Implementation of the Next Generation Science and Engineering Practices

A Unit of Study Designed for Eighth-Grade Students in Minnesota

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A capstone project submitted in partial fulfillment of the requirements for the degree of Masters of Education in Natural Sciences and Environmental Education

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Summary

This capstone project was designed for an eighth grade classroom and aligns to the 2019 Minnesota Science Standards. A focus on these lessons includes opportunities for students to practice the Next Generation Science Standards (NGSS) Science and Engineering Practices (SEPs). This curricular unit includes nine lessons around the core science idea of thermal energy transfer. The capstone project aims to help answer the focus question: *how can teachers best implement the Next Generation Science and Engineering Practices to facilitate engaging and effective science instruction in an 8th grade classroom?*

This capstone project will begin with a unit storyline. The idea of the unit storyline is often used with NGSS instruction and it describes the unit plan in a narrative tone. I included a storyline in my project in an effort to align with the style of NGSS instruction, and also because it helps to better understand where this unit starts and the direction it is headed (Next Generation Science Standards, 2022).

The lesson plans in this curricular unit were organized in a modification of the 5E lesson plan template. This style breaks a lesson down into five sections. The sections include: engage, explore, explain, elaborate, and evaluate. In the engage section students are being introduced to the topic. In the explore section, students are exploring the topic on their own. The elaborate section often involves a time of full class discussion to better understand the topic. The elaborate section allows students to further deepen their understanding. Finally, the evaluate section explains how the teacher will be evaluating student understanding (Smith, 2017).

Finally, all of the templates and much of the style of instruction are original and based on what I learned throughout the research portion of this capstone. However, the overarching

activities conducted throughout this unit plan were inspired by a curriculum published by OpenSciEd. Specifically, it is OpenSciEd's Unit 6.2 titled, *How can containers keep things from heating up and cooling down?* (OpenSciEd, 2021).

Unit Overview

Course & Grade Level:	**Grade 8 Physical Science**

Minnesota Science Content Standards:

1.2.1 Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena.

- 8P.1.2.1.1 Plan and conduct an investigation of changes in pure substances when thermal energy is added or removed and relate those changes to particle motion.
- 8P.1.2.1.4 Plan and conduct an investigation to determine how the temperature of a substance is affected by the transfer of energy, the amount of mass, and the type of matter.

3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to design solutions that meet established criteria and constraints.

- 8P.3.2.2.3 Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Essential Understandings:

Science Understandings
Students will understand that:

- When a pure substance is warmer the particles are moving faster.
- When a pure substance is cooler the particles are moving slower.
- When a substance transfers energy the temperature and speed of that substance decreases.
- When a substance gains energy the temperature and speed of the particles increases.
- The more mass a substance has the longer time it takes to change temperature.
- Different types of matter will take longer amounts of time to change temperature.

Science & Engineering Practices Understandings
Students will be able to:

- Ask questions about a scientific phenomenon
- Design an investigation
- Collect and organize data.
- Write a claim based on evidence.
- Design a device to either minimize or maximize thermal energy transfer.
- Test a device to either minimize or maximize thermal energy transfer.

Key Formative Assessment

Learning Objective and Type of Assessment (conceptual knowledge, science practices knowledge, engineering practices knowledge)	Description of Task
Thermal energy transfer particle level model	Students will start this task in lesson two with their initial understandings of what thermal energy transfer looks like at the particle level. At the end of lesson four they should have a good understanding of what is going on and will turn in a finalized version of this model.
Scientific Claims	At the end of investigations students will be completing claims to state what they learned about the focus question. The teacher should grade these claims to ensure student understanding of the scientific concepts. This will be at the end of lesson 3, 5 and 6.
Investigation Templates	Students will use the same template to guide them through investigations in many of the lessons in this unit. The teacher may choose to formatively grade any or all of these templates to assess student understanding of the Science and Engineering Practices.
Engineering Templates	For the final lesson, students will be using the engineering template. The teacher may choose to formatively grade this template to assess student understanding of the engineering

	practices.

Summative Assessment

Learning Objective and Type of Assessment (conceptual knowledge, science practices knowledge, engineering practices knowledge)	Description of Task
Solar Cooker Rational Form	This is where students will share what they learned throughout the unit and how they rationalized it in their solar cooker design.

Unit Storyline

This unit begins with the first lesson, when students are asked to think about common to-go cups. These can be disposable cups or reusable cups they may see their teachers drinking coffee from at school! Students will be shown a variety of cups designed to insulate hot and cold liquids, then they will be asked to take a guess at which cup will be best at retaining heat energy. Afterwards, as an entire class group, the students will come up with a procedure to test each of the to-go cups and see how well they insulate hot water. The teacher will guide students through this process. At the end of lesson one students' should have determined what three cup designs are best at keeping a hot liquid warm, and they will have come up with a list of questions related to the design features and the science of keeping the liquid warm.

In the next lesson, students will use an online simulation to determine what motion at the particle level looks like for solids, liquids, and gasses. They will use this information to then make an initial model of what particle motion looks like for hot water compared to cool water.

In the third lesson, after they have thought about how particles move faster the warmer a

substance is, they will start to think about what is happening when two substances interact. They will then try this out with their cups, by creating an environment where they nestle a cup of liquid in a bath of water with a different temperature. From this they should be able to see how the temperature of both fluids changes (the hot transferring energy to the cold). As a result they should be able to update their model to show how the warm water is interacting with the cooler environment around it. After completing the investigation of the ways two different substances interact they will use an online simulation in the fourth lesson to see what is happening at the particle level when substances of different temperatures are interacting.

In lesson five, students will start to think about other factors that are related to temperature. First they will conduct investigations to learn how the amount of mass in a substance affects its temperature. Ultimately they should learn that the more mass the longer it will take for the substance to heat up or cool down. In the next lesson the students will learn about how different types of matter change temperature at different rates. In this portion of the lesson student groups will conduct investigations on different types of matter.

Finally, students will begin to look at cup design features that work to insulate the cup well. As a class, the students will try out various cup features and determine which three are best for insulating hot liquid. In the next lesson students will investigate how the surface material of a cup allows heat energy to transfer into the cup. These lessons are designed to help prepare them for lesson nine, where they will be designing their own solar cooker. The final lesson will take at least five days to complete, and will end with students trying to cook an egg in their hand designed solar cooker. Before the final test students will think critically about their design and go through the entire engineering process before coming up with their final design. The unit ends

with students writing rationales for their design and the rationales should be summatively graded.

Teacher Lesson Plans & Supporting Documents

Lesson Number	1
Standards	8P.1.2.1.1 I can plan and conduct an investigation of changes in pure substances when thermal energy is added or removed and relate those changes to particle motion.
Objectives	I can question how liquids remain warm in to-go cups.
Essential Question	What cup design is best at retaining (holding on to) heat?
Timing	90 Minutes (two 45 minute periods)

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Introduce students to the new unit topic, "Thermal Energy Transfer." 2. Show students all of the different to-go cups, and ask them, ***"Which cup do you think will be best at holding onto heat the longest?"***	- 16 different thermal cups (to go cups, restaurant to go cups, styrofoam cups, etc) If you can't find 16 then get 8 double sets
EXPLORE	1. Pass out the *NGSS Quick Investigation Template* (this is a shortened version of a template used later in the unit). The teacher should model how to use the template with the whole class in lesson one for eased use in later lessons. 2. Instruct all students to fill in the question, ***"What cup design is best at retaining (holding on to) heat?"*** as the focus question. 3. Instruct all students to make a hypothesis based on what cup they think is best at retaining heat. They should write down	- Heat lamps (16) - Thermometers (16+) - Hot Water - 16 thermal cups (used above) - *NGSS Quick Investigation Template*

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their hypothesis in the procedure section.
4. As a whole class, come up with a common design and procedure* for students to follow that will allow them to test how well the to-go cups store heat. All students should write down the information in the procedure section.
a. The investigation might involve students taking an initial temperature of hot water in their cup, waiting a set amount of time, and then taking the temperature again and repeating until a set time.
5. As a whole class, create a data table to record information from the investigation. An example data table might look like this:
<table>
<tr><td>Time</td><td>Temperature</td></tr>
<tr><td>0 min</td><td></td></tr>
<tr><td>2 min</td><td></td></tr>
<tr><td>4 min</td><td></td></tr>
</table>
6. Break students in groups of two. Assign each group a cup, and then allow them to follow the procedure and record the data.

*A copy of the class procedure from this lesson should be saved, it will be used again in another lesson.
</td>
<td></td>
</tr>
<tr>
<td>EXPLAIN</td>
<td>
1. Provide a space for whole class data, where students can share how much heat their liquid lost in the allotted time.
2. Instruct students to add the whole group data to the Class Data section of their worksheet.
3. As a group, analyze and interpret the class data** to see which 3 cups best insulated the water.
4. Pass the cups around so students can analyze the structure of the cups.
5. Facilitate the whole class discussion about
</td>
<td>- Common sharing space (white board)</td>
</tr>
</table>

	what cup features seemed to work best at insulating the cup. **This class data should be saved, it will be used again in another lesson.	
EVALUATE	1. Prompt students to make a list of all the things they noticed about the cups that retain heat best. They will make the list on scratch paper. 2. Prompt students to make a list of questions they have related to the cup **design** AND the **science** of what is happening inside the cup. 3. Facilitate a chance for students to share questions from their list and add them to the *Driving Questions Board* (DQB). Students should write the questions on post-it's or small scraps of paper that can be adhered to the DQB.	- *Driving Questions Board* (DQB). This is a designated area of the room where the class will work together to come up with a list of questions that will be used to pace the entire unit.

Lesson Number	2
Standards	8P.1.2.1.1 I can plan and conduct an investigation of changes in pure substances when thermal energy is added or removed and relate those changes to particle motion.
Objectives	I can model what particle motion looks like in hot and cool substances.
Focus Question	What happens to particles in water when it changes temperature?
Total time:	45 minutes

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Remind students of the previous lesson by asking students to summarize what they	- DQB - Scratch paper or

	learned about the to-go cups. Tell students that today they will be trying to learn what is happening to the small water particles inside the cup. 2. Present students with a question from the DQB that is similar to, ***"What happens to particles in water when it changes temperature?"*** Be sure to emphasize the question on the DQB so that students can tell this unit is being driven by their questions. 3. Instruct students to talk with a small group about this question. After they have discussed they should make a 2D model on a piece of scratch paper or a whiteboard slate to represent their initial thoughts.	individual whiteboard slate
EXPLORE	1. Instruct students to explore a *PHET* simulation to see what is happening at the particle level when a substance gains or loses heat energy. You might ask the following questions: a. What happens to the molecules when you add heat? b. What happens to the molecules when you remove heat? c. In what stages do you think the substances are a solid, liquid or gas? d. How do you think particle motion between hot water and cold water compares?	- Computer - *PHET* simulator: **https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html**
EXPLAIN	1. Initiate full class discussion on what is happening in the PHET simulation. Be sure to discuss: - How particle motion differs between solids, liquids and gasses. - How particle motion differs between substances in the same state (such as a liquid), but at different temperatures.	
ELABORATE	1. Pass out the *NGSS 2D Modeling Template**	- Pencil

	2. Instruct students to make a 2D visual model of what the particles look like in hot water and also what particles look like in cool water. *Students will continue to add to their model as the unit goes on. At this stage the model should be similar to two cups with the same liquid in them. However the hot liquid should show the particles moving quickly and the cool liquid should show the particles moving slowly.	- *NGSS 2D Modeling Template*
EVALUATE	1. Instruct students to show you their model when they finish. Ensure the student has an accurate understanding of the particle motion concepts, and then sign off on the *Teacher Checkpoint 1* on the modeling worksheet.	

Lesson Number	3
Standards	8P.1.2.1.4 I can plan and conduct an investigation to determine how the temperature of a substance is affected by the transfer of energy, the amount of mass, and the type of matter.
Objectives	I understand how the transfer of energy affects the temperature of a substance.
Focus Question	How is the temperature of the water in the cup affected by the temperature on the other side of the cup?
Timing	90 Minutes (two 45 minute class periods)

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Instruct students to take out their particle level model of the liquid in the to-go cup. 2. Ask the question, “Using your model as	

	evidence, would you say that cold is leaving the hot water in the cup or that heat is entering the hot water in the cup?	
EXPLORE	1. Hand out the *NGSS Investigation Template.* 2. Instruct students to fill in the following question in the focus question area of the box, ***"How is the temperature of the liquid in a cup affected by the temperature on the other side of the cup?"*** 3. Instruct students to fill out the questions, hypothesis, predict, procedure*, design and data collection sections on the NGSS Investigation Template. 4. When students have finished up to the data collection section check over their procedure and make sure they have a data table for collection. If they do, initial the teacher checkpoint and instruct them to gather supplies and begin the experiment. *Encourage students to set up an investigation using a water bath in which two containers of different temperature fluids interact with each other. Notice the way the energy flows.	- *NGSS Investigation Template* - To-go cups - heat lamps (16) - thermometers (32) - beakers - water - hot water - ice cubes (supplies may vary based on individual groups investigations)
EXPLAIN	1. Create a place in the room for students to share a summary of their data (white board). 2. Allow students to copy down classmates' results.	- Whiteboard or something similar
ELABORATE	1. Instruct students to answer the Analyze & Interpret the Data section on their NGSS Investigation Template. 2. Create a place in the room for students to share a summary of their data (white board) 3. Allow students to copy down classmates' results. 4. Instruct students to answer the Analyze & Interpret the Class Data section on their NGSS Investigation Template. 5. Initiate whole class discussion about the way heat is transferred. The following	

	topics should be discussed: - Substances in contact with each other always want to balance out and be the same temperature. - Heat is transferred from hot to cold. - Particle motion in warm fluids is faster, that motion is transferred to the cooler fluid as energy.	
EVALUATE	- Hand out the *NGSS Investigation Claim Template* to students. - Instruct students to write a claim that answers the focus question, "How is the temperature of the water in the cup affected by the temperature on the other side of the cup?" *The teacher may choose to formatively grade claims based on the *NGSS Investigation Claim Rubric* OR the teacher may wish to have students evaluate each other's claims. *The teacher may choose to formatively grade the investigation as well.	- *NGSS Investigation Claim Template* - *NGSS Investigation Claim Rubric*

Lesson Number	4
Standards	8P.1.2.1.1 I can plan and conduct an investigation of changes in pure substances when thermal energy is added or removed and relate those changes to particle motion.
Objectives	I understand what happens to substances at the particle level when energy is transferred from one to another.
Focus Question	What is happening at the particle level when hot water loses thermal energy to the environment?
Timing	45 Minutes

Lesson Sequence & Timing	Activities	Materials, Resources, Technology

		(32 students)
ENGAGE	1. Instruct students to play around with the OpenSciEd simulation. Ask them the following questions from the DQB: a. What happens to the speed of the particles when the temperature increases? b. What things seem to happen to increase the speed of a single particle?	- https://htmlsimulations.s3-us-west-1.amazonaws.com/OpenSciEd+Gas+Particle+Motion+and+Temperature.html
EXPLORE	1. Hand out the, *What is happening at the particle level when hot water loses thermal energy to the environment?* worksheet. Instruct students to work in pairs 2. Instruct students to follow the direction on the note sheet to see how particles transfer heat energy at the particle level.	- 16 rimmed pan/cooking sheet - 250 marbles - Computer Access to the OpenSciEd simulator: https://htmlsimulations.s3-us-west-1.amazonaws.com/OpensSciEd+Conduction+in+Solids+Reduced.html
EXPLAIN	1. Go through the worksheet with students and discuss their answers. 2. Be sure to discuss the following concepts: - Particles spread thermal energy when they collide with other particles. - When particles collide the particle that is moving fastest (has the most thermal energy) gives away energy to the slower particle. So the giving particle slows down and the receiving particle speeds up. - Any solids, liquids or gasses that are touching are able to transfer	

	energy to one another.	
ELABORATE	1. Instruct students to make edits to their model to reflect what is happening to the temperature of the cup and the environment around the cup. Encourage students to "zoom in" to show what happens at the particle level as the temperature of the water in the cup cools off.	- Student models from lesson 2
EVALUATE	1. Instruct students to show you their model when they finish. Ensure the student has an accurate understanding of the heat transfer concepts, and then sign off on the *Teacher Checkpoint 2* on the modeling worksheet.	

Lesson Number	5
Standards	8P.1.2.1.4 I can plan and conduct an investigation to determine how the temperature of a substance is affected by the transfer of energy, the amount of mass, and the type of matter.
Objectives	I understand how the amount of mass affects thermal energy transfer.
Focus Question	Does the amount of liquid in a cup affect thermal energy transfer?
Timing	90 Minutes (Two 45 minute class periods)

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Emphasize a question from the DQB that is similar to the following: *Does the amount, or mass, of the liquid in the cup effect how fast or slow the liquid cools down?* 2. Allow students to discuss the question in their groups.	

EXPLORE	1. Hand out the *NGSS Investigation Template.* 2. Instruct students to fill in the following question in the focus question area of the box, ***"Does the amount of liquid in a cup affect thermal energy transfer?"*** 3. Instruct students to fill out the questions, hypothesis, predict, procedure, design and data collection sections on the NGSS Investigation Template. 4. When students have finished up to the data collection section check over their procedure and make sure they have a data table for collection. If they do, initial the teacher checkpoint and instruct them to gather supplies and begin the experiment.	- *NGSS Investigation Template* - heat lamps (16) - thermometers (32) - beakers of all sizes - water - hot water - ice cubes (supplies may vary based on individual groups investigations)
EXPLAIN	1. Create a place in the room for students to share a summary of their data (white board). 2. Allow students to copy down classmates' results.	- White board or something similar
ELABORATE	1. Instruct students to answer the *Analyze & Interpret the Data* section on their NGSS Investigation Template. 2. Create a place in the room for students to share a summary of their data (white board) 3. Allow students to copy down classmates' results. 4. Instruct students to answer the *Analyze & Interpret the Class Data* section on their NGSS Investigation Template. 5. Initiate whole class discussion about the results of the investigations. These topics should be covered in the debrief: - The more mass a substance has the longer it will take to change temperature.	
EVALUATE	1. Hand out the *NGSS Investigation Claim Template* to students. 2. Instruct students to write a claim that answers the focus question, "Does the amount of liquid in a cup affect the	- *NGSS Investigation Claim Template* - *NGSS Investigation Claim Rubric*

	temperature?" *The teacher may choose to formatively grade claims based on the *NGSS Investigation Claim Rubric* OR the teacher may wish to have students evaluate each other's claims.	

Lesson Number	6
Standards	8P.1.2.1.4 I can plan and conduct an investigation to determine how the temperature of a substance is affected by the transfer of energy, the amount of mass, and the type of matter.
Objectives	I understand how the type of matter affects the temperature of a substance.
Focus Question	Do different types of matter heat up differently?
Timing	90 Minutes (Two 45 minute class periods)

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Choose a question off the DQB that is similar to, *Do different types of matter heat up differently?* 2. Allow students to talk about the question in their groups.	
EXPLORE	1. Hand out the *NGSS Investigation Template.* 2. Instruct students to design an investigation that answers the focus question, ***Do different types of matter heat up differently?*** 3. Instruct students to fill out the *questions, hypothesis, predict, procedure, design and data collection* sections on the NGSS Investigation Template.	- *NGSS Investigation Template* - heat lamps (16) - thermometers (32) - beakers of all sizes - water

	4. When students have finished up to the data collection section check over their procedure and make sure they have a data table for collection. If they do, initial the teacher checkpoint and instruct them to gather supplies and begin the experiment.	- Tea, coffee, various liquids - Soil, play dough, various solids - hot water - ice cubes (supplies may vary based on individual groups investigations)
EXPLAIN	1. Instruct students to answer the *Analyze & Interpret the Data* section on their NGSS Investigation Template. 2. Create a place in the room for students to share a summary of their data (white board) 3. Allow students to copy down classmates' results. 4. Instruct students to answer the *Analyze & Interpret the Class Data* section on their NGSS Investigation Template.	
ELABORATE	1. Instruct students to answer the *Analyze & Interpret the Data* section on their NGSS Investigation Template. 2. Create a place in the room for students to share a summary of their data (white board) 3. Allow students to copy down classmates' results. 4. Instruct students to answer the *Analyze & Interpret the Class Data* section on their NGSS Investigation Template. 5. Initiate whole class discussion about the results of the investigations. These topics should be covered in the debrief: - Different types of matter change temperature in different ways. - For example, soil heats up very quickly whereas water takes a longer time, but holds on to heat energy for longer periods of time.	
EVALUATE	3. Hand out the *NGSS Investigation Claim*	- *NGSS Investigation*

	Template to students. 4. Instruct students to write a claim that answers the focus question, "*Do different types of matter heat up differently?"* *The teacher may choose to formatively grade claims based on the *NGSS Investigation Claim Rubric* OR the teacher may wish to have students evaluate each other's claims.	*Claim Template* - *NGSS Investigation Claim Rubric*

Lesson Number	7
Standards	8P.3.2.2.3 I can design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
Objectives	I can determine which to-go cup features are best for keeping a drink warm.
Focus Question	What cup features seem most important for keeping a drink warm?
Timing	45 minutes

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Remind students of lesson one, where they determined which to-go cups were best at retaining heat. Then ask students, ***"What cup features seem most important for keeping a drink warm?"*** let them discuss in groups. 2. Pass around the 3 to-go cups that did the best job at retaining heat. In their science notebooks, have students make a list of what these cups have in common. 3. Pass around the 3 to-go cups that did the worst job at storing heat. In their science notebooks, have students make a list of what these cups have in common.	- 3 cups from lesson one that best stored heat. - 3 cups from lesson one that lost the most heat.

<table>
<tr>
<td>EXPLORE</td>
<td>1. Break students into groups of 2.
2. Give each group one basic paper to-go cup.
3. Tell students that each group will be able to make one modification to their basic cup in an attempt to see if that modification makes it better at storing energy. As a group, students should decide what modification they want to make.
4. Students should modify their cup, then follow the same procedure from lesson one and see how well their cup retains heat energy.</td>
<td>- 16 basic paper to-go cups (whatever you can find)
- Lesson one procedure
- Heat lamps (16)
- Thermometers (16+)
- Hot Water</td>
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<tr>
<td>EXPLAIN</td>
<td>1. Allow students to each share their results in a shared place (white board)
2. Order the cups from best performing to worst performing.
3. As a class, analyze the data to determine which cup features seemed to best help the cup retain heat.</td>
<td>- White board</td>
</tr>
<tr>
<td>ELABORATE</td>
<td>1. As a class, make a list in students’ science notebooks that identifies which features seem to best insulate the cup.
2. As a class, make a list in students’ science notebooks that identifies which features seem to be least useful when insulating a cup.
3. Lists can be organized in a data table like this:
<table>
<tr><th>Good Insulating Design features</th><th>Poor Insulating Design features</th></tr>
<tr><td>1.</td><td>1.</td></tr>
<tr><td>2.</td><td>2.</td></tr>
<tr><td>3.</td><td>3.</td></tr>
</table>
</td>
<td>- Student science notebooks</td>
</tr>
<tr>
<td>EVALUATE</td>
<td>1. On the next page in the science notebook, have students draw out a cup design they think would be good at keeping a liquid warm.
2. Formatively check students' designs.</td>
<td>- Student science notebook</td>
</tr>
</table>

Lesson Number	8
Standards	8P.3.2.2.3 I can design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
Objectives	I can determine what materials are best allowing liquids to warm up.
Focus Question	How does a cup's surface affect how light warms up a liquid inside the cup?
Timing	45 Minutes

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Find a question on the DQB that might be similar to, *How does a cup's surface affect how light warms up a liquid inside the cup?* 2. Allow students to discuss the question with their groups.	
EXPLORE	1. Pass out a blank *NGSS Quick Investigation Template* 7. Instruct all students to fill in the question, ***How does a cup's surface affect how light warms up a liquid inside the cup?*** as the focus question. 8. Instruct all students to make a hypothesis based on what cup they think is best at retaining heat. They should write down their hypothesis in the procedure section. 9. As a whole class, come up with a common design and procedure for students to follow that will allow them to test how different cup surfaces affect water warming up in the cup. All students should write down the information in the procedure section. a. Procedure might involve groups of	- *NGSS Quick Investigation Template* - Water - Heat Lamps - Various cups with different surfaces - Construction paper - Tinfoil

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students testing out different cup surfaces and see how much the temperature changes when light is shined on the surface for a set amount of time.
10. As a whole class, create a data table to record information from the investigation. An example data table might look like this:
<table>
<tr><th>Design</th><th>Temp. 0 min</th><th>Temp. 2 min</th><th>Temp. 4 min</th><th>Temp. 6 Min</th></tr>
<tr><td>Clear</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Black Paper</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tinfoil</td><td></td><td></td><td></td><td></td></tr>
</table>
11. Break students in groups of two. Assign each group a different cup surface and then allow them to follow the procedure and record the data.
</td>
<td></td>
</tr>
<tr>
<td>EXPLAIN</td>
<td>
1. Provide a space for whole class data, where students can share how well their cup did at increasing heat energy.
2. Instruct students to add the whole group data to the Class Data section of their worksheet.
3. As a group, analyze and interpret the class data to see which design best allowed the liquid in the cup to heat up.
</td>
<td>- Whiteboard, or something similar, for data sharing</td>
</tr>
<tr>
<td>ELABORATE</td>
<td>1. Have students make edits to their insulated cup design from lesson 7. Their ideal cup should be good at gaining heat energy from light AND be good at insulating.</td>
<td>- Student cup designs from unit 7</td>
</tr>
<tr>
<td>EVALUATE</td>
<td>1. Check over students' designs and have them verbalize how their cup will be successful at gaining light energy and staying warm.</td>
<td>- Student cup designs from unit 7</td>
</tr>
</table>

Supporting Documents

Lesson Number	9
Standards	8P.3.2.2.3 I can design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
Objectives	I can design, build, and test a solar cooker.
Focus Question	How could we cook an egg without an oven, harnessing only the sun's energy?
Timing	Five 45 minute class periods

Lesson Sequence & Timing	Activities	Materials, Resources, Technology (32 students)
ENGAGE	1. Show the following YouTube video on solar cookers. 2. Encourage students to talk in small groups about how they might design their own solar cooker.	- https://www.youtube.com/watch?v=Ofn7jqPDTeY
EXPLORE, EXPLAIN & ELABORATE	1. Pass out the *NGSS Engineering Template*. 2. Instruct students to fill in the question, ***How could we cook an egg without an oven, harnessing only the sun's energy?*** for the focus problem. 3. Allow students to work in groups of 2 or 3 to come up with a solar cooker design. 4. Encourage students to use their notes from the lessons in this unit when creating their designs. 5. Students will work through Part 1 (design), Part 2 (test), Part 3 (improve) at their own pace. However, students should be sure to check in with the teacher when they reach the checkpoints in order to move on to the	- Cardboard - Plastic wrap - Water - Tinfoil - Tape - Glue - Thermometers - Heat lamps (supplies will vary dramatically depending on student solar cooker designs. It might be helpful to encourage students to bring in some of their own

	next part. 6. Teacher should provide students with deadlines for when the parts need to be done to help students stay on task.	supplies).
EVALUATE	1. Conduct a final test of student solar cookers. Use real eggs and see if they cook. Teacher may take students outside for the final test, or use heat lamps to represent the sun. 2. Pass out the *Solar Cooker Rational Form*, have students each fill out the rational worksheet. 3. Summatively grade student's rational using the *Solar Cooker Rational Rubric*.	- 16 eggs - *Solar Cooker Rational Form* - *Solar Cooker Rational Rubric*.

Resources

Next Generation Science Standards. (2022). Next Generation Science Standards. https://www.nextgenscience.org/

OpenSciEd. (n.d.). *Gas Particle Motion and Temperature*. Retrieved March 31, 2022, from https://htmlsimulations.s3.us-west-1.amazonaws.com/6.3-Lesson-1-Handout-Initial-Model.pdf

OpenSciEd. (n.d.). *Conduction in Solids Reduced*. Retrieved March 31, 2022, from https://htmlsimulations.s3.us-west-1.amazonaws.com/6.3-Lesson-1-Handout-Initial-Model.pdf

OpenSciEd. (2021). OpenSciEd. https://www.openscied.org/access-the-materials/

Smith, M. U. (2017). Teaching the Hardy-Weinberg Equilibrium: A 5E Lesson Plan. The American Biology Teacher, 79(4), 288–293.

Solar Cooking | National Geographic - Youtube. (n.d.). Retrieved March 31, 2022, from https://www.youtube.com/watch?v=Ofn7jqPDTeY

States of matter: Basics - Phet Interactive Simulations. (n.d.). Retrieved March 31, 2022, from https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html