see all the things that need electricity. Lights, computers, TVs, microwaves, radios, refrigerators, fans….My goodness! We must spend a lot of money for all of the electricity that we use! How could we help our school to save money on electricity? Hmm…. We could use an alternative source of energy to produce electricity. We could use wind energy! Wind turbines convert wind energy to electrical energy. Our school could save a lot of money by using wind turbines! So today we are going to create a model of the type of wind turbine that our school could purchase and use to produce electricity. Our goal is to design a turbine that would produce a great amount of voltage. We will check to see how much voltage your turbine is producing with a multi-meter. You will be logging your data on a table. Have fun creating your wind turbine!

- Have students identify and record in their Journals:
  - The problem of the performance task.
  - What they are creating.
  - The criteria and constraints for making this turbine.
- Show students the materials that are available for them to use. Consider keeping all of the materials on a "materials table" for easy access. The materials should be on display so students can easily see and refer to them as necessary. Students need to draw them in the next step…Imagine.
- Have students:
  - Write further questions they may have about constructing this wind turbine.
  - Share questions with class for teacher to answer.
- Review the procedures for the "Ask" section of the process; answer students' questions.

Step 2: Imagine

- Instruct students to independently brainstorm ideas for building a wind turbine and draw or write out ideas in their journals.
- Encourage them to discuss their ideas with the rest of the engineering team. Students must be able to defend their reasons for using specific ideas from their prototype. (Ex. Slant the blade to catch the wind)
- Tell students that each engineering team may then decide on ONE person's design to use or create ONE new hybrid idea incorporating different ideas from team members.
- Review and debrief the procedures for the "Imagine" section of the process, making sure that all students have recorded this step in their journals.

Step 3: Plan

- Designate one person to sketch a diagram of the team's wind turbine prototype onto a piece of paper. This sketch should include labels for each of the parts and possible measurements. The sketcher must be sure to incorporate all the agreed upon ideas into the design. Students then list all possible materials that will be needed to create the prototype.
- Inform students that when all team members are satisfied with the prototype design, each member should copy this diagram of the wind turbine onto their journals.
- Instruct team members to check with each other to see if all drawings and labels are completed and that everyone has the same plan to follow.
- Review and debrief the procedures for the "Plan" section of the process.

Step 4: Create

- Instruct students to follow their team plan as closely as possible when building their prototype. If they are modifying their original prototype to make your prototype work, be sure that each team member adds that information to their journal diagram plans as well.
- Ask each team to share their prototype wind turbine to the large group, stating what modifications were made to the plan and why.
- Review and debrief the procedures for the "Create" section of the process.

Step 5: Experiment

- Review use of the multimeter, including different measurement systems and settings, and remind students to use the lowest setting to measure the electrical voltage output from their turbines (see Lesson 2).
- Demonstrate to students how to connect their turbines to the multi-meter and hold their wind turbines to the fan. Remind them to control variables by consistently placing the turbine in the same position for each trial. (Suggestions: Use the same type of fans with all fans set at the highest level; measure a distance approximately 12 inches from the fan and mark the distance on the floor with masking tape.)
- After positioning their turbines, students should then read the multi-meter and record their data. 3 trials should be conducted for this step of the process. (Round the data to the nearest tenths place).

- Guide students to calculate the average voltage for their prototype.
- Review and debrief the procedures for the "Experiment" section of the process.

Step 6: Improve

- Guide the students to think about what could be changed to make the wind turbine move even faster.
- Have each team share their results to the class, what they are going to change to improve their wind turbine, and the reasons why.
- Repeat the EDP to optimize the product. Students would continue to record the following in their journals…..
  - Ask: What worked? What didn't work? Why?
  - Imagine: Which variables of the wind turbine could you change to increase the amount of voltage produced? Why?
  - Plan: Draw the diagram of the team's 2nd prototype. Label the parts with measurements.
  - Create: Build your second prototype following your team's design. Keep to the plan.
  - Experiment: Students hook their turbines to the multi-meter and hold their wind turbines to the fan. Read multi-meter and record data. Write 3 facts comparing the data tables for prototypes 1 and 2.
  - Do a data analysis and explain the results that are found.
- Review and debrief the procedures for the "Improve" section of the process.

  Note: Students may repeat this EDP cycle many times in order to optimize their products based on the time the teacher can allow for continued modifications to be made.

- Have each team students share their results and final prototype with the class, including what was learned about wind energy and wind turbines.
- Direct students to respond individually to the Summary prompts in their student journals.

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7) **Completed by teacher after instruction has taken place**
4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

RUBRIC: Student Journal Entry 5 - Summary				
	4	**3**	**2**	**1**
Math Practices MP5 MP6	Accurately records data and computes averages.	Accurately records data and computes averages with no more than 1 minor error.	Records data and computes averages with 2 or more minor errors.	Data is incomplete and/or very inaccurate, with numerous or significant errors.
Science and Writing SC.5.1.1 SC.5.1.2 SC.5.6.1 W.5.8	Clearly describes tested variable with details. Clearly explains design modifications in detail with rationale. Clearly explains how wind (motion) energy was transformed into electrical energy in the model wind turbine with details.	Clearly describes tested variable. Explains design modifications with rationale. Describes how wind (motion) energy was transformed into electrical energy in the model wind turbine.	Description of tested variable is somewhat unclear. Describes design modifications. Lack of clarity in description of how wind (motion) energy was transformed into electrical energy in the model wind turbine.	Tested variable is not clearly identified. Response does not clearly address design modifications. The description of energy transfer is inaccurate or incomplete.
Language Arts L.5.2	Accurately uses standard English conventions and grammar with no errors.	Accurately uses standard English conventions and grammar with no more than 1 error.	2 or more errors in the use of standard English conventions and grammar, but meaning is clear.	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.

Name: ____

Engineering Design Process Assessment

A. Write the letter (a-f) that matches each of the Engineering Design Process steps.	
1. Ask: ________________ 2. Imagine: ____________ 3. Plan: _______________ 4. Create: _____________ 5. Experiment: _________ 6. Improve: ____________	A. Test out prototype and collect data. B. Brainstorm ideas of possible solutions. C. Identify the problem and get more information about that problem. D. From your possible solutions, chose the best idea and draw a prototype. E. Review data and redesign your product to make it better. F. Follow the plan and make your design.

B. Explain what you did in this project for each step of the Engineering Design Process.

ASK: ____

IMAGINE: ____

PLAN: ____

CREATE: ____

EXPERIMENT: ____

IMPROVE: ____

C. Why do people engage in the Engineering Design Process?

Wind Turbine Journal

____

Lesson 1: Creating a Pinwheel Turbine

A. How does your pinwheel turbine demonstrate the ability to do work?

B. Based on your observations, what new wonderings do you have?

Lesson 2: Windmill Turbine: Structured Inquiry

Record the data your group collected in your structured inquiry.

Voltage (volts) Based on the Number of Blades

	Trial 1	Trial 2	Trial 3	Average
3 Blades				
4 Blades				

Data Analysis: Compare the data you collected for each of your wind turbine designs. Explain which design was most effective in transferring energy and use facts from your data to support your conclusions.

Record new observations and wonderings based on what you have learned in this investigation.

Lesson 3: Windmill Turbine: Guided Inquiry

Windmill Turbine Data Inquiry

Step 1: Define the Variables

Independent Variable What ONE variable will you change during the investigation?	**Dependent Variable** What will you be measuring or observing?	**Controlled Variables** What will stay constant or the same in each trial?

Step 2: Develop a Hypothesis

What will happen to the Dependent Variable when you manipulate the Independent Variable?

If ____

then____

because____

Step 3: Develop Methods to Test

A. Experimental Design (Materials):

B. Experimental Design (Procedure):

____

____

____

____

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____

Step 4: Data: Testing Your Hypothesis

Voltage (volts) Based on ____

Tested Variable	Trial 1	Trial 2	Trial 3	Average

Step 5: Analysis of Results

A. Data Analysis

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____

B. Summary and Conclusions

C. Implications and Next Steps

Lesson 4: Discovery Education "Wow Windmills!" Constructed Response Assessment

What are your conclusions based on the data collected in the Wow Windmills virtual lab? (SC.5.1.2)

Why is it necessary to test one variable at a time in an investigation? (SC.5.1.1)

How does the wind turbine model help us to understand energy transfer? (SC.5.6.1)

What are some of the different energy transfers that can occur through wind turbine technology? (SC.5.6.1)

Lesson 5: Engineering Design Performance Task

Wind Turbine Engineering Design Process Journal

Performance Task: *Look around our school and see all the things that need electricity. Lights, computers, TVs, microwaves, radios, refrigerators, fans….My goodness! We must spend a lot of money for all of the electricity that we use! How could we help our school to save money on electricity? Hmm…. We could use an alternative source of energy to produce electricity. We could use wind energy! Wind turbines convert wind energy to electrical energy. Our school could save a lot of money by using wind turbines! So today we are going to create a model of the type of wind turbine that our school could purchase and use to produce electricity. Our goal is to design a turbine that would produce a great amount of voltage. We will check to see how much voltage your turbine is producing with a multi-meter. You will be logging your data on a table. Have fun creating your wind turbine!*

Criteria:

- The turbine will be created from recycled items.
- A cork will be used for the hull.
- The motor will be provided.
- A multi-meter will be used to measure the voltage of your turbine.
- The fan will be set at level 3 to test all prototypes.

What is the problem? ____

What are you being asked to design? ____

STEP 1: ASK: Ask questions that pertain to completing the performance task.

____

____

____

____

____

____

STEP 2: IMAGINE: Use your background knowledge about wind energy and wind turbines to design an efficient prototype for a wind turbine. These are the things you should consider as you create your wind turbine: the number of blades, the material, design, thickness, width, pitch, length, weight of the blades, and angle of attack. Draw your possible designs and label the parts. Be ready to share and discuss your design and explain the rationale for your design choices. Each member of your design team will share ideas and then the team will decide on an idea to develop.

STEP 3: PLAN: Draw the diagram of your team's prototype. Label each part. Also, state the type of material used for each part and the possible measurements.

Front View:
Side View:

STEP 4: CREATE: Build your prototype wind turbine following your team's design. Keep to the plan.

<u>After building your prototype, show any changes to materials and measurements on your plan and explain:</u>

What modifications did you need to add in order to be sure that your design would hold together and work?

STEP 5: EXPERIMENT: Test your prototype and record your data.

Conduct and record data for three trials to minimize experimental error.

Data Table 1: Voltage Produced by Prototype #1

Trial Number	Voltage (round to the nearest tenths)
1	
2	
3	
Average	

STEP 6: IMPROVE (REDESIGN PHASE):

1) ASK**:** Looking at your data, answer the following questions about the components (variables) of your wind turbine:

- What worked? Why?
- What didn't work? Why?

Components of the wind turbine	**Cause** Write a description for each component	**Effect** What happened? Why do you think that happened?
Number of Blades		
Material		
Design of blade		
Width of blade		
Length of blade		
Pitch of blade		
Weight of turbine		
Height of turbine		

2) IMAGINE**:** Which variable(s) of the wind turbine will you change to increase the speed of the turbine? Why?

3) PLAN: Draw out a diagram of your team's 2^{nd} prototype. Remember to label your parts, state the type of material used for the part, and possible measurements.

Side View:

Top View:

4) CREATE: Build your prototype wind turbine following your group's design. Keep to the plan. Use the materials listed as well as the measurements that your group decided on.

5) EXPERIMENT: Conduct and record data for three trials.

Data Table 2: Voltage Produced by Prototype #2

Trial Number	Voltage (round to the nearest tenths)
1	
2	
3	
Average	

Compare the data collected for each of your two prototypes.
Write at least three facts comparing Data Tables 1 and 2.

Fact 1	
Fact 2	
Fact 3	

Data Analysis: Based on the comparison of data from prototype 1 and prototype 2, what are your conclusions? Refer to your data and use your background knowledge of light and heat energy to explain your answer.

1. Which prototype was more effective? (circle) **Prototype 1** **Prototype 2**

Explain your answer:

Summary: EDP Performance Task

What variable did your group test?

What changes were made from prototype 1 to prototype 2? Why were these changes made?

Explain how your model wind turbine demonstrates the transfer of energy from one form to another.

Elementary Inquiry Rubric

Component	4-More than Adequate Progress (Exceeding the Standards)	3-Adequate Progress (Meeting the Standards)	2-Limited Progress (Approaching the Standards)	1-No Progress (Well Below the Standards)
Research Question	Question to be answered during the investigation is clearly identified, stated in proper form, & focuses on relevant benchmark(s). It is a meaningful question that drives investigation to help students understand deeply the appropriate benchmark(s). Question is based on initial explorations & observations.	Question to be answered during the investigation is identified & stated in proper form. Question is based on initial explorations & observations.	Question to be answered during the investigation is partially identified & stated in somewhat unclear manner.	Question to be answered during the investigation is irrelevant.
Background Information	Many relevant & significant background sources used & documented correctly. Information is written in student's own words & shows detail & specific connections to the investigation.	Several relevant & significant background sources used & documented correctly. Information is written in student's own words.	Few background sources were used & documented somewhat incorrectly. Some information is written in student's own words.	Little or no background sources used. Information is directly copied from source(s).
Hypothesis	Hypothesis is clearly stated & testable using the form "If ___, then ___ because _______." It is based on observations & prior research.	Hypothesis stated in a testable form "If ___, then ___because ___. Hypothesis is based on general knowledge & observations.	Hypothesis is unclear & poorly stated. Hypothesis is loosely connected to observations or general knowledge.	Hypothesis is missing.

Component	4-More than Adequate Progress (Exceeding the Standards)	3-Adequate Progress (Meeting the Standards)	2-Limited Progress (Approaching the Standards)	1-No Progress (Well Below the Standards)
Experimental Design **(Materials)**	All materials used in the investigation are reasonable and obtainable. They are correctly listed & accurately described.	Most materials used in the investigation are reasonable & obtainable. Most materials are listed & described.	Some of the materials used in the investigation are reasonable & obtainable. Some of the materials are listed.	One or more important materials may not be obtainable. Materials are listed inaccurately.
Experimental Design **(Method)**	Experimental design is well constructed to test the hypothesis. A control is included where appropriate. The investigation is controlled to test one variable. The procedure is clear & easy to follow. Anyone should be able to follow the design so that the investigation can be repeated, if needed. The design includes meaningful data sheets.	Experimental design is adequate to test the stated hypothesis but might need some clarifications. The procedures are generally complete & in sequence; however, minor modifications are needed. Attempts to control variables are made but need modifications.	Experimental design is relevant to the hypothesis but is not a complete investigation. The procedures are incomplete & major modifications are needed. Little attempt to control variables.	Experimental design is not relevant to the hypothesis. The procedures are incomplete & there is no control of variables.

Component	4-More than Adequate Progress (Exceeding the Standards)	3-Adequate Progress (Meeting the Standards)	2-Limited Progress (Approaching the Standards)	No Progress (Well Below the Standards)
Data	Data are well organized & neatly presented. Graphs & tables are labeled, summarized & titled correctly. Graphs & tables accurately & meaningfully present the data.	Data are organized & presented in an appropriate manner. Minor errors are present. Graphs & tables are labeled, summarized & titled.	Data are poorly organized & the presentation is inappropriate. Major errors are present. Graphs or tables are not labeled, titled, or summarized correctly or may be missing.	Data are not organized or & the presentation is inappropriate or data are not shown. Graphs &/or tables are poorly done or missing.
Data Analysis	Highlights of the data are well summarized, capturing the significant details to provide the evidence needed to answer the research question. Important relationships, patterns, & changes observed throughout the investigation are included in the summary to make deep & meaningful connections of understandings.	Most of the obvious highlights are summarized with clarity & some detail. Some comparisons & relationships are made to show connections of understanding.	Some obvious highlights are summarized but may include misconceptions. Connections are not always logical. Some patterns & relationships are not based on the data collected.	Highlights of the data collected may not be included. There is no connection between the summarized data & the actual data collected.
Discussion / Conclusion	Conclusion includes a reasoned decision about the hypothesis & is fully supported by data. Conclusion also includes possible sources of error, what was learned in the investigation & implications/next steps of investigation.	Conclusion includes a decision about the hypothesis & is supported by data. Conclusion also includes what was learned in the investigation.	Conclusion includes a decision about the hypothesis but is not supported by data.	Conclusion is not related to the hypothesis & data support is lacking or missing or no conclusion was included in the investigation.

Engineering Design Process Rubric

	Advanced(ME)	Proficient(M)	Partially Proficient(DP)	Novice(WB)
ASK	☐ Clarifies the problem clearly ☐ Forms the conditions and limitations on their own ☐ Obtains information from prior knowledge and other sources with citation by self	☐ Clarifies the problem ☐ States all the conditions and limitations ☐ Obtains information from prior knowledge by self	☐ Needs more clarification of the problem ☐ States most conditions and limitations ☐ Obtains information from prior knowledge (drawn out by teacher)	☐ Problem is unclear ☐ States few (or no) conditions and limitations ☐ Information given by teacher
IMAGINE	☐ Brainstorms a variety of innovative ideas ☐ Innovative ideas are relevant to the problem	☐ Brainstorms a complete idea ☐ Idea is relevant to the problem	☐ Brainstorms an incomplete idea ☐ Idea is somewhat relevant to the problem	☐ Unable to brainstorm ideas, teacher assistance needed ☐ Brainstormed ideas have little relevance to the problem
PLAN	☐ Chooses the best possible idea that is testable ☐ Draws a useable and accurate prototype design with more than 2 views to scale ☐ Lists all materials needed that are affordable, obtainable, and safe	☐ Chooses one idea that is testable ☐ Draws a useable prototype design with multiple views to scale ☐ Lists all materials needed	☐ Chooses an idea that may be testable ☐ Draws a somewhat useable prototype design with multiple views with inaccurate or incomplete measurements ☐ Most materials needed are listed	☐ Chooses an idea that is not testable ☐ Draws an unusable prototype design with one or more views ☐ Incomplete or inaccurate lists of materials (assistance needed)
CREATE	☐ Able to follow their design plan accurately ☐ Able to improve original design to optimize performance	☐ Able to follow their design plan, with some inaccuracies ☐ Able to add to the original design to make the design work	☐ Able to follow most of their design plan with multiple inaccuracies ☐ Able to add to the original design, but design may still not work	☐ Unable to follow their design plan ☐ Sticks to original design although it may not work
EXPERIMENT	☐ Collects and records detailed data accurately and completely ☐ Analyzes data by comparing patterns and relationships accurately with logic	☐ Collects and records data accurately and completely ☐ Analyzes data by showing patterns or relationships accurately	☐ Collects and records data. Some data may be incomplete or inaccurate. ☐ States obvious patterns or relationships	☐ Data collection inaccurate and incomplete ☐ States obvious patterns or relationships with assistance
IMPROVE	☐ Reviews data to make logical decisions to optimize product ☐ Repeats process until an optimized product is reached with greatly improved data	☐ Reviews data to make decisions to redesign product ☐ Repeats process to optimize a product. Data may/may not show improvement.	☐ Reviews data to make decisions to redesign product with assistance ☐ Repeats process to improve product with some assistance	☐ Unable to review data to make decisions to redesign product (assistance needed) ☐ Does not repeat process to improve product or repeats process with much assistance