Energy Transfer via Solar Ovens

Grade: 4th grade	**Recommended Timeframe: 12 Lesson Periods**

Unit Overview How is energy transferred? In this unit, students will design, test, and refine a device that converts energy from the sun (radiant energy) to heat (thermal energy) to cook hot dogs in a pizza box oven. In order to design the device, students will be introduced to factors that affect solar energy transformation needed for solar cooking (heat)—dark colors for absorbing sunlight, greenhouse effect, light colors for reflecting sunlight, and insulation. Using this scientific knowledge, they will construct and use a solar oven. Students will also learn how to measure angles using a protractor, use knowledge of units of metric measure, and construct and analyze data using line plots. Students will use technology as a tool to access, research, manage, integrate, and communicate ideas and information.

Essential Questions	**Major Concept**s
What is energy? How can radiant energy be transferred to thermal energy? What factors can make the transferring of light/radiant energy to heat/thermal energy more efficient?	**Science:** energy transfer, insulation, absorption **Technology:** Vernier Go!Temp, lab quest **Engineering:** engineering design process **Math:** angle measurement, data analysis.

Suggested Lesson Sequence

Prerequisites: Students should know that we have a sun and that the sun gives off light and heat.

Lesson 1: *Establishing Context.* What is energy? What is light/radiant energy and heat/thermal energy? 50 minutes
Lesson Overview: Students will build a collaborative concept web focusing on energy from the sun.

Lesson 2: *What Is Heat and How Do We Measure It?* 50 minutes
Lesson Overview: Students will learn how heat is created and build a thermometer.

Lesson 3: *How Does Color Affect Temperature?* 50 minutes
Lesson Overview: Students will investigate the effects of color on the absorption of heat energy from the sun.

Lesson 4: *How Do You Effectively Use a Protractor to Measure an Angle, and How Does the Angle of the Sun Affect Energy Transfer of Heat?* 100 minutes
Lesson Overview: Students will learn how to effectively use a protractor to measure angles and investigate the effects of the angle of the sun on temperature.

Lesson 5: *Does Location Matter?* 100 minutes –Guided inquiry
Lesson Overview: Students will write a hypothesis, compare and contrast chart, analyze outcomes regarding the best location around the school grounds to capture the most solar energy.

Lesson 6: *What Is the Most Effective Way to Prevent an Ice Cube from Melting?* 50 minutes
Lesson Overview: Students will learn about insulators and which materials will make effective insulators.

Lesson 7: *Putting It All Together: Engineering Design Problem* (150 to 200 minutes)
Lesson Overview: Students will use their knowledge of energy transfer, insulation, and absorption to solve an engineering problem.

Materials, Tools, & Technology

- ☐ mirrors
- ☐ aluminum foil
- ☐ thermometers
- ☐ Go!Temps
- ☐ LabQuest
- ☐ clear plastic cups—10 oz
- ☐ black and white construction paper
- ☐ glass bottles with narrow necks
- ☐ straws
- ☐ clay
- ☐ red food coloring
- ☐ plastic liter boxes (margarine tubs)
- ☐ protractors
- ☐ insulating materials—cotton, straw, paper, etc.
- ☐ clear plastic wrap
- ☐ duct tape or masking tape
- ☐ pizza boxes
- ☐ Internet access
- ☐ tablets
- ☐ Chromebooks

Vocabulary

conductor, insulator
thermal energy
energy transfer
reflection
refraction
absorption
radiant
temperature
heat
angle
protractor
thermometer
observation
hypothesis
conclusion
graph
data
Celsius
Fahrenheit
comparison
similar
difference
analysis

STEM Professional Involvement Ideas

- Solar energy engineer from solar energy company

Standards

Science

- **4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.**
- **4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.**

Technology

- **Use technology as a tool to access, research, manage, integrate, and communicate ideas and information.**

Engineering

- **3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, and cost.**
- **3-5-ETS1-2 Generate and compare multiple solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**

Mathematics

- **4.MD.6 Measure angles in whole number degrees using a protractor.**
- **4.MD.1 Know relative sizes of measurement units within one system of units, including km, m, cm; kg, g; lb, oz; l, m; hr, min, sec.**

Notes

Appendices

Appendix A: Teacher Resources (background knowledge, rubrics, Powerpoints, web resources, supporting instructional materials, STEM professional involvement guides, assessments)
Appendix B: Student Resources (Student-Friendly Glossary, student handouts)
Appendix C for Literacy Connections: *What Is Energy?* Article

Establishing Context – Lesson 1

Grade Level: 4th Grade	**Time Needed:** 50 minutes	**Subjects:** science, ELA

Objective/ Learning Target: Establishing context: What is energy? What is light/radiant energy? What is heat/thermal energy? Why and how is energy important to you?

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Background Information:

Light/radiant energy: **Radiant energy** is the **energy** transmitted by electromagnetic radiation. Light is one type of electromagnetic radiation.

Heat/thermal energy: **Thermal energy** is an example of kinetic **energy**, as it is due to the motion of particles, with motion being the key. **Thermal energy** results in an object or a system having a temperature that can be measured. **Thermal energy** can be transferred from one object or system to another in the form of **heat**.

Materials:

- ☐ butcher paper concept map with *Energy* in the middle; *light/radiant*, *heat/thermal*, connected to Energy
- ☐ markers
- ☐ Post-its® (six per student)
- ☐ science notebooks (optional) (1 per student)

Vocabulary:

energy
solar
radiant
light
heat
thermal

(See glossary for kid-friendly definitions)

Resources:

See Appendix A for Teacher Resources: Picture of Energy Concept Map—background information about energy

See Appendix B for Student Resources: Kid-Friendly Glossary; Energy Transfer Lesson 1 Exit Ticket

See Appendix C for Literacy Connections: *What Is Energy?* Article

Procedures:

1. Ask students to write down what they know about energy. Give them 3 minutes to write. Have them discuss with their table group and come up with a definition of energy. Share with the class.
2. Groups will read the article at http://www.eia.gov/Kids/energy.cfm?page=about_home-basics to learn more about energy. Students will write their revised definition of energy in their science notebooks.
3. Ask students to write 3 things they know about light energy on their Post-it notes. Groups share out their notes and combine similar ideas.
4. One student from each group will share out and post the group's Post-its on the concept map. The teacher will not discuss any misconceptions at this point. As the class goes through the unit,

any misconceptions will be pulled from this display and revised. Similar ideas are grouped together on the display.

5. Do the same process for heat energy.
6. Students will then write a definition for light energy and heat energy in their science notebooks.
7. Ask students to reflect on how and why energy is important to them.

Differentiation:

Supports

- article can be a shared reading opportunity
- vocabulary cards: energy, solar, radiant, light, heat, thermal

Extensions

- search and share informational websites on light and heat energy.

Assessment Opportunities:

Discussion and concept web is an opportunity for the teacher to assess prior-knowledge level of class and students. An exit ticket can be used in lieu of science notebook, asking students to write their definitions of energy, light energy, and heat energy (see student resources for exit ticket).

Citations:

Definitions from:

www.eschooltoday.com/**energy**/kinds-of-**energy**

http://www.eia.gov/kids/energy.cfm?page=kids_glossary#S

What Is Heat and How Do We Measure It? – Lesson 2

Grade Level: 4th Grade	**Time Needed:** 100 minutes	**Subjects:** science, engineering

Objective/ Learning Target: Students will learn how heat is created and how thermometers work.
How can heat be produced? How do thermometers work?

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, and cost.

Background Information:

One type of energy easily explored by students is heat energy. It is produced in many ways. Heat is produced by friction, electricity, burning, and bending.

Thermometers register heat because the liquid in the thermometer expands when it is heated and contracts when it cools. The liquid is contained in a column so when the liquid is heated it rises and when it cools it falls.

Materials:

- ☐ candle and match (1)
- ☐ lamp (1)
- ☐ wire hangers (class set or 1 per group)
- ☐ block of wood and sandpaper (1 per group)
- ☐ glass bottle with thin neck (like a milk bottle or cruet)

Per group:

- ☐ clear straw
- ☐ clay
- ☐ food coloring
- ☐ 2 deep pans
- ☐ hot water
- ☐ cold water
- ☐ science notebooks (optional) (1 per student)

Vocabulary:

heat
friction
temperature
thermometer
Fahrenheit
Celsius

(See glossary for kid-friendly definitions)

Resources:

See Appendix B for Student Resources: Kid-friendly Glossary

Procedures:

1. Ask students to discuss with their group their answers to this question: How is heat produced? Give them 3 minutes to discuss and then share with class.
2. Light the candle and ask students if heat is produced. Ask students to describe the air above the candle.
3. Turn on the lamp, have students describe the air above the lamp, and ask how the heat is being produced.
4. Hand out the wire hangers to groups or class. Ask students to bend the wire back and forth rapidly for 30 seconds. What happens to the wire?
5. Hand out blocks of wood and sandpaper. Ask students to describe the wood and sandpaper. Then ask students to rub the sandpaper on the wood rapidly for 30 seconds. What happens?
6. Students will then write ways heat is produced in their science notebooks. (optional: exit tickets instead).
7. Ask students: How do we measure heat? How does a thermometer work?
8. Pass out materials to each group.
9. Have students pour cold water into the bottle. Then add a few drops of food coloring (red food coloring will better simulate a thermometer).
10. Put in straw about halfway down the bottle. Mold the clay around the top of the bottle, making sure there aren't any holes or gaps.
11. Put the bottle into one of the deep pans (liter boxes work well).
12. Pour hot tap water into the pan.
13. Direct the students to watch what happens to the water in the straw. Make observations.
14. Put the bottle into the other deep pan. Pour cold water into the pan and watch what happens with to the water in the straw. Make observations.
15. Discuss. Write about what happened in your science notebook (optional).s

Differentiation:

Supports

- Students could describe by using pictures
- Vocabulary cards: heat, friction, thermometer, Fahrenheit, Celsius

Extensions

- Search and share informational websites on the invention of the thermometer.

Assessment Opportunities:

Teachers can use student descriptions and observations written in student science notebooks to assess student knowledge. (Exit tickets, or students may diagram their knowledge instead of notebooks.)

Citations:

lessons adapted from:

AIMS: Energy Explorations: Sound, Light, and Heat

Heat, page 195 Make a Thermometer, page 241

definitions from:

dictionary.com

http://www.physics4kids.com/files/motion_friction.html

How Does Color Affect Temperature? – Lesson 3

Grade Level: 4th Grade	**Time Needed:** 75 minutes	**Subjects:** science, technology, math

Objective/ Learning Target: Students will investigate the effects of color on the absorption of heat energy from the sun.
What colors—dark or light—absorb heat better?

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Use technology as a tool to access, research, manage, integrate, and communicate ideas and information.

4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l, m; hr, min, sec.

Background Information:

Dark colors absorb radiant energy, whereas light colors reflect most of the energy from the sun. Light that is absorbed is changed to heat or thermal energy.

Materials:

Per group:

- ☐ 2 plastic cups—10 oz
- ☐ black construction paper
- ☐ white construction paper
- ☐ 2 thermometers (if possible, use Vernier Go!temps and LabQuest)
- ☐ clock
- ☐ scissors
- ☐ tape
- ☐ pitcher of room temperature water
- ☐ Student handout

Vocabulary:

absorb
hypothesis
variable
control

(See glossary for kid-friendly definitions)

Resources:

See Appendix B for Student Resources: Kid-friendly Glossary; How does color affect temperature student handout

Procedures:

1. Ask class whether they think colors affect temperature. If possible, go on a mini-field trip to the parking lot. Have students touch a light-colored car and a dark-colored car. Which is warmer? Why? Return to classroom.
2. Hand out cups, paper, scissors and tape.
3. Have students cut and wrap the black construction paper around one cup. Then cut and wrap the white construction paper around the second cup.
4. Pour the same amount of room temperature water into each cup.
5. Explain the term *hypothesis*. Ask the students what they believe will happen to the temperature in each cup, if the cups are put in the sun. Students should write their hypothesis on their student handout.
6. Explain the terms *variable* and *control*. Have the students write in their science notebooks what we are controlling in this investigation and what is the variable,
7. Using the handout provided in Student resources, record the temperature of the water before placing it in the sun.
8. Put the cups in the sun for 30 minutes. Record the temperature.
9. Wait 30 minutes and record the temperature again.
10. Discuss: What was the difference in temperature of the 2 cups after 30 minutes? 60 minutes? Why was there a difference? What conclusions can you make about dark/light colors? What do you think would happen if you put plastic wrap over the top?
11. During the wait time, you might want your students to read and discuss articles about the greenhouse effect that would help them with answering the last question.
12. Discuss results and write conclusions.

Differentiation:

Supports

- Students could describe by using pictures.
- Students can work with group to read articles.
- Sentence scaffolding included on student handout.
- Vocabulary cards: absorb, hypothesis, variable, control.

Extensions

- Search and share informational websites on the greenhouse effect

Assessment Opportunities:

Teachers can use student descriptions and observations written on student handout to assess student knowledge.

Citations:

lesson adapted from:

AIMS: Energy Explorations: Sound, Light, and Heat

Heat and Color, p 213

definitions from:

dictionary.com

Greenhouse effect articles:

http://climatekids.nasa.gov/greenhouse-effect/
http://www.clean-air-kids.org.uk/globalwarming.html
http://www.eschooltoday.com/climate-change/how-the-greenhouse-effect-happens.html

How Do You Effectively Use a Protractor to Measure an Angle? – Lesson 4a

Grade Level: 4th Grade	**Time Needed:** 30 minutes	**Subjects:** math

Objective/ Learning Target: Students will investigate the effective use of a protractor.

Standards:

4.MD.6 Measure angles in whole number degrees using a protractor.

Background Information:

Angle: union of two different rays sharing a common vertex.

Acute angle: angle with a measure of less than 90 degrees.

Obtuse angle: angle with a measure greater than 90 degrees but less than 180 degrees.

Perpendicular: two lines are perpendicular if they intersect, and any of the angles formed between the lines is a 90° angle.

Protractor: instrument used in measuring or sketching angles.

Vertex: a point, often used to refer to the point where two lines meet, such as in an angle or the corner of a triangle.

Supplementary angles: two angles with a sum of 180 degrees.

Straight angle: angle that measures 180 degrees.

Materials:

- ☐ student handout (class set)
- ☐ protractors (class set)
- ☐ pencils
- ☐ document camera or overhead

Vocabulary:

acute angle
obtuse angle
supplementary angles
vertex
perpendicular
right angle
protractor
angle
straight angle

Resources:

See Appendix B for Student Resources: Kid-friendly Glossary

Procedures:

1. Review angle terminology students learned in 3rd grade: angle, acute, obtuse, right, and straight angles.
2. Hand out protractors. Go over the parts of the protractor.
3. Demonstrate use of the protractor.
4. Use materials on angle measurement from your curriculum materials, *Engage NY* or *Bridges* curriculum
5. Give exit ticket from your materials as final assessment.

Differentiation:

Supports

- Vocabulary cards: angle, acute angle, obtuse angle, right angle, straight angle.

Extensions

- Provide students with angles worksheets where they measure and draw the angles.
- Have students measure objects around the room that have angles.

Assessment Opportunities:

Teachers can use exit ticket to assess student knowledge.

Citations:

How Does the Angle of the Sun Affect Energy Transfer of Heat? – Lesson 4b

Grade Level: 4th Grade	**Time Needed:** 50 minutes	**Subjects:** science, math

Objective/ Learning Target: Students will investigate how the angle of the sun affects temperature.

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4.MD.6 Measure angles in whole number degrees using a protractor

Background Information: If you hold a flashlight at a right angle to a surface, you get a uniform, bright circle. Now, tilt the flashlight to a 45° angle and that same beam of light gets spread over a larger area. The beam of light is both larger and less intense. The same happens at the equator and the polar regions. The equator gets sunlight at a direct right angle, so all the solar energy gets concentrated in this area. But because the earth is round, the polar regions receive the sun's rays as if they were the tilted light, so the same solar energy is spread over a larger area and the result is a lower temperature. Just think: if Earth were flat, the polar regions would be just as warm as the tropics, because they would receive the same intensity of solar energy!

Earth's Tilt Causes the Seasons

The angle of the sun's rays not only creates temperature differences across Earth, but it's also responsible for the seasons in temperate regions. Remember how I said most people think the Earth is farthest from the sun during winter months? The Earth is actually closer to the sun when the Northern Hemisphere is experiencing winter but is just tilted away from the sun! This means that in the Northern Hemisphere, the sun's rays act more like the tilted flashlight during the winter and more like the right angle flashlight during the summer. The opposite is true for the Southern Hemisphere, which is why they have their summer during our winter and their winter during our summer.

Materials:

- ☐ mirrors (1-2 per group)
- ☐ thermometer (1 per group)
- ☐ protractor (1 per group)
- ☐ Archimedes story of the Death Ray: Science of Destruction: Archimedes' War Machines

http://www.discovery.com/tv-shows/mythbusters/videos/death-ray-minimyth/

Vocabulary:

reflection
refraction

Resources:

See Appendix A for Teacher Resources: Archimedes Story of the Death Ray—Science of Destruction: Archimedes' War Machines
See Appendix B for Student Resources: Student Handout

Procedures:

1. Ask: Does the angle of the sun affect temperature? Discuss.
2. Ask: Has anyone heard of Archimedes? Tell the story: Science of Destruction: Archimedes' War Machines
3. Show the Discovery Video on Mythbusters: Death Ray mini-myth. Discuss
4. Time to explore. Ask groups to achieve the highest temperature reading using one to two mirrors and a thermometer. Students are to measure the angles created by the mirror to the ground and record the angle and the temperature.
5. Discuss how the highest temperature was achieved. What was the measure of the angle(s)?

Differentiation:

Supports

- Students work as a group to investigate.

Extensions

- Have students read about the MIT investigation in 2009 : http://web.mit.edu/2.009/www/experiments/deathray/10_ArchimedesResult.html
- Compare with the Mythbusters investigation.

Assessment Opportunities:

Teachers can use student handouts to access student knowledge.

Citations:

Mythbusters: Death Ray episode
http://www.discovery.com/tv-shows/mythbusters/videos/death-ray-minimyth/
MIT 2009 investigation
http://www.discovery.com/tv-shows/mythbusters/videos/death-ray-minimyth/
How Stuff Works: Archimedes
history.howstuffworks.com/historical-figures/archimedes-death-ray.htm
definitions:
physics4kids.com: Light&Optics

Does Location Matter? – Lesson 5

Grade Level: 4th Grade	**Time Needed:** 50 minutes	**Subjects:** science, technology, math

Objective/ Learning Target: Students will write a hypothesis, comparison chart, and analysis paragraph regarding the best location around the school grounds to capture the most solar energy.

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Use technology as a tool to access, research, manage, integrate, and communicate ideas and information.

4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l, m; hr, min, sec

Background Information:

Different surfaces around the school can absorb or reflect thermal energy. For example, darker surfaces, such as asphalt, will absorb more energy and will be hotter.

Materials:

per group:

- ☐ thermometers

(if possible, use Vernier Go!temps and LabQuest)
Student Handout: Compare and Contrast Chart, Hypothesis and data table handout if not using a science notebook.

Vocabulary:

comparison
similar
difference
analysis

Resources:

See Appendix A for Teacher Resources: Comparison Paragraphs for Analysis of Data
See Appendix B for Student Resources: Comparison Chart; Does Location Matter?

Procedures:

1. Ask students if they think location matters if they want to achieve the highest temperature. What factors would make one location better than another?
2. Have students write a hypothesis about their thinking. I think _____ would be the best location because _____.
3. Hand out thermometers (3 for each group) and student handouts. Direct students to chose 3 different locations to test.
4. Discuss results and fill in the comparison chart.
5. Students write their analysis using the paragraph frame.

Supports

- Students use the paragraph frame for writing their analysis using only two locations.

Extensions

- Students can write their analysis without the paragraph frame.

Assessment Opportunities:

Teachers can use the analysis paragraphs to assess student knowledge.

Citations:

Writing in Science: How to Scaffold Instruction to Support Learning

Betsy Rupp Fulwiler, Heinemann

What Is the Most Effective Way to Prevent an Ice Cube from Melting? – Lesson 6

Grade Level: 4th Grade	**Time Needed:** 50 minutes	**Subjects:** science, technology, math

Objective/ Learning Target: Students will learn about insulators and which materials will make effective insulators.

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l, m; hr, min, sec.

Background Information:

When water temperature reaches 32 degrees, it is at its freezing point. Water changes from a liquid to a solid (ice). To keep ice a solid, air temperature needs to remain at 32 degrees or lower. Heat energy moves from areas of warm to cold. If warm air (containing faster moving molecules) comes in contact with slowing moving molecules (in the ice), energy will be transferred from the air to the ice. When the water molecules begin to move faster, the ice melts. Some materials don't transfer this energy well. These are called insulators.

Per student pairs:

- ☐ 2 pint-size milk cartons, rinsed, with both top flaps opened
- ☐ materials for insulating the ice (straw, hay, grass, cotton cloth, sawdust or cedar shavings, dirt, sand, dried beans)
- ☐ 2 ice cubes
- ☐ graduated cylinder
- ☐ masking tape

Vocabulary:

insulator

Resources:

See Appendix B for Student Resources: Keeping it Cool Chart

Procedures:

1. Ask students if they know how people kept food cold before we had electricity.
2. Tell students that ice was used. This ice was cut from lakes and ponds and kept year round in ice houses or caves. Ice was also transported to warmer climates. How do you think they kept the ice from melting while it was being transported?
3. Show students the materials that could be used for insulators. Have students hypothesize which material would be the most effective insulator.
4. Hand out milk cartons, graduated cylinders, and offer students the chance to choose which materials they want to test.
5. Instruct students to write their names on the outside of the milk cartons. Give each student pair two ice cubes. Have them pack one ice cube with insulating material of their choice inside the carton. Write on this carton, "insulated." The other milk carton is their control and will just have one ice cube in it. Label this carton, "control." Direct the students to close up the milk cartons with the masking tape.
6. Place the cartons in direct sunlight (inside or outside).
7. Every two hours, have students open the cartons, pour out the water, measure it, and record.
8. Compare the amount of water collected from the insulated carton and the control carton.
9. Discuss and compare outcomes of the different materials used.
10. Questions: How long did it take for the ice cube to melt away? Which materials were most effective? Were any ice cubes still frozen at the end of the day? Which materials were the least effective?

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<u>Supports</u>

- Students work as group to measure and record.

<u>Extensions</u>

- Students can think of other materials that may be effective.

Assessment Opportunities:

Teachers can use the student handout to assess student knowledge.

Citations:

Adapted from: "Cold Cash in the Icebox," *Project Wet*

Putting It All Together: Engineering Design Problem – Lesson 7

Grade Level: 4th Grade	**Time Needed:** 150 minutes	**Subjects:** science, technology, engineering, math

Objective/ Learning Target: Students will be presented with an engineering design problem that will require them to use information gained in this unit to design a solar oven.

Standards:

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Use technology as a tool to access, research, manage, integrate, and communicate ideas and information.

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, and cost.

3-5-ETS1-2 Generate and compare multiple solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l, m; hr, min, sec

Background Information:

See Appendix A: Teacher Resources for a picture of a pizza box solar oven.

Materials:

Per student groups:

- ☐ pizza box
- ☐ scissors
- ☐ aluminum foil
- ☐ insulator materials
- ☐ black construction paper
- ☐ protractor

Vocabulary:

criteria
constraint

- ☐ thermometer (Vernier Go!Temp, LabQuest)
- ☐ hot dogs, buns, ketchup/mustard
- ☐ clear plastic wrap
- ☐ duct, masking, or scotch tape
- ☐ tablets or camera

Resources:

See Appendix A for Teacher Resources: Solar Oven Picture

See Appendix B for Student Resources: Solar Oven Engineering Design Work Sample

Procedures:

1. Review lessons taught and knowledge gained with students. Review vocabulary.
2. Tell students they are going to be presented with an engineering design problem that they will need to use their experiences in this unit to solve.
3. Present the problem: You are on a hiking trip in August, in the Wallowa Mountains. You had planned to cook your hot dogs. You received a message that due to extreme fire danger, campfires or any open flame are not allowed in wilderness areas. Lucky you, you ate take-out pizza the first night of your hike and have the box in your backpack. Using only the materials available, design and build a solar oven that will cook a hot dog to 160 degrees Fahrenheit.
4. Have students form groups and fill out the top portion of the work sample sheet; team members and problem to be addressed.
5. Discuss and list the criteria and constraints together while students write it on their sheet.
6. Students then will write what they know, using the knowledge they gained throughout the unit.
7. Students will draw and label individually, their first design idea. Then groups will meet and come up with a collaborative design and evaluation.
8. Students then gather their materials and build their prototype, documenting the process by taking pictures.
9. When ready, take students outside to test their ovens. Redesign and retest as needed, making sure to document time and temperature.
10. Take a picture of each final design to put on the work sample.
11. Students will need to label their final design and analyze their results.

<u>Supports</u>

- Students work as group to complete this design problem.

<u>Extensions</u>

- Students make a commercial for their solar oven.

Assessment Opportunities:

Teachers can use the engineering design template to score student work.

Citations:

Pizza box solar oven picture from:
https://ostprojects.files.wordpress.com/2012/11/pizzaboxoven.jpg