Unit Title: Solar Energy **Date Developed/Last Revised:** June 13, 2013 **Unit Author(s):** K. Umeda, B. Jennings, L. Lum, R. Saito	**Grade Level:** 3 **Time Frame:** 12 - 15 class periods (~50 min. ea) **Primary Content Area:** Science, Language Arts

UNIT DESCRIPTION:

Students will investigate the physical science concept of energy through engagement in the scientific inquiry process. They will learn what energy is, and that energy makes things move, creates heat and light, makes technology work, and makes things grow. More specifically, students will learn that the sun is a primary source of energy here on Earth and that the sun produces energy in the form of light and heat. Students will demonstrate their understanding through written and oral communication.

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

Students will investigate the nature of energy through engagement in the scientific inquiry process. They will learn what energy is, and that energy makes things move, creates heat and light, makes technology work, and makes things grow. More specifically, students will learn that the sun is a primary source of energy here on Earth and that the sun produces energy in the form of light and heat.

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 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 solar energy towards engineering solar water heaters of their own design.

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

- How do we conduct inquiry investigations?
- What is energy and what kinds of energy does the sun produce?
- How has technology harnessing solar energy influenced society?
- How does the Engineering Design Process enable us to create and innovate?

BENCHMARKS/STANDARDS/LEARNING GOALS	
Science (HCPS III)	• SC.3.1.1: Pose a question and develop a hypothesis based on observations (L4) • SC.3.1.2: Safely collect and analyze data to answer a question (L3) • SC.3.2.1: Describe ways technologies in fields such as agriculture, information, manufacturing, or communication have influenced society (L2) • SC.3.6.1: Define energy and explain that the sun produces energy in the form of light and heat (L1) *Note: The "L" codes at the end of each benchmark refer the Marzano's Taxonomic Level of Understanding, which the benchmark was assigned. So for example, "L3" refers to Taxonomic Level 3: Analysis.*
Technology	• SC.3.2.1: Describe ways technologies in fields such as agriculture, information, manufacturing, or communication have influenced society (L2)
Engineering	• CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Mathematics (CCSS)	*Mathematical Standards:* • CCSS.Math.Content.3.MD.A.1: Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram. • CCSS.Math.Content.3.MD.A.2: Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[1] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[2] *Supporting Mathematical Practices:* **1.** Make sense of problems and persevere in solving them. **2.** Reason abstractly and quantitatively. **3.** Construct viable arguments and critique the reasoning of others. **4.** Use appropriate tools strategically. **5.** Attend to precision.
English Language Arts and Literacy (CCSS)	*Language Arts Standards:* • CCSS.ELA-Literacy.RI.3.3: Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. • CCSS.ELA-Literacy.RI.3.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.

	• CCSS.ELA-Literacy.W.3.1: Write opinion pieces on familiar topics or texts, supporting a point of view with reasons. • CCSS.ELA-Literacy.W.3.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • CCSS.ELA-Literacy.W.3.7: Conduct short research projects that build knowledge about a topic. • CCSS.ELA-Literacy.W.3.8: Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. • CCSS.ELA-Literacy.SL.3.1: Engage effectively in a range of collaborative discussions (one-on-one. in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly. • CCSS.ELA-Literacy.SL.3.4: Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. • CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
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 (multi-meter/internet/apps)

LESSON SEQUENCE

	Lesson Title/Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame
INVESTIGATION 1: ENGAGEMENT				
1	What Kinds of Energy Do We Get from the Sun?	Students can- • Collect and describe data based on observations about the sun. • Generate questions based on observations. • Begin to explain that the sun provides energy to the Earth in the form of light and heat.	- Teacher observation - Class charts - Student journals	1 class period
Investigations 2 and 3 describe two different investigations that could be implemented with students—one on heat and one on light. If you have limited instructional time, it is recommended that you implement just one investigation (e.g. heat) and teach light through demonstrations, digital resources, or other activities to develop student's content knowledge.				
INVESTIGATION 2: HEAT ENERGY FROM THE SUN				
2A	Structured Inquiry: Measuring Temperature of Earth Materials	Students can- • Accurately measure and record temperature. • Explain that heat from the sun is absorbed differently by different earth materials. • Use data to make inferences and to generate questions.	- Teacher observation - Data Recording Sheet - Student journal	1 class period
2B	Research on Earth Materials and Heat from the Sun	Students can- • Work in groups to research identified questions and design an investigation to test a hypothesis related to heat from the sun. • Describe the selected hypothesis and explain how it will be tested.	- Teacher observation - Investigation Template - Student journal	1 class period
2C	Guided Inquiry: Exploring Earth Materials and Heat from the Sun	Students can- • Work in groups to conduct an investigation including data collection, recording, and analysis. • Accurately measure and record temperature. • Describe and explain how findings inform their understanding of the affect of heat from the sun on different earth materials and surfaces.	- Teacher observation - Investigation Template - Student journal	1 class period

INVESTIGATION 3: LIGHT ENERGY FROM THE SUN (OPTIONAL)				
3A	Structured Inquiry: Observing the Effects of Sunlight	Students can- • Make observations as they explore the affect of light on UV-sensitive beads under different conditions. • Collect and organize data including reading and recording of time. • Use data to make inferences, and explain that there is visible light, and there is light energy that you cannot see.	- Teacher observation - Data Recording Sheet - Student journal	1 class period
3B	Research on Types of Light	Students can- • Work in groups to research identified questions and design an investigation to test a hypothesis related to light from the sun. • Individually describe the selected hypothesis and explain how it will be tested.	- Teacher observation - Investigation Template - Student journal	1 class period
3C	Guided Inquiry: Observing the Effects of Sunlight	Students can- • Work in groups to conduct an investigation including data collection, recording, and analysis. • Describe and explain how findings inform their understanding of how light from different sources is detected by UV-sensitive beads.	- Teacher observation - Investigation Template - Student journal	1 class period
ENGINEERING DESIGN PROCESS				
4A	Engagement Activity: Building Background Knowledge Through Discovery Learning	Students can- • Work in groups to engage in discovery learning including data collection, recording, and analysis. • Describe their findings to inform their understanding of the effects of light and heat from the sun on various materials.	- Teacher observation - Data Recording Sheet - Student journal	1 class period
4B	Performance Task: Engineering a Solar Water Heater (EDP) EDP Step 1: Ask EDP Step 2: Imagine EDP Step 3: Plan EDP Step 4: Create EDP: Step 5: Experiment	Students can follow the steps of the Engineering Design Process to- • Identify the problem and requirements of the task (construction of solar water heater). • Ask and record questions about the parameters of the task. • Individually brainstorm, draw and write engineering ideas. • Share and collaborate with team members, including providing reasons for selection of a specific prototype. • Follow the team plan and build the prototype; agree upon and	- Teacher Observations - EDP Journal - EDP Assessment Sheet - Student journal	6 - 8 class periods

	EDP Step 6: Improve	record initial modifications to plan. • Test the solar water heater: Measure temperature and record data at regular intervals. • Review and discuss collected data. • Repeat the engineering design process to make improvements to the design of the solar water heater. • Compare and analyze both sets of data and explain conclusions.		
OTHER LESSONS/ASSESSMENTS				
5	How Does Solar Energy Technology Influence Society?	Students can- • Describe and provide examples of ways solar energy technology influences society.	- Teacher observation - Class charts - Student journals	1 class period
6	Unit Assessment (Summative): Constructed Response	Students can - • Define energy • Explain the types of energy that the sun produces • Describe how solar technology has influenced society	-Written response	1 class period

BACKGROUND INFORMATION

- The definition of energy: In science, energy is the ability to do work and work is done when a force moves an object through a distance. Energy can cause motion. It can also cause changes in matter. (ScienceSaurus, 2005)

- The sun as a source of heat and light energy: Most of the energy on Earth comes from the sun. The sun's energy heats the Earth's surface, which in turn, heats the air above it.

- Only a small portion of the energy radiated by the sun into space strikes the earth, one part in two billion. Yet this amount of energy is enormous. Every day enough energy strikes the United States to supply the nation's energy needs for one and a half years. About 25 to 30 percent of the radiant energy that reaches the earth is reflected back into space. The land and the ocean absorb about 51 percent of radiant energy. The atmosphere and the clouds absorb the rest.

- Once a substance absorbs radiation, the atoms in the substance move faster and the substance increases in temperature over time. The absorbed energy is transformed into heat energy. This heat energy plays an important role in regulating the temperature of Earth's crust, surface waters, and lower atmosphere.

- Temperature: A measure of how hot or cold something is. It is often measured using a thermometer.

- Thermometer: A technological tool which consists of a closed glass tube containing a liquid such as alcohol. When the substance around the tube (e.g. air) heats the liquid, the liquid expands and moves up the tube. The thermometer has a measurement scale that indicates what the actual temperature is. To make an accurate reading, your eyes should be level with the top of the liquid in the thermometer's tube.

- Hypothesis: A hypothesis is "an idea that can be tested by an experiment or an observation. " It is generally stated in an "*If…then…" or "If…then…because…"* format. A good hypothesis is testable and linked to the research question.

- Light can be reflected, refracted and absorbed. Heat energy can be transferred by conduction, convection, and radiation.

- Light is a form of energy that travels in waves. The light that you can see is called visible light.

- UV beads contain a chemical that changes color when exposed to ultraviolet (UV) light. Ultraviolet light has a range of wavelengths that are invisible to the human eye except when they come in contact with chemicals such as those found in these beads. Scientists are interested in ultraviolet light because it can be harmful to humans.

- In addition to supplying a large amount of energy directly, the sun is also the source for many different forms of energy. Solar energy powers the water cycle, allowing us to harness the energy of moving water. Solar energy drives wind formation allowing us to use wind turbines to transform kinetic energy into electricity. Plants use solar energy in the process of photosynthesis. Biomass can trace its energy source back to the sun. Even fossil fuels originally received their energy from the sun.

Sources:
www.need.org
http://beyondweather.ehe.osu.edu/issue/the-sun-and-earths-climate/the-sun-earth%e2%80%99s-primary-energy-source

Unit Title: Solar Energy Lesson Title: INVESTIGATION 1: What Kinds of Energy Do We Get from the Sun? Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 1 Grade Level: 3 Primary Content Area: Science Time Frame: 1 – 2 class periods

DESCRIPTION

In this lesson, students investigate and record data about the sun based on observations made in different locations on the school campus. These observations will provide a foundation for learning more about solar energy.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.2 Safely collect and analyze data to answer a question (INVESTIGATION) (L3)
- SC.3.6.1 Define energy and explain that the sun produces energy in the form of light and heat. (NATURE OF MATTER/ENERGY) (L1)

CCSS: Language Arts

- CCSS.ELA-Literacy.W.3.1: Write opinion pieces on topics or texts, supporting a point of view with reasons.
- CCSS.ELA-Literacy.L.3.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

Students can-

- Generate questions based on observations.
- Explain that the sun provides energy to the Earth in the form of light and heat.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Group data chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Question: How do observations help us learn about energy from the sun?

Vocabulary: *(Sources: Encarta Dictionary, ScienceSaurus)*

- *observation:* the attentive watching of somebody or something
- *energy:* the ability or power to work
- *temperature:* a measure of how hot or cold something is

Materials/Needs:

- A sunny day
- Student journals or notebooks
- Writing tools

Handouts/Other Resources:

- See Sample Student Journal for this unit

Procedure:

Explain to students that they will be going outside to observe the effects of sunlight. Emphasize that they are going to be scientists, and that their task is to make careful observations. Review safety guidelines with students for an outdoor investigation, including:

- Site boundaries
- Any hazards within the site boundary
- The amount of time exposed to the sun
- Students must NEVER look directly at the sun, due to the risk of permanent damage to their vision.

Explain that students will be making observations using only their senses (no thermometers at this time) in a variety of different locations, and that they are encouraged to talk about their observations with others. Determine whether you want students to make observations as a whole class or in small groups, and direct students accordingly.

Outdoor Observations

- In this particular investigation, students make observations of how hot they feel-
    - In full sun on the dirt and on a concrete sidewalk
    - In the shade on the dirt and on a concrete sidewalk

  In addition, students should also carefully touch the ground and make observations of how hot it feels.

- Students will discuss their observations and make connections between how hot they feel and the weather conditions.

- Teacher will prompt students' thinking by asking questions: Did it make a difference in how hot you felt if you were standing in the sun vs. in the shade? How about whether you were standing on the dirt or on the concrete sidewalk? What do you think might cause a difference? Guide students to realize that in addition to feeling different when in the shade vs. in the sun, the material they were standing also might make a difference in terms of how hot it feels outside.

- Teacher will continue to prompt the discussion through the following guiding questions:
    - What is it that makes us feel hot?
    - What is heat?
    - How can we measure it?

- Optional: Have students try to rank order the surfaces they observed from hottest to coolest (For example, standing on grass in the shade might feel the coolest, while standing on concrete in the sun might feel hottest)

Debrief the Activity and Record Observations

- Return to the classroom and ask students to share some of their observations with the whole class.
- Record observations on a class chart.
- Ask students to record at least 3 observations in their science journals notebooks, and tell which observation was most interesting and why. (See Sample Student Journal, approx. 15 min. total)

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 1				
	1	**2**	**3**	**4**
Science Content	Describes one observation about heat from the sun, based on outdoor activity. Expressed opinion is missing or unclear and is not supported with a reason.	Accurately describes two observations about heat from the sun, based on outdoor activity. Expresses an opinion but does not support it with a reason.	Accurately describes three observations about heat from the sun, based on outdoor activity. Expresses an opinion and supports it with a reason.	Accurately describes three observations about heat from the sun with many relevant details, based on outdoor activity. Expresses an opinion and supports it with a factual reason.
Writing Skills	Multiple errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: INVESTIGATION 2: Heat Energy From the Sun - Lesson 2A: Structured Inquiry: Measuring Temperature of Earth Materials Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 2A Grade Level: 3 Primary Content Area: Science Time Frame: 1 – 2 class periods

DESCRIPTION

In this unit, two different multi-step investigation sequences are described. In most cases, teachers should select either INVESTIGATION 2 OR INVESTIGATION 3 for full implementation. INVESTIGATION 2 (heat) is recommended for full implementation, followed by direct teaching of concepts related to INVESTIGATION 3 (light). This is the first of the three lessons for INVESTIGATION 2, which will help students learn the inquiry process. In this structured inquiry lesson, students will conduct an inquiry and record data about the effects of the sun on different types of earth materials, such as sand, soil, concrete chips, gravel, cinder, water, etc. Based on the data collected, they will make inferences about absorption of heat in different materials.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.2 Safely collect and analyze data to answer a question (INVESTIGATION) (L3)
- SC.3.6.1 Define energy and explain that the sun produces energy in the form of light and heat (NATURE OF MATTER/ENERGY) (L1)

CCSS: Math

- CCSS.Math.Content.3.MD.A.1: Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram.
- CCSS.Math.Content.3.MD.A.2: Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[1] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[2]

CCSS: Language Arts

- CCSS.ELA-Literacy.W.3.8: Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

Students can-

- Accurately measure and record temperature.
- Use data to make inferences and to generate questions.
- Begin to explain that heat from the sun is absorbed differently by different earth materials and surfaces.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Inquiry Data Recording Sheet (1 per small group)
- Whole class chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Question: How is heat from the sun absorbed differently by different earth materials and surfaces?

Vocabulary: *(Sources: Encarta Dictionary, ScienceSaurus)*

absorption: the ability of a substance to take in light, noise, or energy
data: information, often in the form of facts or figures obtained from experiments
inference: a conclusion drawn from evidence or reasoning
thermometer: a tool designed to measure temperature

Materials/Needs:

- A sunny day
- Student notebooks or journals

For each team of 4 students:

- 4 - 1 cup or 250 ml size clear plastic containers
- 100 ml of each of the following materials:
    - soil
    - sand
    - concrete chips, gravel , or other rocky material
    - water
    - timer or stopwatch
    - thermometer
    - clipboards
    - pencils

Handouts/Other Resources:

- See Sample Student Journal for this unit
- Data Recording Sheet

Procedure:

Note: This investigation presumes that the students have been introduced to the concept of energy and have experience using thermometers. Results of this investigation will be most dramatic when conducted between 10:30 a.m. and 2:00 p.m.

Introduce this investigation by saying that today we are going to explore why we feel hotter in some places than others. Emphasize that students are going to be scientists as they measure temperature and record data, and that it is important for them to make precise and accurate measurements. Review safety guidelines with students for an outdoor investigation, including:

- Site boundaries
- Any hazards within the site boundary
- The amount of time exposed to the sun
- Students must NEVER look directly at the sun, due to the risk of permanent damage to their vision.

Outdoor Observations

Group students into teams of 4 to perform the following:

- Put 100 ml of one material (soil, sand, water or concrete chips) in each container.
- Add a thermometer, making sure the bulb is embedded in the material.
- Take the containers outside and place them in the shade for 5 minutes and record the starting temperature.
- Set the containers in the sun and record the temperature every 5 minutes for 20 minutes.

- Set the containers back in the shade and record the temperature every 5 minutes for 20 minutes.

Share Data and Debrief

- Return to the classroom, and ask student teams to share their data as you create a class graph (T-chart or 2-column table) of their findings.
- Record findings in the left-side column; explain that the right-side column will be used to record their thinking, based on the data.
- Explain that scientists make inferences (explanations) based on data (facts).
  (Note: Inferences are required by Gr. 4 benchmarks)
- Ask students to volunteer some inferences that can be made from the class data graph and chart responses.

Record Findings (approx. 15 min. total):

- Use the provided Student Journal entry for this lesson, or direct students to draw a "T" chart or table in their science notebooks. Title the columns "Data" and "Inference" as shown below:

Data	**Inference**
What am I wondering now?	

- Ask students to write 2- 3 factual statements (Data), then provide an explanation for each statement (Inference). In the last box, ask students to generate a new question as a result of their observations.

Adapted from: FOSS Solar Energy Module

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 2A				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness prevents the reader from determining student's level of understanding. One or more elements are missing or completely unrelated to the inquiry.	Accurately records at least 2 pieces of data from the inquiry. Inferences and/or question are missing or only marginally relevant to the inquiry.	Accurately records at least 2 pieces of data collected from the inquiry. Makes inferences based on those data. Generates a question relevant to the inquiry.	Accurately records at least 3 pieces of data collected from the inquiry. Makes inferences based on those data. Generates 2 or more questions relevant to the inquiry.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than 1 error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: INVESTIGATION 2: Heat from the Sun - Lesson 2B: Research on Earth Materials and Heat from the Sun Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson: 2B Grade Level: 3 Primary Content Area: Science Time Frame: 1-2 class periods

DESCRIPTION

In this second lesson for INVESTIGATION 2, students are guided through the process of doing research and designing an investigation to help them prepare for Lesson 2C. As a class, a research question is developed, research is conducted, and the information obtained is used to inform the development of a testable hypothesis. Students work as a group to develop an experimental design, including materials and procedures for testing the hypothesis that they will apply in the next lesson.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.1: Pose a question and develop a hypothesis based on observations (INVESTIGATION) (L4)

CCSS: Language Arts

- CCSS.ELA-Literacy.RI.3.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.
- CCSS.ELA-Literacy.W.3.7: Conduct short research projects that build knowledge about a topic.
- CCSS.ELA-Literacy.W.3.8: Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.
- CCSS.ELA-Literacy.SL.3.1: Engage effectively in a range of collaborative discussions (one-on-one. in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly**.**
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

Students can-

- Generate questions based on data from an investigation as part of a group.
- Identify and conduct research to answer a question based on data collected from an investigation as part of a group.
- Use findings from research to develop a hypothesis and design an investigation with other members of a group.
- Describe the selected hypothesis and explain how it will be tested in an individual journal entry.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Small group data chart
- Whole class chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Question: How do observations and research lead to the development of a scientific investigation?

Vocabulary: *(Sources: Encarta Dictionary, ScienceSaurus)*

- *hypothesis:* "an idea that can be tested by an experiment or an observation" (ScienceSaurus, 2005). It is generally stated in *an "If…then…" or "If…then…because…"* format. A good hypothesis is testable and linked to the research question.
- *procedure:* the means of doing or accomplishing something
- *variable:* something capable of changing or varying (Note: used by teacher to model the language of science)

Materials/Needs:

- Data from previous lessons
- Selection of resources (visual and digital) for student research
- Chart paper and/or projection screen for computer
- Student journals or notebooks

Handouts/Other Resources:

- See Sample Student Journal for this unit

Procedure:

- Prepare a class chart based on the format shown on the provided Investigation Template.

- Introduce this lesson by reviewing the class summary of the previous days' investigation, what was learned about heat energy, and how different materials were observed to absorb heat differently. In their teams have students identify one of the observations they are curious about. Explain that the differences in materials or the conditions under which they were tested are referred to as "variables" in the language of science. (Note: Students should not be assessed on their knowledge of this term).

- Using the Investigation Template as a guide, lead a discussion with students that will enable you to fill in the appropriate sections on the chart.

- Observations and Wonderings: In their teams, ask students to discuss wonderings they now have about heat as it relates to the earth materials (Students can refer to science notebook entry from Lesson 2A). You may need to ask questions to facilitate their thinking. Have students share their wonderings and chart their responses. Possible wonderings include:
  - Do different types of the same earth material absorb heat differently?
  - Does the amount of material affect the amount of heat absorbed?
  - If water is added to sand or soil, does that affect how heat is absorbed?
  - Does the time of day affect the amount of heat absorbed?

- Explain that for this next phase of the investigation, we will select one of their wonderings to investigate as a class. Guide students to come to a consensus as to which wondering or "variable" they would like to select for the class investigation.

- Research Question: Guide students to create an appropriate research question (Ex.: How does the amount of material affect the amount of heat absorbed?), and record it on the class chart.

- Explain that more research is needed in order for the class to develop a testable hypothesis. Select and provide specific resource materials to assist students with their research on energy, heat energy, sunlight, and/or temperature. The nature and quantity of the selected materials should be developmentally appropriate for this grade level. Sources might include one or more of the following; however other resources you have on hand may be used.

- ScienceSaurus (blue edition)
  - Energy: pg. 284-286
  - Energy: pg. 287
  - Heat: pg. 288-294
- Energy Kids: http://www.eia.gov/kids/
- Discovery Education

  On the DE homepage, click on Science Elementary and select from the following resources:
  - "Energy Makes It Happen" Fun-damental
  - "About Energy" reading passage
  - "Forms of Energy" reading passage
  - "How Special is Our Sun" video segment (locate by typing the title into the search box)
- Temperature Measure: http://www.newton.dep.anl.gov/askasci/wea00/wea00136.htm
- The Difference Between Air Temperature in Shade and in Sun: http://www.ehow.com/facts_5899718_difference-air-temperature-shade-sun.html
- NASA: "Sunlight and Solar Heat" http://genesismission.jpl.nasa.gov/science/mod3_SunlightSolarHeat/index.html
- Solar Energy Facts for Kids: http://www.ehow.com/facts_5024335_solar-energy-kids.html
- PBS Kids: http://pbskids.org/dragonflytv/show/solarcar.html

- Debrief: Debrief the research portion of the lesson by having students share and discuss their findings.
  - Have students share and record in small groups, then create a class chart to capture information, OR
  - Have students contribute a selected piece of information to a Google document. (Students are numbered off, teacher creates a numbered table in Google documents that is shared with the class; students enter information in the row that corresponds to their assigned number).

- Continue to model the development of a science investigation by guiding students through each step of the process to complete the class chart:
  - Testable Hypothesis: Introduce "hypothesis" and explain that a hypothesis is "…an idea that can be tested by an experiment or an observation." (ScienceSaurus, 2005). Keeping students' abilities and safety in mind, guide students to develop a hypothesis for an experiment that will answer their research question, is "doable" within the constraints of materials available, and is based on what they have learned from their research. Record the hypothesis on the class chart.
  - Experimental Design - Materials: Have students work in small groups to determine what materials will be needed to conduct the investigation. Have groups share out to determine if all agree about what will be needed. Record materials list on the class chart.
  - Experimental Design – Procedure: Have students work in small groups to discuss the procedure that should be used to conduct the investigation. Have groups share out to determine if procedural steps are clear to all. Record the procedure on the class chart.

- Student Journal: Direct students to describe the hypothesis and procedures that their group has decided upon in a journal entry.

Note: Based on the agreed-upon materials and procedures, the teacher will need to insure that needed supplies are provided for the next session in which students will carry out the investigation.

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 2B				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness prevents the reader from understanding the hypothesis to be tested and/or the procedures that will be used to conduct the investigation.	Describes a hypothesis that may or may not be testable; procedures are described but are somewhat unclear.	Clearly describes a testable hypothesis and the procedures that will be used to conduct the investigation.	Gives a detailed description of a testable hypothesis and the procedures that will be used to conduct the investigation.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy **Lesson Title:** INVESTIGATION 2: Heat from the Sun – Lesson 2C: Guided Inquiry: Exploring Earth Materials & Heat from the Sun **Date Developed/Last Revised:** 6/13/13 **Unit Author(s):** K. Umeda, B. Jennings, L. Lum, R. Saito	**Lesson #:** 2C **Grade Level:** 3 **Primary Content Area:** Science **Time Frame:** 1 class period

DESCRIPTION

In this third lesson for INVESTIGATION 3, the teacher directs students through a guided inquiry as they investigate how heat from the sun affects different earth materials. Students collect, record, and analyze data based on the experimental design determined in the previous lesson. They share and explain their findings as a group and in individual student journal entries.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.1: Pose a question and develop a hypothesis based on observations (INVESTIGATION) (L4)
- SC.3.1.2 Safely collect and analyze data to answer a question (INVESTIGATION) (L3)
- SC.3.6.1 Define energy and explain that the sun produces energy in the form of light and heat (NATURE OF MATTER/ENERGY) (L1)

CCSS: Math

- CCSS.Math.Content.3.MD.A.1: Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram.

CCSS: Language Arts

- CCSS.ELA-Literacy.RI.3.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.
- CCSS.ELA-Literacy.SL.3.1: Engage effectively in a range of collaborative discussions (one-on-one. in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly.

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

Students can-

- Conduct an investigation as a member of a group, including data collection, recording, and analysis.
- Accurately measure and record temperature.
- Individually describe results of an investigation and explain how findings inform their understanding of the affect of heat from the sun on different earth materials and surfaces.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Small group data chart
- Whole class chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Questions:

- How can I conduct an investigation to answer a question?
- How do material properties affect the amount of heat absorbed?

Materials/Needs:

- A sunny day
- Investigation Template
- Clear plastic containers from the previous investigation
- Different types of soil, sand, concrete and water (e.g. salt vs. fresh, different concentrations of salt)
- Student journal or notebook

Handouts/Other Resources:

- Data Recording Sheet

Procedure:

- Review the steps on the Investigation Template that were recorded in Lesson 2B, including the testable hypothesis that was selected by the class and the procedures for the investigation.

- Provide students with a new Data Recording Sheet and check for understanding on how columns are to be labeled to correspond with the selected investigation.

- Guide students as they implement their experimental procedures and prompt their thinking as they collect and record data.

- After data has been collected, have student groups share the results of their investigations and create a class graph of their data.

- Facilitate a discussion in which students are asked to analyze the data. Optional – create a new class chart to record data (facts) and inferences (explanations).

- Guide students to develop a summary and conclusion about heat from the sun and different earth materials. Record on the class chart.

- Discuss possible implications and next steps for scientific inquiry. Record.

- Conclude this inquiry by reviewing the driving questions for the lesson and discussing them in light of what was learned:
  - How can I conduct an investigation to answer a question?
  - How do material properties affect the amount of heat absorbed?

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 2C				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness in the description of the investigation prevents the reader from determining student understanding of key concepts. Conclusion is missing or unrelated to the investigation.	Description of the purpose of the investigation and/or the data that were collected are somewhat unclear. Conclusion is unclear or marginally related to the investigation.	Clearly describes the purpose of the investigation and the data that were collected. States a conclusion about how material properties affect the amount of heat absorbed.	Clearly explains the purpose of the investigation and the data that were collected. Supports a clearly stated conclusion about how material properties affect the amount of heat absorbed with references to the data.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: INVESTIGATION 3: Light Energy from the Sun – Lesson 3A: Structured Inquiry: Observing the Effects of Sunlight Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 3A Grade Level: 3 Primary Content Area: Science Time Frame: 1 class period

DESCRIPTION

In this unit, two different multi-step investigation sequences are described. In most cases, teachers should select either INVESTIGATION 2 OR INVESTIGATION 3 for full implementation. INVESTIGATION 2 (heat) is recommended for full implementation, followed by direct teaching of concepts related to INVESTIGATION 3 (light). Where time permits, teachers may opt to have students deepen their understanding of the inquiry process through full implementation of INVESTIGATION 3. This is the first of the three lessons in the series, in which students will learn that the sun produces energy that we can see (visible light) as well as energy that we cannot see (ultraviolet rays). They will explore how light from the sun affects UV-sensitive beads under different conditions. In lesson 3A, students will be led through the structured inquiry process.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.1 Pose a question and develop a hypothesis based on observations (INVESTIGATION) (L4)
- SC.3.1.2 Safely collect and analyze data to answer a question (INVESTIGATION) (L3)
- SC.3.6.1 Define energy and explain that the sun produces energy in the form of light and heat (NATURE OF MATTER/ENERGY) (L1)

CCSS: Math

- CCSS.Math.Content.3.MD.A.1: Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram.

CCSS: Language Arts

- CCSS.ELA-Literacy.SL.3.1: Engage effectively in a range of collaborative discussions (one-on-one. in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly.
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

Students can-

- Accurately read and record time.
- Collect and organize data.
- Use data to make inferences.
- Explain that there is visible light, and there is light energy that you cannot see.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Small group data chart
- Whole class chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Question: How can we detect both visible and invisible light energy from the sun?

Vocabulary: *(Sources: Encarta Dictionary, ScienceSaurus)*

- *visible:* capable of being seen by the human eye
- *invisible:* not able to be seen with the human eye
- *ultraviolet (UV) light:* invisible energy from the sun; beyond the violet end of the visible light spectrum
- *control:* used to keep all variables in an experiment the same except for the one being tested

Materials/Needs:

- A sunny day

For each pair of students:

- 2 UV beads (1 will be your control bead and the other will be the "testing bead")
- 1 sheet of white paper
- Timer
- Student notebooks or journals

Handouts/Other Resources:

- See Sample Student Journal for this unit
- Data Recording Sheet

Procedure:

- Assign students to work together in pairs.
- Introduce the investigation by saying that today we will be working with some "special" beads.
- Have the students place the white sheet in front of them with the two beads on top of it.
- Take the "testing bead" and place it under the palm of your hand for one minute.
- Place the "testing bead" on the white sheet of paper next to the control bead.
- Observe whether the bead changed color and use the timer to measure how long the color lasted.
- Record your findings on your Data Recording Sheet.
- Discuss or hypothesize what has caused the beads to change or not change color.
- Cover the control bead with a piece of paper.
- Take the "testing bead" outside under a shady tree and hold it in the open palm of your hand for one minute.
- Follow the same procedure for comparing it with the control bead, making observations, and recording your findings.
- Discuss or hypothesize what has caused the beads to change color.
- Follow the same procedure of taking the "testing bead" outside, but this time take it to an area that has strong sunlight.
- Conclude by discussing and creating a class summary of what was observed when the beads were in the sun vs. in the shade. Identify that the beads they were working with are called UV beads and explain the following:
    - UV beads contain a chemical that changes color when exposed to ultraviolet (UV) light.
    - Light is a form of energy that travels in waves. The light that you can see is called visible light. Ultraviolet light has wavelengths that are invisible to the eye except when they come in contact with chemicals such as those found in these beads. Scientists are interested in ultraviolet light because it can be harmful to humans.
    - In Science, energy is the ability to do work and work is done when a force moves an object through a distance (ScienceSaurus, 2005). The sun produces light 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 3A				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness prevents the reader from determining student's understanding. One or more elements are missing or completely unrelated to the inquiry.	Accurately records at least 2 pieces of data from the inquiry. Inferences and/or question is missing or only marginally related to the inquiry.	Accurately records at least 2 pieces of data collected from the inquiry. Makes inferences based on those data. Generates a question related to the inquiry.	Accurately records at least 3 pieces of data collected from the inquiry. Makes inferences based on those data. Generates a question directly related to the inquiry.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: INVESTIGATION 3: Light Energy from the Sun - Lesson 3B: Research on Types of Light Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 3B Grade Level: 3 Primary Content Area: Science Time Frame: 1 class period

DESCRIPTION

In this second lesson for INVESTIGATION 3, students are guided through the process of doing research and designing an investigation. As a class, a research question is developed, research is conducted, and the information obtained is used to inform the development of a testable hypothesis. Students work as a group to develop an experimental design, including materials and procedures for testing the hypothesis that they will apply in the next lesson.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.1: Pose a question and develop a hypothesis based on observations (INVESTIGATION) (L4)

CCSS: Language Arts

- CCSS.ELA-Literacy.RI.3.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.
- CCSS.ELA-Literacy.SL.3.1: Engage effectively in a range of collaborative discussions (one-on-one. in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly.
- CCSS.ELA-Literacy.W.3.7: Conduct short research projects that build knowledge about a topic.
- CCSS.ELA-Literacy.W.3.8: Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

Students can-

- Generate questions based on data from an investigation as part of a group.
- Identify and conduct research to answer a question based on data collected from an investigation as part of a group.
- Use findings from research to develop a hypothesis and design an investigation with other members of a group.
- Describe the selected hypothesis and explain how it will be tested in an individual journal entry.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Small group data chart
- Whole class chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Question: How do observations and research lead to the development of a scientific inquiry?

Vocabulary: *(Sources: Encarta Dictionary, ScienceSaurus)*

- *hypothesis:* "an idea that can be tested by an experiment or an observation " (ScienceSaurus, 2005). It is generally stated in an "*If…then…" or "If…then…because…"* format. A good hypothesis is testable and linked to the research question.
- *procedure:* the means of doing or accomplishing something

Materials/Needs:

- Investigation Template
- Data Recording Sheet
- UV bead bracelets from previous investigation
- Various light sources including incandescent light, CFL or LED light, fluorescent light, colored light, and a black light
  Note: Lights are to be set up as stations at various locations around the room such that 2-3 student teams can be working at a station simultaneously
- Student notebooks or journals

Handouts/Other Resources:

- See Sample Student Journal for this unit

Procedure:

- Prepare a class chart based on the Investigation Template.
- Template to guide a class discussion.
- Review the class summary of the previous days' investigation and what was learned about energy, light, and UV beads. In their pairs have students discuss and record 1-2 observations that they are curious about. Chart the student's observations.
- In their pairs, ask students to discuss wonderings they now have about sunlight as it relates to the UV beads. You may need to ask questions to facilitate their thinking. Have students share their wonderings and chart their responses. Possible wonderings include:
  - How do UV beads react to differences in temperature?
  - How do UV beads react to different types of light?
  - How does the time of day affect the reaction of the UV beads?
  - How does the amount of time in the sun affect the reaction of the beads?
  - Does the color of the bead affect its reaction to sunlight?

- Explain that for this next phase of the investigation, we will investigate one of their wonderings **as a class.** The selected inquiry is *how UV beads react to different types of light.*
- Guide students to create the research question: What is the effect of the type of light on the reaction of UV beads? Or, How does the type of light affect the reaction of UV beads? Different types of light sources that could be used include sunlight, incandescent light, fluorescent light, and LED light. Be sure to show students the different types of light sources that they will be using and discuss how they are alike and different.
- Guide students to research information on energy, sunlight, and UV beads using any of the following resources or others that are available to you:
  - ScienceSaurus (blue edition)
    - Energy: pg. 284-286
    - Energy: pg. 287
    - Light: pg. 308-312
  - Energy Kids: http://www.eia.gov/kids/
  - Discovery Education
    On the DE homepage, click on Science Elementary and select from the following resources:

- "Energy Makes It Happen" Fun-damental
- "About Energy" reading passage
- "Forms of Energy" reading passage

Have students share their research findings by sharing and recording in small groups, large groups, and/or Google document. Discuss as a class.

- Continue to model the development of a science investigation by guiding students through each step of the process to complete the class chart:

    - Testable Hypothesis: Review "hypothesis" and explain that a hypothesis is "…an idea that can be tested by an experiment or an observation." (ScienceSaurus, 2005). Keeping students' abilities and safety in mind, guide students to develop a hypothesis for an experiment that will answer their research question, is "doable" within the constraints of materials available, and is based on what they have learned from their research. Record the hypothesis on the class chart.

    - Experimental Design - Materials: Have students work in small groups to determine what materials will be needed to conduct the investigation. Have groups share out to determine if all agree about what will be needed. Record materials list on the class chart.

    - Experimental Design – Procedure: Have students work in small groups to discuss the procedure that should be used to conduct the investigation. Have groups share out to determine if procedural steps are clear to all. Record the procedure on the class chart.

- Journal Entry: Direct students to describe the hypothesis and procedures that the class has decided upon.

Note: Based on the agreed-upon materials and procedures, the teacher will need to insure that needed supplies are provided for the next session in which students will carry out the investigation.

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 3B				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness prevents the reader from understanding the hypothesis to be tested and/or the procedures that will be used to conduct the investigation.	Describes a hypothesis that may or may not be testable; procedures are described but are somewhat unclear.	Clearly describes a testable hypothesis and the procedures that will be used to conduct the investigation.	Gives a detailed description of a testable hypothesis and the procedures that will be used to conduct the investigation.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy **Lesson Title:** INVESTIGATION 3: Light Energy from the Sun - Lesson 3C: Guided Inquiry: Observing the Effects of Sunlight **Date Developed/Last Revised:** 6/13/13 **Unit Author(s):** K. Umeda, B. Jennings, L. Lum, R. Saito	**Lesson #:** 3C **Grade Level:** 3 **Primary Content Area:** Science **Time Frame:** 1 class period

DESCRIPTION

In this third lesson for INVESTIGATION 3, the teacher directs students through a guided inquiry as they investigate how light from different sources is detected by UV-sensitive beads. Students collect, record, and analyze data based on the experimental design determined in the previous lesson. They share and explain their findings as a group and in individual student journal entries.

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks Assessed in this Lesson:

HCPS III: Science

- SC.3.1.1 Pose a question and develop a hypothesis based on observations (INVESTIGATION) (L4)
- SC.3.1.2 Safely collect and analyze data to answer a question (INVESTIGATION) (L3)
- SC.3.6.1 Define energy and explain that the sun produces energy in the form of light and heat (NATURE OF MATTER/ENERGY) (L1)

CCSS: Math

- CCSS.Math.Content.3.MD.A.1: Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram.
- CCSS.Math.Content.3.MD.A.2: Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[1] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[2]

CCSS: Language Arts

- CCSS.ELA-Literacy.W.3.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- CCSS.ELA-Literacy.SL.3.1: Engage effectively in a range of collaborative discussions (one-on-one. in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly.
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

Students can-

- Accurately measure and record temperature.
- Use data to make inferences.
- Explain that heat from the sun is absorbed differently by different earth materials and surfaces.

2B. Assessment Tools/Evidence:

Formative:

- Teacher's anecdotal notes based on observations about student participation
- Small group data chart
- Whole class chart
- Student journal entry

3. Learning Experiences (Lesson Plan)

Driving Questions:

- How can I conduct an investigation to answer a question?
- What are the differences in visible light produced by various light sources?

Materials/Needs:

- A sunny day
- Various light sources including incandescent light, CFL or LED light, fluorescent light, colored light, and a black light
  Note: Lights are to be set up as stations at various locations around the room such that 2-3 student teams can be working at a station simultaneously

For each pair of students:

- Investigation Template
- UV bead bracelets from previous investigation
- Student notebooks or journals

Handouts/Other Resources:

- See Sample Student Journal for this unit
- Data Recording Sheet

Procedure:

- Review the steps on Inquiry Recording Chart that were recorded in the previous session, including the testable hypothesis that was selected by the class and the procedures for the investigation.
- Guide students as they implement their experimental procedure, and prompt their thinking as they collect and record data.
- After data has been collected, have student groups share the results of their investigations and create a class graph of their data.
- Facilitate a discussion in which students are asked to analyze the data. Optional – create a new class chart to record data (facts) and inferences (explanations).
- Guide students to develop a summary and a conclusion about heat from the sun and different earth materials. Record on the class chart.
- Discuss possible implications and next steps for scientific inquiry. Record.
- Conclude this inquiry by returning to the Essential Questions and discussing them in light of what was learned from this investigation.

Adapted from:
solar-center.stanford.edu/webcast/wcpdf/SunBurns5-8.pdf
www.arborsci.com/Data_Sheets/P3-6500_DS.pdf

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 3C				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness in the description of the investigation prevents the reader from determining student understanding of key concepts. Conclusion is missing or unrelated to the investigation.	Description of the purpose of the investigation and/or the data that were collected are somewhat unclear. Conclusion is unclear or marginally related to the investigation.	Clearly describes the purpose of the investigation and the data that was collected. States a conclusion about how material properties affect the amount of heat absorbed.	Clearly explains the purpose of the investigation and the data that was collected. Supports a clearly state conclusion about how material properties affect the amount of heat absorbed with references to the data.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: Engineering Design Process – Lesson 4A: Engagement Activity: Building Background Knowledge Through Discovery Learning Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 4A Grade Level: 3 Primary Content Area: Science Time Frame: 1 – 2 class periods

DESCRIPTION

The Engineering Design Process involves a sequence of steps in which students create, test, and redesign a product that fulfills a specific purpose. In this lesson, students will be introduced to the Engineering Design Process that will be fully implemented in Lesson 4B. They will explore and record data related to tests conducted on different materials that could be used as insulators and/or conductors of heat energy.

PLANNING (Steps 1, 2, & 3)

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

HCPS III: Science

- SC.3.1.1: Pose a question and develop a hypothesis based on observations (INVESTIGATION) (L4)
- SC.3.1.2: Safely collect and analyze data to answer a question (INVESTIGATION) (L3)
- SC.3.6.1: Define energy and explain that the sun produces energy in the form of light and heat (NATURE OF MATTER/ENERGY) (L1)

CCSS: Language Arts

- CCSS.ELA-Literacy.RI.3.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.

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

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

Students can-

- Collect and record data to answer questions related to light and heat from the sun.

2B. Assessment Tools/Evidence:

Formative:

- Data Recording Sheet
- Student journal entry

3. Learning Experiences (Lesson Plan)

Engagement Activity: Introduction to the Engineering Design Process

- Show students a pencil and ask the following:
  - What is an engineer? (A person who applies their scientific knowledge to solve problems by creating technological tools and products.)
  - How is this pencil an example of engineering?
- Show students a mechanical pencil and ask:
  - 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 about how to do things is similar to the Engineering Design Process that they will be using in future lessons.

Building Background Knowledge Through Discovery Learning

Create stations for students to experiment with light and heat. Depending on the ability level of your students, you may implement all 4 stations at once or introduce just 1-2 stations per day. All stations need to be outside in the sunlight and created well in advance of the activity so the materials have time to "heat" up.

Prerequisite Learning: Students will need prior experiences with reading a thermometer.

Materials and Resources:

- Student Data Sheet
- ScienceSaurus: Heat Energy and Transfer of Heat Energy: pages 288-294
- Ask Newton: Color and Heat Absorption: http://www.newton.dep.anl.gov/askasci/phy00/phy00156.htm

Note: Materials and procedures for each specific station are indicated below.

Procedure:

- Have students follow the instructions to conduct mini-experiments at each of the stations.
- Record their observations and data on their Student Data Sheet.
- Read and discuss the information provided by the resources indicated above and have students validate information with data from their experiments.
-

Station 1: Colored Mitts (Which color absorbs the most heat?)

- Materials: Paper mitts of the following colors: white, black and pink
- Procedure:
    - Students place their hands in the different colored mitts and makes observations as to which one feels the warmest.
    - Students record their observations on their Student Data Sheet.

Station 2: Surface Area (Which surface area absorbs the most heat? Small or large?)

- Materials:
    - Two Styrofoam sheets 8-1/2" x 11, pieces of black construction paper attached to each: one 5-1/2 x 8-1/2" and one 5-1/2 x 4-1/4"
    - 2 quart size Ziploc bags filled with one-half cup of water and a thermometer placed inside the bag
      Place a bag on each of the black construction papers.
- Procedure: Students read the thermometers in each of the bags and record their data on the Student Data Sheet.

Station 3: Insulation (Which cup retains the most heat? Covered or not covered)

- Materials:
    - Two cups: One open and one sealed with a cover
    - 2 thermometers (1 placed in each cup)
- Procedure: Students read the thermometers in each of the cups and record their data on the Student Data Sheet.

Station 4: Conductors (Which type of material conducts the most heat?)

- Materials:
  - A glass jar, metal cup, foam cup, plastic cup, and paper cup of similar size
  - 5 thermometers (1 placed in each cup)
- Procedure: Students read the thermometers in each of the containers and record their data on the Student Data Sheet.

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 4A				
	1	**2**	**3**	**4**
Science Content	Lack of clarity and/or completeness in the description of any specific investigation station prevents the reader from determining student learning of key concepts.	Description of one investigation station and/or the data that was collected are somewhat unclear. Unclear what student learned from the data.	Clearly and accurately describes at least one of the investigation stations including the data that was collected. Describes what was learned from the data at each station.	Clearly and accurately explains at least two investigation stations including the data that was collected at each. Explains what was learned from the data at each selected station.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: Engineering Design Process – Lesson 4B: Performance Task: Engineering a Solar Water Heater (EDP) Date Developed/Last Revised: 6/13/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 4B Grade Level: 3 Primary Content Area: Science Time Frame: 6– 8 periods (~50 min. each)

DESCRIPTION

The Engineering Design Process involves a sequence of steps in which students create, test, and redesign a product that fulfills a specific purpose. Students will practice these steps over a series of several sessions as they apply what they have learned to design an effective solar water heater.

PLANNING (Steps 1, 2, & 3)

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

- SC.3.1.1: Pose a question and develop a hypothesis based on observations (L4)
- SC.3.1.2: Safely collect and analyze data to answer a question (L3)
- SC.3.6.1: Define energy and explain that the sun produces energy in the form of light and heat (L1)
- CTE Standard 1**:** TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
- CCSS.ELA-Literacy.W.3.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

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.

2B. Assessment Tools/Evidence:

Formative:

- Teacher observation
- Engineering Design Rubric
- EDP Assessment Sheet
- Completed EDP "Solar Water Heater" Journal entries
- Student journal entry

3. Learning Experiences (Lesson Plan)

Materials:

- Sandwich-sized Ziploc bags filled with ½ cup of water
- Cups of different sizes and different composition
- Foil
- Thermometers
- Saran Wrap
- Recycled materials: cardboard, plastic containers, paper, etc.
- Earth materials: sand, soil, rocks, and water
- Tape
- Timer

- Student notebook or journal

Handouts/Other Resources:
- EDP "Solar Water Heater" Journal

Procedure:
Please Note: The class will go through each step of the process together. Stop after each step to discuss what the students did and the criteria needed. 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 one 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.

Introduction of the Performance Task: Scenario
Mmmm…. hot cocoa! You love drinking hot cocoa while watching TV. You are too young to use the stove to make hot water. How could you make hot water for your cocoa without using any electrical appliances? You could use the sun's energy to heat up water. Good idea! So your job is to design a solar water heater that would harness the sun's energy and heat up a half-cup of water that you would use to make your hot cocoa. You will be measuring the temperature of the water that you put into your solar water heater in 5-minute increments to see if your water is heating up. Then you may make your hot cocoa and enjoy your drink! Mmmm….

- Show the sample of a poorly designed heater and give temperature of water.
- Show the Ziploc bag with a half-cup of water and a thermometer in it that will be put into their heater.
- Pass out "Solar Water Heater" Journals to each student.

Ask (Step 1):
- Explain the criteria for the Ask section of this process.
- Ask students to identify:
  - the problem of the performance task.
  - what they are creating.
- Discuss and clarify the criteria and constraints for making this heater.
- Show students the materials that are available for them to use. 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.
- Ask students to record any questions they may have about constructing this heater.
- Review the criteria for the "Ask" section of the process.

Imagine (Step 2):
- Instruct students to individually brainstorm ideas for building a solar water heater and draw or write out their ideas in the journal.
- Have individual students share out their ideas to the rest of their engineering team. Students must defend their reasons for using specific ideas in their prototype. (Ex. Use black paper because it absorbs more heat.)
- Review the criteria for the "Imagine" section of the process.

Plan (Step 3):

- Inform the engineering teams that they will now decide on ONE person's design to use or create ONE new hybrid idea incorporating all the differing ideas.
- Designate one person in each engineering team to sketch a diagram of the team's solar water heater prototype with labels of parts and possible measurements onto a piece of paper. The sketcher must be sure to incorporate all the agreed upon ideas into the design. Students list all possible materials that will be needed to create the prototype.
- When all team members are satisfied with their prototype design, ensure that each member copies this diagram of the solar water heater onto their journals.
- Instruct students to check with their team members to see if all drawings and labels are completed and everyone has the same plan to follow.
- Review the criteria for the "Plan" section of the process.

Create (Step 4):

- Explain that students should follow their team plan as closely as possible when building their prototype. If they modify their original prototype to in order to make the prototype work, they should be sure each person writes down and adds that information to their journal diagram plans as well.
- Have student teams share their prototype solar heaters with the large group stating what modifications were made to the plan and why.
- Review the criteria for the "Create" section of the process.

Experiment (Step 5): Test it out!

- Pass out a Ziploc bag filled with a ½ cup of water and a thermometer to each student team.
- Instruct student teams to:
  - Take the initial temperature of water and log it into their journals.
  - Place bag into their solar heater.
  - Take the solar heater outside.
  - Take the temperature of the water every 5 minutes.
  - Log the data into their journals.
- Review the criteria for the "Experiment" section of the process.

Improve (Step 6):

- Guide students to review the results from their data.
- Have them repeat the EDP to optimize their product:
  - Ask: What worked? What didn't work? Why?
  - Imagine: Ask students to think about which variables of the solar heater could they change to increase the temperature of the water? Why?
  - Plan: Direct students to draw the diagram of their team's 2nd prototype. Label the parts with measurements. List the materials needed. Remind each member to copy the agreed upon team diagram.
  - Create: Have students build a second prototype following the team's design. Remind them to keep to the plan.
  - Experiment: Instruct students to…
    - Take the initial temperature of the water. Log the temperature into the journal.
    - Take temperature of water every 5 minutes.
    - Log the data.
- Write 3 facts comparing the data tables for prototypes 1 and 2.
- Analyze the data and explain the results that were found.
- Review the criteria for the "Improve" section of the process.

Note: You may go through this EDP cycle many times to get an optimized product that you want. It all depends on the amount of time you have available.

Optional: Give students a foam cup and cocoa with marshmallows. Enjoy!

- Remind students that each group must complete the EDP student journal.

- Direct students to respond to the following prompt in their student journals or notebooks: "How did the Engineering Design Process help you create and improve your solar water heater? Did ideas from other groups help you make improvements? Describe why and how your design ideas changed after you tested your first model."

SAMPLE WATER HEATER:

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 4B				
	1	**2**	**3**	**4**
Science Content	Little or no reference to the EDP is made. Description of why and how design ideas changed after the product was tested may be missing or is unclear. No reference is made to learning from other groups.	Description of how the EDP guided product development is somewhat unclear. Student describes changes to product after testing, but explanation for such changes is lacking. Marginal reference, if any, to learning from other groups.	Clearly describes how following the EDP helped product development, including why and how design ideas changed after the product was tested. Makes clear reference to learning from other groups.	Clearly explains how following the EDP helped product development, including why and how design ideas changed after the product was tested. Provides details about ideas gained from other groups.
Writing Skills	Numerous errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	Two or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Unit Title: Solar Energy Lesson Title: Other Lessons/Assessments – Lesson 5: How Does Solar Energy Technology Influence Society? Date Developed/Last Revised: 6/3/13 Unit Author(s): K. Umeda, B. Jennings, L. Lum, R. Saito	Lesson #: 5 Grade Level: 3 Primary Content Area: Science/CTE Time Frame: 1 class period

DESCRIPTION

Students will gain an understanding of how technologies developed to harness solar energy influence society. They will learn that some people choose engineering as a career field in order to help develop solutions to real world challenges.

PLANNING (Steps 1, 2, & 3)

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

- SC.3.6.1: Define energy and explain that the sun produces energy in the form of light and heat (NATURE OF MATTER/ENERGY) (L1)
- SC.3.2.1: Describe ways technologies in fields such as agriculture, information, manufacturing, or communication have influenced society (NATURE OF SCIENCE) (L2)
- CCSS.ELA-Literacy.W.3.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- CCSS.ELA-Literacy.L.3.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

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

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

Students can-

- Explain that the sun produces energy in the form of light and heat.
- Give examples to explain how solar energy technology influences society.

2B. Assessment Tools/Evidence:

Formative:

- Student journal entry

3. Learning Experiences (Lesson Plan)

Materials:

- Computer
- Projection screen
- Internet access: http://sopogy.com/about/index.php?id=10&entryid=1

Teacher Preparation:

The teacher should preview the provided website in order to obtain background information to effectively guide student discussion.

Procedure:

- Project this website: http://sopogy.com/about/index.php?id=10&entryid=1

Career Opportunities in Solar Technology

Daren Kimura: Sopogy – The Total Solar Solution

- Ask students to generate questions based on what they see in the projected images.
- Explain the technology shown on the website and discuss how this solar energy technology influences our society.
- Discuss other ways we harness the sun's energy to benefit society.
- Consider using the following resource to deepen student's understanding of solar energy technology.

http://environment.nationalgeographic.com/environment/global-warming/solar-power-profile/

Direct students to write a journal entry in which they provide examples of how solar energy technology influences the way people live and work.

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				
	1	**2**	**3**	**4**
Science Content	Entry lacks a clear statement about the importance of solar energy technology. Example is missing or incomplete.	States that people use solar energy to live and work, but does not refer to any specific technologies. Example is marginally related to topic and/or not well explained.	Describes how solar energy technology influences the way people live and work. Provides at least 2 reasonable examples.	Describes in detail how solar energy technology influences the way people live and work. Provides 3 or more well articulated examples.
Writing Skills	Multiple errors in the use of standard English conventions and grammar make it difficult for the reader to determine the author's meaning.	One or more errors in the use of standard English conventions and grammar, but meaning is clear.	Accurately uses standard English conventions and grammar with no more than one error.	Accurately uses standard English conventions and grammar with no errors.

Name _____ Date: _____

Summative Assessment: Solar Energy

1. What is energy?

2. Name 2 types of energy that are produced by the sun.
   Give at least one example of each type.

3. Describe 2 different solar energy technologies and explain how they influence the way people live and work.

RUBRIC: Summative Assessment				
	1	**2**	**3**	**4**
Energy	Student makes no connection between energy and the ability to do work.	Student infers that energy is related to doing work, but does not explicitly state this.	Student states that energy is the ability to do work.	Student states that energy is the ability to do work and includes examples.
Types of Solar Energy	Student does not identify light or heat as types of energy produced by the sun. No examples are provided.	Student identifies light or heat as a type of energy produced by the sun and provides an example OR identifies light and heat without providing examples.	Student identifies light and heat as types of energy produced by the sun and provides at least one example for each.	Student thoroughly explains at least one example of light energy and heat energy.
Solar Energy Technologies	Examples are missing or incomplete. Entry lacks a clear statement about the way solar energy technologies influence the way people live and work.	Identifies less than 2 solar energy technologies. Explanation of how they influence the way people live and work is not well articulated.	Identifies at least 2 different solar energy technologies and explains how they influence the way people live and work.	Describes in detail how at least 2 different solar energy technologies influence the way people live and work.

Name_____ Date_____

Data Recording Sheet: Title of Inquiry_____

	Elapsed Time				
	0 minutes				
Sun	5 minutes				
	10 minutes				
	15 minutes				
	20 minutes				
Shade	25 minutes				
	30 minutes				
	35 minutes				
	40 minutes				
	Temperature Change in the Sun				
	Temperature Change in the Shade				
New wonderings based on observations:					

Name_____ Date_____

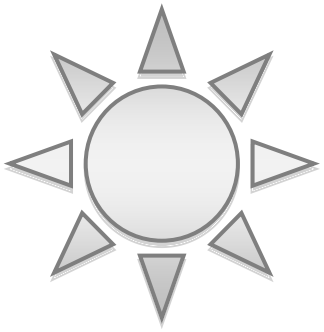
Investigation Template

Observations and Wonderings:
Research Question:
Background Information: • • • • • • •
Testable Hypothesis: *If…* *then…* *because…*
Experimental Design (Materials):
Experimental Design (Procedure):

Data:
Data Analysis:
Summary and Conclusions:
Implications and Next Steps:

My Journal

_____

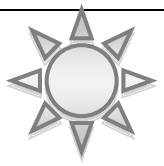


Gr. 3: Solar Energy

1A. Based on your field experience, describe at least 3 observations you made about how the sun affects the environment.
Tell which of your observations was most interesting and explain why.

2A. Data Recording Sheet: Observations and Inferences

In the data column shown below (left side), write 2 – 3 factual statements based on the observational data collected by the class. Then, on the right side column, write an inference for each of your data-based statements. In the box at the bottom of the page, write a new question that you have about heat energy from the sun.

Data	Inferences
What am I wondering now? 	

2B. Based on research and wonderings from your team, describe the hypothesis chosen by your group and explain how you will test it.

2C. Describe the results of your investigation. What data did you collect? How did the data inform your hypothesis?
Explain what you have learned from your investigation about how different materials absorb heat energy.

3A. Data Recording Sheet: Observations and Inferences

In the data column shown below (left side), write 2 – 3 factual statements based on the observational data collected by the class. Then, on the right side column, write an inference for each of your data-based statements. In the box at the bottom of the page, write a new question that you have about light energy from the sun.

Data	Inferences
What am I wondering now? 	

3B. Based on research and wonderings from your team, describe the hypothesis chosen by your group and explain how you will test it.

3C. Describe the results of your investigation. What data did you collect? How did the data inform your hypothesis?
Explain what you have learned from your investigation about light energy from different sources.

4A. Describe what you learned at one or more of the solar energy exploration stations. What data did you collect? What did you learn from this data?

4B. How did the Engineering Design Process help you create and improve your solar water heater? Did ideas from other groups help you make improvements? Describe why and how your design ideas changed after you tested your first model.

5. Explain how solar energy technology influences the way people live and work. Include 2 or more examples to support your explanation.

Name: _____ Date: _____

Solar Water Heater Engineering Design Process Journal

Performance Task

Mmmm…. hot cocoa! You love drinking hot cocoa while watching TV. You are too young to use the stove to make hot water. How could you make hot water for your cocoa without using any electrical appliances? You could use the sun's energy to heat up water. Good idea! So your job is to design a solar water heater that would harness the sun's energy and heat up a half-cup of water that you would use to make your hot cocoa. You will be measuring the temperature of the water that you put into your solar water heater in 5-minute increments to see if your water is heating up. Then you may make your hot cocoa and enjoy your drink! Mmmm….

Criteria:

- You are limited to the materials available for construction of this heater.
- You will be given a Ziploc bag filled with a half cup of water that will be placed inside your heater.
- The sun's energy will need to be harnessed to make your solar heater work.

What is the problem? _____

What are you being asked to design? _____

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

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

STEP 2: IMAGINE: Use your background knowledge of light and heat to design a prototype of a solar water heater. These are the things you should consider when creating your solar water heater:

- What materials are available for you to use?
- What design would best capture the sun's energy?

Draw your possible designs and label the parts. Be ready to share and discuss your design and explain the rationale for your design choices. Your design team will be choosing one 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.

Side View:
Top View:

STEP 4: CREATE: Build your prototype solar water heater following your team's design. Keep to the plan. What modifications did you need to add in order to be sure that your design would hold together and work? Be sure to record these modifications on your plan.

STEP 5: EXPERIMENT:

Data Table 1: Temperature of Water

Minutes	Temperature in Fahrenheit	Temperature in Celsius
Beginning Temp		
After 5 minutes		
After 10 minutes		
After 15 minutes		
After 20 minutes		

Temperature Scale (Fahrenheit)

Cool: 70-100	Just Right!: 100-110	Hot!: 110 and up

STEP 6: IMPROVE:

ASK: Looking at your data, answer the following questions:

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

Things to Consider	Did it work?	Why or why not?
Did the water temperature increase?	Yes A little No	
Size of the area of the water exposed directly to the sun (reflection)	Yes A little No	
Color of paper used to absorb heat	Yes A little No	
Covered or not covered	Yes A little No	
Materials container is made from (conductivity)	Yes A little No	

IMAGINE: Which variable(s) of the solar water heater will you change to increase the temperature of the water? Why?

_____

_____

_____

_____

_____

_____

_____

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

Side View:

Top View:

CREATE: Build your 2nd prototype following your team's design. Keep to the plan. Use the materials listed as well as the measurements that your group decided upon.

EXPERIMENT:

Data Table 2: Temperature of Water

Minutes	Temperature in Fahrenheit	Temperature in Celsius
Beginning Temp		
After 5 minutes		
After 10 minutes		
After 15 minutes		
After 20 minutes		

Temperature Scale (Fahrenheit)

Cool: 70-100	Just Right!: 100-110	Hot!: 110 and up

Write at least three facts comparing the data from Tables 1 and 2.

Fact 1	
Fact 2	
Fact 3	

Data Analysis: Compare the data from prototype 1 and prototype 2.

1. Which prototype was more effective? **Prototype 1** **Prototype 2**

Use your background knowledge of light and heat and your data to explain your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

IMPROVE: If you had more time and materials, what would you do to optimize your solar water heater even more? Explain your thinking.

Name: _____

Engineering Design Process Assessment

1. 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.

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

Ask:
Imagine:
Plan:
Create:
Experiment:
Improve:

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

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