Strand: 6.2.3

**Emphasis:** Energy flow

**Anticipated Time Required:**
- LE 1: 20-30 minutes
- LE 2: 45-60 minutes
- LE 3: 45 minutes
- LE4: 20 minutes
- LE 5: 40-60 minutes

**Dominant CCC:** Energy and matter

**Dominant SEP:** Planning and carrying out investigations, engaging in argument from evidence

**Management Strategies** to support equitable access to content:
- Explain-regroup-explain the explanation (students work with a group to construct an explanation; new groups are made, and students explain their explanations to their new group members)
- Group discussion with alternating leaders (students take turns leading their group in a discussion)
- Question stems for partner and small group discussions

**Shopping list:**

<table>
<thead>
<tr>
<th>LE</th>
<th>What</th>
<th>How many</th>
<th>Where to get it/$$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ice melting blocks (a wooden block and metal jar lid could also be used)</td>
<td>1 set</td>
<td>Ice melting blocks can be ordered for $17-25 from Educational Innovations, Amazon, Flinn Scientific, etc.; google “ice melting blocks”</td>
</tr>
<tr>
<td>2</td>
<td>1” steel spheres</td>
<td>1 per 3 students (10ish)</td>
<td>Can be ordered from Amazon: <a href="https://www.amazon.com/gp/product/B007B2AA0K/ref=oh_aui_detailpage_o00_s00?ie=UTF8&amp;psc=1">https://www.amazon.com/gp/product/B007B2AA0K/ref=oh_aui_detailpage_o00_s00?ie=UTF8&amp;psc=1</a></td>
</tr>
<tr>
<td>2</td>
<td>1” wooden spheres</td>
<td>1 per 3 students (10ish)</td>
<td>Can be bought at a craft store or ordered from Amazon: <a href="https://www.amazon.com/gp/product/B00R3F4K1U/ref=oh_aui_detailpage_o01_s00?ie=UTF8&amp;psc=1">https://www.amazon.com/gp/product/B00R3F4K1U/ref=oh_aui_detailpage_o01_s00?ie=UTF8&amp;psc=1</a></td>
</tr>
<tr>
<td>2</td>
<td>1” glass spheres</td>
<td>1 per 3 students (10ish)</td>
<td>Can be bought at toy store (large marbles) or ordered from Amazon: <a href="https://www.amazon.com/POPLAY-Marbles-1-inch-Whistle-Random/dp/B01C852ETE/ref=sr_1_1?ie=UTF8&amp;qid=1499964667&amp;sr=8-1-spons&amp;keywords=1+inch+marbles&amp;psc=1">https://www.amazon.com/POPLAY-Marbles-1-inch-Whistle-Random/dp/B01C852ETE/ref=sr_1_1?ie=UTF8&amp;qid=1499964667&amp;sr=8-1-spons&amp;keywords=1+inch+marbles&amp;psc=1</a></td>
</tr>
<tr>
<td>Quantity</td>
<td>Item Description</td>
<td>Required per Group</td>
<td>Purchase Options</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>Thermometers</td>
<td>1 per 3 students (10ish)</td>
<td>See LE 5 supply list for ordering ideas</td>
</tr>
<tr>
<td>2</td>
<td>Cups/containers that can hold 3 1&quot; spheres and hot water; can use plastic or styrofoam cups</td>
<td>1 per 3 students (10ish)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cups/containers that can hold hot water; can use disposable plastic cups; using cups that can conduct heat (not styrofoam) will reduce the amount of time students need to investigate</td>
<td>3ish per group of 3 students (30ish)</td>
<td></td>
</tr>
</tbody>
</table>
| 5        | Thermometers                                                                      | 1-3 per group; more thermometers will allow groups to collect more accurate data and complete the investigation faster | Nasco (10 for $8.50) [Link](https://www.enasco.com/product/TB19654J)  
Amazon (10 for $12.44-$16.52) [Link](https://www.amazon.com/Learning-Resources-LER0302-Student-Thermometers/dp/B0006PJ0L4/ref=sr_1_1?ie=UTF8&qid=1499994113&sr=1-1&keywords=student+thermometer)  
Carolina (5 for $15.50) [Link](http://www.carolina.com/lab-thermometers/immersion-thermometers-20-to-110-c-0-to-230-f-pack5/745512.pr) |
6.2.3 Heat Transfer and Engineering Storyline Overview

Anchor Phenomenon: Ice melts on a block that feels cold and doesn’t melt on a block that feels warm

Real-world examples of this could be brought in at some point; these could include:
- Snow that doesn’t melt on a bridge but does melt on the road leading to and from the bridge
- Oven mitts let you touch something without getting burned

Student Performance Expectation (please note that part students will continue investigating the relationship between heat transfer and type/amount of matter in storyline 6.2.4):

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.


<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Energy and matter</td>
<td>Planning and carrying out investigations, developing and using models</td>
</tr>
</tbody>
</table>

Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Ice melting blocks 1</td>
<td>Gather: Students are introduced to anchor phenomenon and record their observations about how the blocks feel and then what happens to the ice when placed on the blocks. Reason: Students create an initial model to show how the molecules in the ice are</td>
<td>Molecules in the ice cube that is melting are gaining thermal energy and their motion is increasing; molecules in the ice cube that is not melting are not gaining energy and their motion is largely unchanged</td>
<td>Why would the ice melt on the block that feels cold? Why aren’t both of the ice cubes melting at the same rate?</td>
<td>Formative: Student models, inferences, and participation in partner/class discussions should be used to check for understanding of concepts from 6.2.2</td>
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<td><strong>2: Conduction investigation</strong></td>
<td><strong>Gather</strong>: Students investigate the flow of heat energy in a system by measuring how the temperature of hot water changes after spheres of different materials are added to it. They also gather evidence from the resulting temperature of the spheres.</td>
<td><strong>Communicate</strong>: Students share and compare/contrast their models with each other.</td>
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</tr>
<tr>
<td><strong>CCC</strong>: systems, energy and matter</td>
<td><strong>Reason</strong>: Students work together to describe the flow of thermal energy in the system. In small groups, they use evidence from their investigation to construct a model to show the energy flow in the system.</td>
<td><strong>Communicate</strong>: Students explain their models to a partner, then participate in a class discussion about the energy and motion of the molecules in the water</td>
<td></td>
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<tr>
<td><strong>SEP</strong>: carrying out investigations, interpreting data, developing models</td>
<td>Thermal energy flowed through the system from the water to the spheres to the air; more energy flowed to some of the spheres than to others.</td>
<td>and identify misconceptions that will need to be addressed throughout the unit</td>
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<tr>
<td><strong>Formative assessment</strong>: Students’ ability to measure data and then interpret it to construct an explanation should be used as a formative assessment of these skills; their ability to communicate their understanding and answer other students’ questions about their models/explanations should also be used as formative assessments. Group models should be used to assess how well they understand the energy flow in the system and to identify misconceptions they may have.</td>
<td><strong>Why didn’t all the spheres heat up the same amount or cool down at the same rate?</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>CCC</strong>: energy, stability and change, systems</td>
<td><strong>Thermal energy always moves from the hotter substance to the colder substance.</strong></td>
<td><strong>Which block (from first lesson) is a conductor? Which is an insulator? Why does one block feel cold and one feel warm? How do you know?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SEP</strong>: developing</td>
<td><strong>Some substances absorb less thermal energy than others.</strong></td>
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<td></td>
<td></td>
<td><strong>Formative</strong>: Revisions of group models and student discussions should be used as formative assessments of their understanding of</td>
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<tr>
<td><strong>Reason:</strong> Students work together to revise the diagram they made during the last lesson. Their model should include information learned during the game regarding heat flow at the molecular level. <strong>Communicate:</strong> Students use evidence to construct and support an argument supporting a claim about energy flow in the system.</td>
<td><strong>Reason:</strong> Thermal energy moves from air through the conductor and into the ice, causing the ice to melt; thermal energy is blocked from the ice by the insulator, causing the ice to stay cold. <strong>Communicate:</strong> Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm).</td>
<td><strong>Reason:</strong> Students construct an explanation for why the blocks feel like they are different temperatures, even though they are not. <strong>Communicate:</strong> Students use evidence to construct and support an argument supporting a claim about energy flow in the system.</td>
<td><strong>Reason:</strong> Students work together to explain the results of their investigation by using evidence collected during the investigation to support a claim. <strong>Communicate:</strong> Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm).</td>
<td><strong>Reason:</strong> Students construct an explanation for why the blocks feel like they are different temperatures, even though they are not. <strong>Communicate:</strong> Students use evidence to construct and support an argument supporting a claim about energy flow in the system.</td>
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</tbody>
</table>

| **Gather:** Students use digital thermometer to learn that the blocks (from the first lesson) are actually the same temperature. | **Gather:** Students plan and carry out an investigation to determine how the amount of matter is related to energy transfer. **Reason:** Students work together to explain the results of their investigation by using evidence collected during the investigation to support a claim. **Communicate:** Students rewrite the porridge section of the Goldilocks story and include an explanation for why the | **Gather:** Students use digital thermometer to learn that the blocks (from the first lesson) are actually the same temperature. **Reason:** Students construct an explanation for why the blocks feel like they are different temperatures, even though they are not. **Communicate:** Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm). | **Gather:** Students plan and carry out an investigation to determine how the amount of matter is related to energy transfer. **Reason:** Students work together to explain the results of their investigation by using evidence collected during the investigation to support a claim. **Communicate:** Students rewrite the porridge section of the Goldilocks story and include an explanation for why the | **Gather:** Students use digital thermometer to learn that the blocks (from the first lesson) are actually the same temperature. **Reason:** Students construct an explanation for why the blocks feel like they are different temperatures, even though they are not. **Communicate:** Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm). | **Gather:** Students use digital thermometer to learn that the blocks (from the first lesson) are actually the same temperature. **Reason:** Students construct an explanation for why the blocks feel like they are different temperatures, even though they are not. **Communicate:** Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm). |

<p>| <strong>Communicate:</strong> Students use evidence to construct and support an argument supporting a claim about energy flow in the system. | <strong>Communicate:</strong> Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm). | <strong>Communicate:</strong> Students use evidence to construct and support an argument supporting a claim about energy flow in the system. | <strong>Communicate:</strong> Students rewrite the porridge section of the Goldilocks story and include an explanation for why the | <strong>Communicate:</strong> Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm). | <strong>Communicate:</strong> Students revisit the original models of the ice melting blocks. They revise their models to show why the ice melted faster on the block that feels cold (and slower on the block that feels warm). |</p>
<table>
<thead>
<tr>
<th>Information</th>
<th>Cereal cooled at different rates.</th>
<th>Goldilocks story</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>The rewriting of the Goldilocks story could be used as a formative or summative assessment</td>
</tr>
</tbody>
</table>
6.2.3 Learning Episode 1

**Student Science Performance**

<table>
<thead>
<tr>
<th>Topic: Heat Transfer</th>
<th>Title: Ice Melting Blocks 1</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

**Lesson Performance Expectations:**

Students will observe the changes that take place in two systems and will use their observations to develop models of the systems. Students should be able to identify which system remained stable and which changed, and use a model to communicate their understanding of the changes that took place in the matter of the system.

CCC: Systems, stability and change (in one system, water changes from solid to liquid and in the other system, the water is more stable and remains solid for a much longer time)

SEP: Developing models, asking questions

<table>
<thead>
<tr>
<th>Students Will... To Construct Meaning</th>
<th>Teacher Will... To Support Students</th>
</tr>
</thead>
</table>
| **Engage with a Phenomenon:** Ice melts on a block that feels cold but does not melt on a block that feels warm**  
  **Gather:** Discuss the similarities and differences you observe in the blocks.** |
| Display the ice melting blocks to the class and ask them to find similarities/differences in the blocks. You can ask them to share their ideas with their partners and/or ask them to record their ideas in the lab books or on a graphic organizer. Walk around the room to allow everyone to see the blocks up close (if logistics allow, you could also stand at the door as students enter the room at the beginning of class, after recess, etc. and have each student observe the blocks as they come in). Also allow students to feel the blocks. Help the class summarize the differences what you overheard students sharing or that they recorded. Make sure you include student observations regarding the perceived temperatures of the blocks; if no one offers this, ask questions and allow students to feel the blocks again to draw it out. Everyone should agree that one block feels warm and one feels cold. **  
  **Tell the students you will be placing an ice cube on each block and ask them to write their predictions. If needed, provide sentence stems so that they stay on topic and also explain their reasoning. Before placing the ice on the blocks, conduct a quick class survey of students’ ideas. Allow a few students to share their reasoning. Almost all of the students will predict that the ice will melt faster on the “warm” block, because it is warmer.** |

Predict what will happen when an ice cube is placed on each block. Write your prediction in your lab book, using one of these sentence stems:

- “I think that the ice cube on _________ block will melt faster because ______.”
- “I think the ice cubes will melt at the same rate because ______.”

Once the ice cubes are placed on the blocks, record your observations.

| **Place an ice cube on each block and ask the students to record their observations below their predictions.** | **Tell the students you will be placing an ice cube on each block and ask them to write their predictions. If needed, provide sentence stems so that they stay on topic and also explain their reasoning. Before placing the ice on the blocks, conduct a quick class survey of students’ ideas. Allow a few students to share their reasoning. Almost all of the students will predict that the ice will melt faster on the “warm” block, because it is warmer.** |

E. Haward
**Reason:** In your lab book, create a model showing how the water molecules in each ice cube were affected. Which molecules changed? How did they change? Which molecules didn’t change? Your model should include:

- Water molecules in the ice on each block
- Water molecules in the liquid water that melted
- Why the water changed from a solid to a liquid

**Communicate:** With your partner, identify the system in which you observed more stability and the system in which you observed more changes happening. Add these descriptions to your models.

Share your model with your partner. When it is your turn to talk, show your partner how you represented the water molecules, and how you represented the motion of the molecules in your model. When it is not your turn to talk, show your partner that you are actively listening by:

- Facing your partner
- Looking at his model and making eye contact
- Giving your partner one piece of feedback on his model after he finishes talking:
  - “I like the way you ___ because ___.”
  - “___ makes it easy to understand ___.”
  - “___ is confusing because ___.”
  - “If you ___, it might improve your model because ___.”

As a class, we will be discussing the following questions. Before we discuss, take two minutes to write a response to each question.

- What can we infer about the motion of the

Students will want to know why the ice on the “cold” block is melting faster and will start coming up with ideas. Although they will not be investigating what is causing the ice to melt faster during this lesson, it may be good to conduct a short class discussion to allow students to share their ideas. If you do this, you don’t need to comment on or validate their responses; just give them the chance to voice their ideas so they can step back to what they already know while constructing their models.

While giving instructions to develop a model, focus their attention back to what they know about the water molecules in the ice. Instruct them to create a model in their lab book that shows what happened to the water molecules in each of the systems. From previous lessons, they should know that as the temperature of the water increases, the ice will melt and the water molecules will move faster. As they work on their models, circulate through the class and use questions to help students clarify the ideas they are trying to communicate through their models. Also make note of misconceptions that may need to be addressed at some point (for example, if students are showing that the composition of the water molecules changed).

Tell students how you would like them to label the systems they modeled; writing the labels on the board will be useful to ELL students (for example, maybe you would like students to add “the water in this system was stable” and “the water in this system changed” to their models).

Display the tasks that students will be completing with their partners, including sentence stems for the partner providing feedback. If needed, model the discussion they should have and assign which partner will talk first (for example, “partner on the left will talk first, and partner on the right will listen first”). Tell students how much time they have to discuss and display a timer.

After students have had a chance to write their response, facilitate a class discussion to check for student understanding. From the previous storyline, students should remember that substances change
What questions could you ask that would help us understand these systems better? What do we need to know to explain why the ice melted faster on one block than on the other? With your partner, write 1-3 questions that you think would help us learn more about this system. Write each question on a sticky note and post it on the question board.

- What can we infer about the heat energy in each system?
- What can we infer about the molecules in each system?

Management Strategy: As students write their responses to the questions, circulate through the room with a clipboard and make note of student responses that will help facilitate the class discussion. You may also want to give some students a heads-up that you will be asking them to share during the discussion; if you do this, consider telling them why you would like them to share and be specific about what you want them to share. During the class discussion, try not to do the explaining yourself. Use strategies such as questioning, summarizing, or connecting student ideas to allow students to be the ones doing the explaining.

Allow students a few minutes to discuss questions, write them on sticky notes, and post them on the board. Depending on what type of space/technology is available, you could also use whiteboard space or a large piece of poster paper that students write directly on, or an app like padlet. Once students have posted their questions, sort them into groups and identify the grouping to your students. If needed, you could group them at a later time and then start the next lesson by reminding students of the questions and showing them how they are grouped. Possible groupings:

- Questions about where the energy came from
- Questions about the blocks
- Questions about how changing part of the system would affect the results

The groups you create will vary depending on the questions students asked.

Assessment of Student Learning

*This is an introductory/review activity; student models of the water molecules should be used to identify misconceptions from the previous storyline.*

Students' models of the ice cubes should indicate that they understand the relationship between molecular motion and states of matter (the molecules in the liquid water are moving faster than the molecules in the solid...
water). Student models should include:
- A representation of water molecules
- The motion of the molecules
- Explanation of what caused the water to change from a solid to a liquid

Misconceptions students have might include:
- The number of molecules changing as the ice melts
- The composition of the molecules changing as the ice melts.

Participation in the class discussion should also be used to assess student understanding and possible misconceptions that may need to be addressed.

Example student product:
Blocks

Record your observations about the two blocks:

Block 1

Block 2

Prediction:

Observation:
Ice Melting Blocks

Create a model that includes:

- Water molecules in the ice on each block
- Water molecules in the liquid water that melted from the ice
- Explanation of why the water changed from a solid to a liquid

As you develop your model, think about what you have learned about molecules. Are the molecules in the ice different from the molecules in the liquid water? How are they different?

What can we infer about the motion of the molecules in each system?  What can we infer about the heat energy in each system?
### 6.2.3 Learning Episode 2

<table>
<thead>
<tr>
<th><strong>Student Science Performance</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Conduction/transfer of thermal energy</td>
</tr>
</tbody>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:**

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

**Lesson Performance Expectations:**

Students will carry out an investigation to collect evidence to develop a model of energy flow through a system. Students should be able to model the flow of heat energy from a hotter substance (water) to cooler materials (the spheres). Students will also begin to ask questions about why the heat energy did not flow uniformly through the system (why did more heat flow to the metal sphere than to the wood sphere?).

**CCC:** Systems, energy and matter (heat energy flows through the different materials in the system)

**SEP:** Carrying out investigations, analyzing and interpreting data, developing models

### Students Will . . . To Construct Meaning

*Engage with a Phenomenon: When different materials are exposed to heat energy, some of them heat up more than others*

*Gather: We know that the ice melting blocks are made of different materials. To gather information to help explain the phenomenon, you will be investigating different materials. You will need to gather evidence about how the different materials interact with heat energy.*

Make sure you record the evidence you collect during the investigation.

### Teacher Will . . . To Support Students

Review what students observed during the last learning episode, and explain that they will be gathering information that will help them make the models of the ice melting blocks more complete. Remind them that we know the blocks are made of different materials (if needed, help students recall some of their observations of the blocks that indicate they are different materials; for example, one block was shiny and the other was not). Point out any questions (from the previous lesson) that students asked about the materials/blocks, and tell them that is what they will be investigating today.

Explain the investigation and hand out investigation sheets, or instruct students on how they should record their data/observations in their lab books. Since students will be using their hands (instead of a thermometer) to measure the relative temperature of the spheres, you may want to provide examples, or allow students to make suggestions, of different ways to record the temperature of the spheres. For example, they could use descriptive words, or rank the spheres according to their temperatures. Because the data is somewhat time sensitive, make sure you go through the entire procedure with the students and allow them to ask questions, so they understand what to do and when to do it. If students are recording data on the data
Once your group has recorded your data/observations and cleaned up, answer the following two questions about the system you investigated. You should answer these questions individually, but will have a chance to discuss your ideas with others later.

1. Define the system you investigated. (You could make a list of the parts of the system or make a diagram of the system and label the parts.)
2. How do you think heat energy flowed through the system? (You can use words to describe how energy moved through the system, or make a picture of the system and use arrows or other symbols to show how energy flowed through the system.)

**Reason:** Share your ideas with your group. Discuss one question at a time, and allow everyone in the group to share his ideas. When it is your turn to share, you can either read your response, or show your diagram to the group and explain it. When it is not your turn to share, you should be actively listening; this means you should be looking at the group member who is talking.

Once everyone has shared their ideas about both questions, use the following format to discuss your ideas; when it is your turn to be the group leader, you will pose the question to your group and make sure that everyone has a chance to participate in the discussion. Remember that being a leader does not mean that you are the one doing the talking!

- **Person A:** What similarities are there in our ideas about the parts of the system?

---

sheet, review where they record the data. If they will be recording data in their lab books, allow them time to set up their data tables before they begin.

Allow students a minute to collect their materials (which may include getting the hot water from you). As students work, circulate through the room to help redirect students, check how they are recording data (particularly for the temperature of the spheres), etc.

**Management Strategy:**

*Asking students what they think is going on as they are investigating is a great way to find out what they are thinking, and also to help them start thinking about what they think. As you ask students what they think is going on, listen to their answers and ask further questions, but don’t tell them if their ideas are right or wrong.*

If needed, go over the questions with students before they answer them; as students work individually, circulate through the class and use questions to help students clarify their ideas and provide verbal instructions for students who may be having a hard time getting started.

Explain/model how students should share their ideas with their group; if needed, review active listening with students and set up procedures for deciding who goes first, time limits, etc.

Explain the **group discussion with alternating leaders** strategy to your students. When using this strategy, students are placed in a group and one student is given the opportunity to be the group leader as they discuss a question. When time is up, or they are done discussing
Person B: What similarities are there in our ideas about the energy flow through the system?

Person C: Now that we have talked about the parts of the system and the energy flow through the system, what ideas can we all agree on? What evidence can we use to support our ideas?

Now that you have had a chance to discuss your ideas, you will be working with your group to make a model of the energy flow through the system. Your model should include:

- The system (what were the parts of the system?)
- Why did the temperature of the substances change? How was energy moving through the system?

After explaining the strategy, identify the first leader and post the question for the group to discuss.

Management Strategy:
You can allow students to decide who will be the A, B, or C, or can assign these roles. Assigning roles can be done while students are sharing their answers in the previous activity by circulating through the room and writing a letter on each students’ paper or placing a card next to each student. An advantage of assigning roles is that you can assign ELL or other students who may struggle with this to be student B. This will allow them to observe how student A leads the discussion on a similar question. If needed, model the role of the group leader. Use a timer so students can monitor themselves; each time the timer goes off you can display the next question and students can switch discussion leaders.

As students discuss their ideas, circulate through the room and listen to what they are saying. Make note of student interactions that you may want to bring up to the whole class, and/or comment directly to students as you see quality interactions happening. For example:

- “I love the way you asked ____ for more evidence to support her idea.”
- “I noticed that your group took a second...”
system?

- Evidence you have to support your idea about how energy flowed through the system

Communicate: When your new group gets to the model you helped create, allow them 30-60 seconds to examine it. Then ask what questions they have, and provide answers. If there is any part of the model that you didn’t explain when you answered their questions, explain it to your group members. When your group is at a model that you didn’t create, examine the model, ask questions about it, and then listen to the explanation to complete the graphic organizer.

- “____’s group did a great job of not interrupting or talking over each other.”

For this section, students will be using the explain-regroup-explain your explanation strategy. Students will work with their group to construct an explanation; in this case, their explanation will be in the form of a model. Students are then scrambled into new groups, and take turns explaining their explanations (models) to their new group members. This allows each student to take ownership of his understanding as he explains his group’s model to others, and to hear ideas from other groups.

Provide poster paper and markers and allow them time to work on their group models. Display the expectations for the model on the board or provide a list of “gotta haves” to each group so they can check to make sure they meet the expectations.

Ask students to either hang their models or leave them on their tables. Models need to be displayed in a way that allows students to examine them in groups.

Scramble the groups so each student is with new people. One quick way to reassign groups would be to point to three groups, and say, “all the A’s from these three groups will start here (point to one of the group’s models), all the B’s from those groups will start here (point to another group’s model), and all the C’s will start here (point to the last group’s model); when it is time to rotate, you’ll rotate with your new group in this direction (indicate the direction students will move among the three models).” This can be repeated until all the students have been reassigned to a new group. Once students know where they will be moving, tell them that they will be explaining their model to their new group members. If needed, model what their discussion should look like and how to fill in the graphic organizer. If the class will be successful with more rigid procedures, set a timer and allow students a set amount of time to present their model before moving to the next one. Otherwise, you can allow students to move through the models with their groups at their own pace. Emphasize that all students should fill in
their own graphic organizer. As students work, circulate through the room and listen to their explanations so you have an idea of what they are thinking (as well as misconceptions they may have). Collect the group models; students will be revising them during the next lesson.

**Assessment of Student Learning**

*This is a formative assessment and should be used to understand students' ideas and misconceptions that may need to be addressed.*

Students ability to collect and interpret data should be used as a formative assessment; their participation with their groups should be used to assess both their understanding of the data they collected, as well as their ability to use evidence to support their ideas and communicate effectively. Student work (discussions, group models, and individual work, including the graphic organizer at the end of the lesson, etc.) should be used to assess student understanding of energy flow; at this point, students should understand that heat energy can move from one material to another when the materials are in contact with each other, and that the amount of energy transferred can depend on the material. A major misconception that students may have at this point is that “cold” energy moves from something that is cold to something that is warm, cooling it down. They may think that the spheres somehow gave their coldness to the water (instead of heat moving from the water to the spheres).

Student models could be assessed according to the following rubric:

<table>
<thead>
<tr>
<th>Above proficiency</th>
<th>Meets requirements for proficiency, and may include the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Recognition of second system after the spheres are removed (spheres and the air); energy flow in this system is from the spheres to the air; evidence is that the spheres are cooling down; recognition that there is not evidence that air temperature around the spheres increased, but this inference could be made based on what happened in the sphere-water system</td>
</tr>
<tr>
<td></td>
<td>- Inclusion of air as part of the sphere-water system, with heat energy also moving from the water to the air</td>
</tr>
<tr>
<td></td>
<td>- Inclusion of heat flow into the cup (or not); for example, if students were using styrofoam cups and noticed that the cups got warm but not hot, they could include flow of some heat energy to the styrofoam; if plastic or glass cups were used, they may include more heat energy flowing to the glass/plastic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proficient</th>
<th>Model includes the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- System includes water, spheres (and possibly cup and thermometer)</td>
</tr>
<tr>
<td></td>
<td>- Heat energy flows from the water to the spheres <em>at this point, some groups may think that “cold energy” is moving from the spheres to the water; their evidence might support this (the water did get colder, so maybe the cold from the spheres moved to the water); these groups would need to be reassessed for their understanding of the flow of heat energy after the next lesson, which is designed to address this misconception</em></td>
</tr>
<tr>
<td></td>
<td>- More heat energy flows to the metal sphere than to the wooden sphere</td>
</tr>
<tr>
<td></td>
<td>- Evidence to support flow of energy includes: temperature of water decreased, temperature of metal sphere increased more than the temperature of the wooden sphere</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Approaching proficiency</th>
<th>Elements required to meet proficiency is included, but may be incomplete or contain errors. For example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Students may have included their stopwatch or other materials as part of the system, or may have left out part of the system</td>
</tr>
<tr>
<td></td>
<td>- Heat energy is shown flowing only to the metal sphere, or to all spheres equally</td>
</tr>
<tr>
<td></td>
<td>Evidence is not sufficient to support claims made by the model or is unrelated to the</td>
</tr>
</tbody>
</table>
claims made by the model. For example:
  - Decrease in water temperature is included but nothing about the temperature of the spheres
  - Times from student data are included but the model makes no claim about the rate of energy flow

<table>
<thead>
<tr>
<th>Below proficiency</th>
<th>Model is missing most elements needed to meet proficiency; elements that are present are inaccurate and/or incomplete</th>
</tr>
</thead>
</table>

Example of a proficient student model:

![Diagram of a student model showing temperature changes before and after adding spheres. The text on the diagram explains the temperature changes and the movement of heat energy.]
Energy Flow Investigation

Collect your materials:
- Cup with hot water
- Plastic spoon
- Four spheres
- Thermometer
- You’ll also need a timer; you can use your phone or the clock on the wall

Put the thermometer in the water, and once the temperature stops rising, record the starting temperature of the water. Then add the four spheres to the water, and continue to record the temperature every 30 seconds.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (starting)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
</tr>
</tbody>
</table>

After the spheres have been in the water for two minutes, use the spoon to take them out. Gently touch each sphere (don’t burn your hands!) and record how hot it feels. Continue to record how hot each sphere feels every 30 seconds for three minutes.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Metal</th>
<th>Wood</th>
<th>Plastic</th>
<th>Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (starting)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
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<td>60</td>
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<td>90</td>
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<tr>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Once you have recorded all of your data, follow your teacher’s instructions for cleaning up. Then answer the following questions. Later, you will be discussing these questions with your group.

**Define the system that you investigated.** You could make a list of the parts of the system, or draw a picture of the system and label the parts.

**Why did the materials in the system change temperature?** How did energy move through the system? You can use words to describe how the energy moved, or draw a picture and use arrows or other symbols to show how the energy moved through the system.

---

**Models**

As you examine the other groups’ models, ask questions, and listen to explanations, fill in the table below.

<table>
<thead>
<tr>
<th>Group member who created the model</th>
<th>How is this model similar to the model I made?</th>
<th>What are some things this model are useful?</th>
<th>How does this model represent the flow of energy?</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Haward</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# 6.2.3 Learning Episode 3

## Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Conduction/transfer of thermal energy</th>
<th>Title: Conduction Game</th>
</tr>
</thead>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

**6.2.3** Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

### Lesson Performance Expectations:

Students will use observations made while participating in a game to continue developing their model to show how heat energy flows through a system. They will then use the evidence collected throughout the unit to support a claim regarding the flow of energy in the water-sphere system. By the end of this lesson, students should understand that heat energy flows from molecules with more energy to molecules with less energy. They should also be able to relate the amount of heat energy to the motion of the molecules (specifically, that molecules with more heat energy are moving faster, and that when they contact a molecule with less energy, some of their energy is transferred, which results in a change in the motion of both molecules).

CCC: Energy and matter, systems (heat energy is conducted through a system from molecules with more energy to molecules with less energy and results in a change in motion of the molecules)

SEP: Arguing from evidence and developing models

<table>
<thead>
<tr>
<th>Students Will . . . To Construct Meaning</th>
<th>Teacher Will . . . To Support Students</th>
</tr>
</thead>
</table>

**Engage with a Phenomenon: When different materials are exposed to heat energy, some of them heat up more than others**

**Gather:** You will be participating in an activity to model energy flow through the molecules in a system. As you participate in the activity, pay attention to how your number of cards changes.

When you hear the timer go off, you'll drop off your cards and return to your seat.

**Reason:** Your group will be discussing three questions. When it is your turn to be the group leader, you will be in charge of the discussion. This does NOT mean that you will be the only one talking! It will be your job to direct the discussion; these sentence stems may be helpful to the leader:

- “What do you think about _____?”
- “We haven’t heard from ____ yet; what is your idea about ____?”
- “Can you explain what you mean?”
- “What evidence do you have to support your idea?”

**Explain the activity (instructions are included with the lesson materials), pass out the cards, and remind the students to pay attention to how their number of cards changes. Instruct the students to return their cards and then return to their assigned seats when they hear the timer go off. Allow students to play the game for two minutes (two minutes allows them enough time to find patterns in the way the cards are being passed without getting too rowdy).**

**Instruct students to sit with the group they made their model with during the last lesson, and drop off a set of colored pencils (one pink, one green, and one blue) to each group. Tell the students that they should each take one colored pencil. They will be using the group discussion with alternating leaders strategy that they learned last time.**

**Tell students that they will be discussing three questions with their group, and each of them will have a turn to lead the discussion. Remind students what they should be doing when it is their turn to be the**
Discussion questions (the discussion leader is the student with the corresponding colored pencil):

- **Green:** What happened to the number of cards you had? What would have happened to the number of cards everyone had if we had played the game for an hour?
- **Pink:** Describe the way the heat energy moved through the system. What factors affected how the energy flowed?
- **Blue:** How does the way the energy moved through the system during the game relate to the data we collected during the sphere investigation last time?

You will be revising the group model you made last time. Find the graphic organizer you filled out last.

You will be revising the group model you made last time. Find the graphic organizer you filled out last.

Display the first question on the screen and tell students how much time they will have to discuss it (approximately 2 minutes per question); when time is up, move on to the second and then the third question. Students will be using the ideas they are discussing as they revise their models; you may want to tell them this upfront so they know why they are discussing these particular questions.

**Management Strategy:** As students are discussing, circulate through the room and redirect group leaders if needed (particularly if there are students who are using their leadership role to dominate the discussion or diminish others’ ideas); make note of students/groups you may want to call on during the class discussion to share the ideas they are discussing. Also make note of communication/leadership skills that students are displaying that you would like to share with the class; if a particular student might be embarrassed to be recognized this way in front of the class, you can quietly compliment them as you are moving through the class.

- “I noticed that Johnny’s group moved their chairs so they were all facing each other.”
- “I liked the way Zoe asked someone in her group for evidence to support his idea.”
- “I noticed that everyone in Henry’s group had a different idea about ____; can you share with the class how you were able to come to consensus?”

If needed, facilitate a short class discussion. Before students start revising their models, they should come
time, and look over the third row, where you recorded things from other groups’ models that you found useful. Take one minute and let everyone in the group share the things they liked about the other models you saw. Your group may want to consider some of these things as you revise your own model. After you have all had a chance to share the things you liked about the other models, pick up your own model from the teacher. Use the ideas you just discussed with your group to revise your model; when you get done it should include the following information:

- What is happening to the energy and the molecules where the water and wooden sphere are touching
- What is happening to the energy and the molecules where the water and metal sphere are touching
- Why the temperatures of the water and spheres is changing

Remember that you can include zoom-in boxes to show what is happening to the molecules and written descriptions.

Communicate: You will be sharing your model with the class. You will be sharing your group’s idea about ONE of the following:

- What is happening to the molecules and energy where the water and metal sphere touch
- What is happening to the molecules and energy where the water and the wooden sphere touch
- What is causing the change in temperature of the water and the spheres

When it is your group’s turn to share:

- Tell the class which of the ideas you will be sharing “Our group is going to share our idea about what is happening where the water and metal are touching.”
- As you explain your idea to the class, show how you represented it on your model “We think that ___, and we used ___ symbols to represent ____ and ____.”

Management Strategy: As students revise their models, circulate through the class and use questions to help students clarify and explain their ideas:

- “Why did you choose to include ___?”
- “How could you include the evidence you have for ___?”
- “What do these symbols represent? How can you make that clear?”
- “Earlier I heard you discussing ___. How are you going to incorporate that into your model?”

If you notice that there are students who have not grasped these concepts, a class discussion that allows other students in the class to express these ideas may help struggling students.

At this point, if students in the class demonstrate understanding the concept of insulators and conductors, you can introduce these terms; you could also wait until the next learning episode to introduce this vocabulary.

Direct students to the “what are some things this model has that are useful?” section of the graphic organizer they filled out as they viewed others’ models last time. Allow them time to share and discuss the useful features with their groups.

Explicitly tell students the additional information that their models should contain and invite them to revise/cross off anything that they included last time that they now realize may be incorrect. Sticky notes may also be helpful to provide more writing space for groups who didn’t leave much white space on their poster. Display the information that should be included in the revision and/or provide a hard copy that students can refer to as they revise their models. Give them a time limit, and consider displaying the timer so they can self-monitor.
Individually, make a claim about how the energy flowed through the system and then use evidence to support your claim. Record your claim and the evidence to support it in your lab book, and then construct an argument for how the evidence supports the claim.

Allow a few minutes for groups to prepare to share their models. Give them the information that they will be expected to share, and if needed, model what their presentation will look like and/or provide sentence stems. Suggest that students arrange who is going to say what before they present. Depending on the class, you may also want to give them a time limit (“each group will only have one minute to present, so make sure that everyone in the group knows what they are going to say”).

Once groups have had a few minutes to prepare, allow each group to quickly present their model. After all the groups have presented, facilitate a short class discussion to help resolve conflicts (in case different groups came to different conclusions) and address misconceptions. Use questions to help students explain their ideas to their peers during the discussion:

- Why weren’t the spheres the same temperature when you took them out of the water?
- What is happening on the molecular level when energy is transferred from the water to the sphere?
- If the spheres stayed in the water for several hours, what would happen to the temperature of all the parts of the system? Support your answer.
- Bonus: What caused the spheres to cool down?
- Bonus: How does the fact that the surface water in the cup was touching the air make that system different than the system in our activity?

You may also want to bring up the mechanics of the models during the discussion, to allow students to
share features (zoom-in boxes, symbols, keys, descriptions, etc.) that they liked in the different models.

**Management Strategy:**
Depending on the students in your class, you may want to create a class model during the discussion. As students discuss both the content and the mechanics of the various models, play the role of the scribe and record their ideas in a new model. Constructing a model together can be very beneficial to ELL and other students who may struggle with understanding the discussion without visual cues, or who may need to interact with the information a second time.

As an individual assessment, have students summarize their understanding of energy flow by constructing an argument about the energy flow through the system. *Please note that this is hard for students!* If this is the first time students have been asked to make a claim, provide evidence to support it, and then construct an argument, you will need to model what to do, possibly walk students through the process, and/or provide scaffolding. A graphic organizer can be provided to students, or you can show them how you would like them to format their responses in their lab books. Suggestions for scaffolding and a graphic organizer are included in the lesson materials.

**Assessment of Student Learning**
This is a formative assessment and should be used to understand students’ ideas and misconceptions that may need to be addressed. If a graded assessment is needed at this point, you could use the rubric below as a guide for grading their claim and evidence. When assessing student claims/evidences, a student’s ability to argue from evidence should be valued at least as much as having the correct answer about energy flow through the system.

Student models should include:
- Molecules (zoom-in boxes could be included to show the molecules; water, metal, and wood molecules should be included)
- Symbols and/or descriptions to show molecular motion (for example, students may use squiggly lines to show the motion, with longer lines indicating more motion)
- Transfer of heat energy from the water to the metal (for example, students could use arrows to show that energy moves from the water molecule to the metal molecule)
- Key/descriptions to communicate what different symbols represent
- Temperature change of the water and metal/wood
- Evidence to support the claims made by their model (for example, an explanation that the temperature changes show that heat is moving from the water to the metal, making the water cool down as it loses heat energy and the metal heat up as it gains heat energy)
Example of a revised model:

The claim/evidence statements should be used to assess individual student understanding. The rubric below can be used as a guide to assess their arguments; adjustments would need to be made if additional scaffolding is used to help some students construct their arguments.

<table>
<thead>
<tr>
<th>Surpasses proficiency</th>
<th>Meets requirements for proficiency, PLUS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Analysis of the system of the spheres in the air is included to support the claim</td>
</tr>
<tr>
<td>Proficient</td>
<td>- Claim is included</td>
</tr>
<tr>
<td></td>
<td>- Evidence to support the claim is included, sufficient and correct (for example, a student shouldn’t have evidence that the temperature of the water increased)</td>
</tr>
<tr>
<td></td>
<td>- The evidences are used in an argument to support the claim</td>
</tr>
<tr>
<td>Approaching proficiency</td>
<td>- Claim is included</td>
</tr>
<tr>
<td></td>
<td>- Evidence to support the claim is included and correct, but may be insufficient (for example, the student may only have one piece of evidence)</td>
</tr>
<tr>
<td>Below proficient</td>
<td>- Claim is included</td>
</tr>
<tr>
<td></td>
<td>- Evidence is missing, incorrect, and/or insufficient or may not support the claim</td>
</tr>
<tr>
<td></td>
<td>- No argument is made</td>
</tr>
</tbody>
</table>
Example claim-evidence-reasoning:

<table>
<thead>
<tr>
<th>Claim: Energy flowed through the system when a molecule with more energy touched a molecule with less energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence:</td>
</tr>
<tr>
<td>● Temperature of the water before the spheres were added was 98°.</td>
</tr>
<tr>
<td>● Temperature of the water one minute after the spheres were added was 72°.</td>
</tr>
<tr>
<td>● The water started out hotter than the spheres.</td>
</tr>
<tr>
<td>● During the game, cards were passed from high to low.</td>
</tr>
<tr>
<td>● Temperature of the spheres increased after they were in the water.</td>
</tr>
<tr>
<td>Reasoning:</td>
</tr>
<tr>
<td>When the spheres were in the water, they got hotter and the water temperature lowered by 26°. This shows that the water was losing heat energy and the spheres were gaining heat energy. Since the water was hotter than the spheres to start with, the heat must have been moving from molecules with more energy in the hot water to molecules with less energy in the colder spheres. This supports the part of my claim that says the heat energy moves from something with more energy to something with less energy.</td>
</tr>
<tr>
<td>But this only happened after the spheres and water were touching. Before the spheres touched the water, they weren’t getting hotter and the temperature of the water stayed the same. Also, during the game, the energy cards couldn’t get passed from one person (or molecule) to another unless they were touching. If you didn’t actually bump into someone, you couldn’t get any energy from them. These evidences support the part of my claim that says the molecules must be touching each other for the heat energy to move.</td>
</tr>
</tbody>
</table>

Note: This “student” example is probably more than you should expect from your students if this is the first time they have done a CER. If time allows, have students review each other’s CERs and make revisions to polish their reasoning. Also present some excellent student-produced examples from the class at the end so that students can see what is expected the next time they do a CER. Also note the use of the word “support” in this example, which is very intentional. Students may say that their evidence “proves” their claim. It is important for students to understand that scientists don’t claim to prove their ideas. Using the word “prove” implies that the game is over, when in reality, scientists realize that no matter how overwhelming the evidence, there is always room for further questioning and discovery.
Conduction Game Instructions


Pass out 0-4 slips of paper (or tokens, or paper clips, etc.) to each student (this does not need to be precise). Tell the students that the class will be modeling the system you investigated last time. The students are molecules and the cards represent how much energy they have. The more cards they have, the faster they are allowed to move through the room. When they bump into another student (you may need to explain and/or model what “bumping” into another student should look like), each student will hold up their cards. The student with more cards must give one card to the other student. If the students have the same number of cards, they can either do nothing or exchange one card each (they will end up with the same number of cards). Pick a few students and tell them that they have to keep their hands in their pockets. If they don't have actual pockets, they can just pretend. What this means is that they don’t have hands to take cards from anyone. So even if they bump into someone with more cards, they can't take any of them. One way to pick these students is to look around the room and call out a color that you see 2-4 students wearing. (“If you are wearing a red shirt, you have your hands in your pockets.”) You could also make a mark on a couple of the slips of paper and then tell the students that if they got that slip of paper they have their hands in their pockets. Emphasize that students should pay attention to how their number of cards changes as they play the game.

Claim, Evidence, Reasoning Scaffolding Ideas

Note: Students may be familiar with the term “argument” from writing arguments in their ELA classes. In many science lessons and teaching resources, the “reasoning” section is similar to the argument used in ELA. In the claim-evidence-reasoning (CER) model, the reasoning section is where students provide an argument that the evidence they cited actually supports their claim. Differentiating between the evidence and reasoning is difficult for students and takes practice. The evidence consists of the data they collected and/or the observations they made, while the reasoning is an explanation of how or why the data supports the claim. In this case, let us say that students collected data that the water started at 100° and then dropped to 70° after the spheres were added. Students may want to use this evidence to support a claim that energy moved from the water to the spheres, but this one piece of evidence is not enough to support the claim. They may need to combine it with an additional piece of evidence (maybe that the metal and glass spheres got hot while they were in the water). In the reasoning section, they would describe how these two pieces of evidence could be used together to support the claim. The first few times students do a CER, they will need some scaffolding. Three different levels of scaffolding are included below, with level III providing the most scaffolding.

**Level I:** Provide students with possible claims and allow them to select the claim they have the most evidence to support. They can then use the evidence they generated to construct their argument. Possible claims:
- More heat energy moved from the water to the metal sphere than to the wooden sphere
- Heat energy moved from the water to the spheres
- Heat energy moved from the spheres to the water
- In order for the heat energy to move from the water to the spheres, they must be touching
- If the water started out hotter, the metal sphere would have gotten hotter

Additionally, sentence stems could be provided to help students write their reasoning. This could be particularly helpful to ELL students.

**Level II:** Provide students with claims and evidences; allow them to determine which pieces of evidence could support each claim. Note that some of the evidences could be used to support multiple claims, and that all the claims could be supported by the evidence that students gathered. Students then select one claim and use the evidence to construct their argument. You could provide these in a list and allow students to draw lines from the evidence to the claim that it supports, or cut them into strips that students can sort. Possible claims/evidence:
<table>
<thead>
<tr>
<th>Claims</th>
<th>Evidences</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Heat energy moved from the water to the spheres</td>
<td>● The water went from _____° to _____°</td>
</tr>
<tr>
<td>● The sphere must be touching the water for the heat to move from the water to the sphere</td>
<td>● The metal sphere got hotter than the wooden sphere</td>
</tr>
<tr>
<td>● More energy moved from the water to the metal than to the wood</td>
<td>● When we played the game, you had to touch someone before you could get their energy</td>
</tr>
<tr>
<td></td>
<td>● When we played the game, energy always went from the molecule with more to the molecule with less</td>
</tr>
<tr>
<td></td>
<td>● The metal sphere and the wooden sphere both got hotter when they were in the water</td>
</tr>
</tbody>
</table>

**Level III:** Provide students with only one claim and a list of evidences (these could be from the examples in the table above). Students determine which of the evidences could be used to support the claim, and then use the evidences they selected to write their reasoning. If additional scaffolding is needed:

- Students could be given the claim and the evidence to support it, and then asked to write their reasoning. In this case, students would be responsible to explain why/how the evidence provided supports the claim given to them.
- Sentence stems could be provided to help students write their reasoning; this may be particularly helpful for ELL students.
# Flow of Heat Energy

<table>
<thead>
<tr>
<th>Claim</th>
<th>(remember that this is a statement about how heat energy flows through the system):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence</td>
<td>(what data did you collect that supports the claim you made?):</td>
</tr>
<tr>
<td>Reasoning</td>
<td>(this is your argument; explain <em>how/why</em> the evidence you listed above supports the claim you made):</td>
</tr>
</tbody>
</table>
# 6.2.3 Learning Episode 4

<table>
<thead>
<tr>
<th>Student Science Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Conduction/transfer of thermal energy</td>
</tr>
</tbody>
</table>

### Overarching Performance Expectations (Standard) from State Standards or NGSS:

| **6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.** |

### Lesson Performance Expectations:

- Students will use evidence to develop a model that shows the relationship between temperature, particle motion, and state, and the relationship between the amount of heat energy transferred and the type of material.

- ** CCC: Stability and change, cause and effect, energy and matter (student models should show that heat transfer to a material causes change in the system and that materials that limit heat transfer can result in more stability in the system) **

- **SEP: Constructing explanations, developing and using models**

### Students Will . . . To Construct Meaning

*Engage with a Phenomenon: When ice cubes are placed on two blocks, one melts and the other does not*

*Gather:* We’ll be using a digital thermometer to find the temperatures of the ice melting blocks that we used in class earlier. Find the models you made of the ice melting blocks and record the temperature of each block.

What questions do you have about your observations?

*Reason:* Come up with an explanation for why one block feels colder than the other, even though they are the same temperature. Write your idea in your lab book. If you have more than one possible explanation, write them both/all.

Share your idea and/or comment on another student’s idea during the class discussion.

### Teacher Will . . . To Support Students

Show the students the ice melting blocks and ask if they remember how they felt; allow students to feel the blocks again to reinforce that one feels colder than the other.

Instruct students to find their original models and then use the digital thermometer to read the temperature of each block. If students don’t believe that they are the same temperature, allow a few students to come up and verify the results.

Ask for questions (if needed; many students will begin asking questions related to their surprise that the blocks are the same temperature); tell students that they will be constructing an explanation for the "how can they be the same temperature?" questions.

Display the task on the board ("construct an explanation for why one block feels colder than the other, even though they are the same temperature"). Tell students that they can use words and/or pictures in their explanations. You may also want to suggest that students find their sphere system models and/or CERs from previous lessons to help inform their explanations.

### Management Strategy:

E. Haward
Communicate: Find your original ice melting block models from a few lessons ago. You will be revising your model so that it shows what causes the ice to melt on one block but not the other. Revise your original models to include:

- Water molecules in the ice on each block
- Water molecules in the liquid water that melted
- Why the water changed from a solid to a liquid
- How heat energy is transferred from the block to the ice
- Why the ice melts on one block but not the other

Give students a specific amount of time to work on their explanation(s) and display a timer so they can monitor themselves. As they work, circulate through the room with a clipboard and note any students whose ideas you would like them to share with the class. You could also give those students a heads-up, but quietly telling them that you will be asking them to share their explanation with the class. Also use questions to help guide students who look like they are struggling to get started:

- “What makes your fingers feel cold?”
- “What would your fingers feel like if the heat were removed?”
- “What do you think happens to the heat energy in your fingers when you touch the block that feels cold?”

Facilitate a class discussion to help all students understand that one block is a conductor, and heat energy flows from their fingers to the block, causing their fingers to feel cold (since the heat is leaving). The other block is an insulator, so the heat energy in their fingers stays put instead of being transferred to the block. Once these concepts become clear, focus the discussion on the ice. One block conducts heat to the ice, causing it to melt. The other does not.

Management Strategy: Construct the discussion so that students are the ones explaining the concepts; you can do this by strategically selecting which students should share their ideas, and/or asking questions during the discussion to allow students to develop and express their ideas. Referring students to the model they made previously of the spheres in the water may also be useful in helping them apply their understanding from that activity to the ice melting blocks.
You may also want to explicitly tell students that as they hear new ideas or realize their initial explanation is flawed, to make notes/revisions to their explanation.

You could choose to have students make a new model, based on their first one to reduce the amount of clutter. Display a list (or hand out hard copies) of the features that the models must have and allow students time to work on them. As students work, circulate through the room and use questions to help students clarify their ideas and models. This model is fundamentally the same as the revised model of the water-sphere system, with the addition of the relationship between thermal energy and state.

**Assessment of Student Learning**

*Student explanations of why the blocks feel like they are different temperatures should be used as formative assessments that drive the discussion; student participation in the discussion should also be used to assess understanding. Individual models of ice melting blocks could be used as a formative or summative assessment at this point.*

Suggested rubric for grading student models:

| Surpasses proficiency | Model includes requirements to meet proficiency, plus additional information regarding relationships between temperature, state and molecular motion, and transfer of heat energy. Examples could include the following:
|                       | ● Flow of energy from the air, through the conducting block to the ice
|                       | ● Flow of energy through the water, showing water molecules with more heat energy transferring the energy to water molecules with less heat energy
|                       | ● Possible flow of energy from a water molecule with more energy to a metal molecule with less energy, with the recognition that the net flow of energy is initially from the metal block to the water
|                       | ● Recognition that if allowed to sit long enough, all the molecules in the ice-block system would have the same amount of heat energy
|                       | ● Explicit mention of how the water molecules are changed as heat energy is added or removed; that is, they are made of the same atoms but their motion and placement relative to other molecules changes
|                       | ● Since air is not very dense, not as much thermal energy can flow directly from the air to the ice (not as many air molecules available to contact the outside of the ice and transfer energy) |
| Proficient            | Model includes evidence of the following:
|                       | ● Relationship between temperature, state and molecular motion (for example, zoom-in boxes with symbols that represent molecules and how fast they are moving with molecules in the ice moving more slowly than molecules in the liquid water)
|                       | ● Transfer of heat energy between molecules (for example, a zoom-in box showing the metal and water molecules; symbols/descriptions included to show that when the metal molecule with more heat energy bumps into the water molecule with less heat energy, some of the energy is transferred from the metal to the water molecule) |
- Difference between conductors and insulators (for examples, symbols and/or description that indicate heat energy flows through the metal block into the ice but not through the foam block)

<table>
<thead>
<tr>
<th>Approaching proficiency</th>
<th>Model includes the following, but may contain incomplete and/or incorrect information:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Relationship between temperature, state and molecular motion</td>
</tr>
<tr>
<td></td>
<td>● Transfer of heat energy between molecules</td>
</tr>
<tr>
<td></td>
<td>● Difference between conductors and insulators</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Below proficiency</th>
<th>Model does not include:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Relationship between temperature, state and molecular motion</td>
</tr>
<tr>
<td></td>
<td>● Transfer of heat energy between molecules</td>
</tr>
<tr>
<td></td>
<td>● Difference between conductors and insulators</td>
</tr>
<tr>
<td></td>
<td>Information that is included is incomplete/incorrect</td>
</tr>
</tbody>
</table>

Example of student revised model:

![Diagram of heat transfer between metal and foam blocks](image-url)
Ice Melting Blocks Explanation

Construct an explanation for why one block feels colder than the other, even though they are the same temperature. You can use words and pictures in your explanation.

If you have more than one idea, you can write them both.
6.2.3 Learning Episode 5

Student Science Performance

<table>
<thead>
<tr>
<th>Topic: Conduction/transfer of thermal energy</th>
<th>Title: Goldilocks (amount of matter and transfer of heat energy)</th>
</tr>
</thead>
</table>

Overarching Performance Expectations (Standard) from State Standards or NGSS:

6.2.3 Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

Lesson Performance Expectations:

Students will plan and carry out an investigation to determine the relationship between the amount of material and the amount of heat energy transferred. They will use the evidence they gather during the investigation to support a claim about the relationship between amount of material and amount of heat energy transferred.

CCC: Energy and matter; scale, proportion and quantity

SEP: Plan and carry out an investigation, analyzing and interpreting data, constructing explanations, communicating information

Students Will. . . To Construct Meaning

Engage with a Phenomenon: Different volumes of hot water that start at the same temperature do not cool down at the same rate.

Introduction: In the story of Goldilocks and the Three Bears, Baby bear’s porridge is “just right” but Mama and Papa bears’ porridges are too hot. You are going to investigate how this is possible. Assuming the porridge all came out of the same pot, why would some be hotter than others?

Gather: You will have access to plastic cups, thermometers, measuring cups, and hot water. Your task is to figure out how the porridge in the bears’ bowls could be different temperatures. You will be making a claim, and using the evidence you collect during your investigation, to support it.

With your group, determine how you will conduct your investigation. Set up your data tables, collect your materials, and then start investigating! You can do more than one investigation to collect the evidence you will need to make and support a claim.

Teacher Will. . . To Support Students

Note: You could integrate this lesson into the storyline or start introducing this concept earlier by adjusting the investigation with the spheres in learning episode 2 by including a metal sphere of a different size. Students will then be able to gather information about how the type and the amount of material affects heat transfer at the same time. This could help streamline the lessons, but could also result in cognitive overload for some students, since they will be working to understand two different variables at the same time.

Read the beginning of the Goldilocks story to students and make sure that everyone knows what “porridge” is (especially ELL students). Conduct a short discussion about how porridge was made back in the day; instead of microwaving individual bowls, like students might do at home now (if they eat oatmeal), all the porridge would be made together in one pot and then portioned out. This is important, because students should understand that the porridge all started out the same temperature.

Provide students with their task, which is to determine how it is possible for the porridge to be poured into bowls and then end up being different temperatures. Depending on the class, you can:

- Allow students to start planning and conducting their investigations.
- Provide additional information/support and then allow students to start planning and
**Reasoning:** With your group, write a claim that both matches the story and can be supported by evidence. This means that your claim should state how it is possible for Baby bear’s porridge to be cooler than Mama and Papa’s. Also determine which pieces of evidence collected during the investigation could be used to support the claim.

Write your claim and the evidence to support it in your lab book. Although you are working with your group, everyone is responsible to record the information in their own lab books.

**Communicate:** You will be meeting with a partner and sharing your claims and evidence with each other.

- Each partner should share his claim
- Together, compare your claims. Are they the same? How are they different?
- Partner 1 should share the evidence to support his claim; partner 2 should listen and ask questions/provide feedback:

  Conducting their investigation. This may include clarifying that students are trying to find a way to replicate the temperatures in the story; how can they make it so the water in one cup cools down faster than the water in another cup? It may also involve discussing data collection: what data could students possibly collect (amount of water, temperature, time, etc.) and how they will record the data.

- Help the students plan the investigation together as a class. This may be beneficial if you have several students who will struggle with planning the investigation or data collection without specific instructions. This could also be a useful strategy if time is limited; making sure that all students have a clear plan that will get them the data they need will require less time for them to conduct the investigation.

**Management Strategy:**

*Students should be in groups of three. Provide limits on time and supplies to students. (“Each group can have three cups, three thermometers, and start with 200 ml of hot water” and/or “You will have ___ minutes to plan and ___ minutes to investigate.”) If students are planning their investigations with their group, structure their time so that they have planning time before collecting their materials. This can be short; you also have the option to ask students to write down their investigation plan and show it to you before they are allowed to collect their materials.*

To help students focus their claims, display a question on the board, such as “what causes the water to cool down at different rates?” If needed, you can provide scaffolding by providing 2-3 claims to the students and allowing them to select claim to support. As students work with their groups, circulate through the room; if needed, remind students that they should all be recording the claim and evidences (not just one person); also use questions to help students focus the
○ “How does ____ relate to the claim?”
○ “How did your group gather that piece of evidence?”
○ “I don’t think that piece of evidence supports your claim because ____.”
● Switch roles, so partner 2 can share his evidence and partner 1 can ask questions/give feedback.

When you are finished discussing with your partner, return to your assigned seat.

Participate in the class discussion to help construct an explanation for how the amount of water in the cup affects the rate of temperature change. You will be using this information to write a story later, so you should be recording your ideas during the discussion.

You will be rewriting the part of Goldilocks and the Three Bears where Goldilocks eats the porridge to be scientifically accurate. Your story should include:
○ The amount of porridge in each bowl
○ An explanation of why the porridge is different temperatures

Your story could include:
○ Pictures
○ Scientific drawings

evidence that they are recording.

Group students so that they are paired with someone that they did not do the investigation or claim/evidence statements with. Review the norms for the discussion, and if needed, provide sentence stems and/or model what the discussion should look like. You may also want to establish time limits for each part of the discussion and display the timer so students can monitor their conversations.

Management Strategy: As students discuss, circulate through the class with a clipboard and make note of student ideas that you would like to bring up during the class discussion. Listen for students whose claims/evidence focus on the amount of water, and make a note to ask those students to share during the class discussion. You can also give those students a heads-up, so they know that you will be asking them to share a specific idea during the discussion.

Facilitate a class discussion to emphasize the relationship between the amount of water and the rate of cooling. Before starting, you may want to provide a graphic organizer or specific task to help all students engage in the information being discussed. For example, you could ask students to put a star by an claim or evidence written on their paper that the class decides is important during the discussion, or to add it to their paper if they don’t already have it. Allow students to share their evidences to help convince everyone that the less water, the faster the rate of cooling. Then continue the discussion by asking students why this would be the case. By the end of the discussion, students should understand that the more total molecules in the water to start with, the more heat energy it will contain, and the longer it will take for this heat energy to be transferred to the air. Creating a class model during the discussion can help visual students and ELLs understand the concept. When creating a class model, act as the scribe, and record ideas that the class agrees are important, and include features/symbols that the class agrees will make the model effective.
Assessment of Student Learning

Student investigation techniques (including data collection), claim-evidence statements, and discussions should be used as formative assessments of skills and understanding that can help drive the class discussion. Goldilocks stories could be used as formative or summative assessments of student understanding of the relationship between heat transfer and the amount of material.

Examples of claims and evidence that would be acceptable:

<table>
<thead>
<tr>
<th>Claim</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>The less water there is, the faster it cooled down</td>
<td>100 ml of water went from 98°C to 96°C in 3 minutes 50 ml of water went from 98°C to 94°C in 3 minutes 20 ml of water went from 98°C to 90°C in 3 minutes</td>
</tr>
<tr>
<td>The more water there is, the longer it took to cool down</td>
<td>100 ml of water took 7 minutes to drop 4 degrees 50 ml of water took 5 minutes to drop 4 degrees 20 ml of water took 2 minutes to drop 4 degrees</td>
</tr>
<tr>
<td>When the water starts out hotter, it cools down faster</td>
<td>98°C water cooled down 2 degrees in 3 minutes 80°C water cooled down 1 degree in 3 minutes</td>
</tr>
</tbody>
</table>

Note: The last claim reveals that the students misunderstood the background for the investigation or the question they were supposed to investigate. When assessing, the teacher should take into account that the students were able to plan and carry out an investigation, and were clearly able to make a claim that is supported by the evidence they collected.

Example of Goldilocks story:

E. Haward
"This porridge is too hot!" said Goldilocks. She looked through her special magnifying glass to see the molecules moving around. She noticed that when the molecules bumped into an air molecule, some of their heat transferred to the air. "There are so many porridge molecules! It will take forever for all their heat to get there isn't very much porridge. It didn't take as long for the heat to move into the air because there.

Possible Goldilocks rubric:

| Surpasses proficiency | Story meets the requirements for proficiency, and contains information regarding the relationship between the amount of porridge and temperature beyond what was explicitly discussed in class. For example, the story may include a prediction about how long the porridge had been sitting on the table, based on data the students collected during the investigation. |
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| Proficient | Story includes:
• Relative amounts of porridge related to temperature ("too hot" bowl has the most porridge while the "too cold" bowl has the least)
• Explanation of why the porridge is different temperatures; this could be done in pictures and/or words; for example, Goldilocks could offer explanations for why the porridge is too hot or cold, or there could be a zoom-in box showing the molecules and containing a description of why molecules in one bowl are moving faster than others
Pictures and explanations help make the concepts more clear. |
| Approaching proficiency | Story includes the how the relative amounts of porridge relate to temperature and an explanation of why the porridge is different temperatures, but the information may be incomplete and/or contain misinformation. |
| Below proficiency | Story does not include the relationship between amount of porridge and temperature and/or an explanation of why the porridge is different temperatures; information that is included is incomplete or wrong. |
Goldilocks Investigation

You will be planning and conducting an investigation to discover what could cause the porridge to cool down at different rates. Instead of porridge, you will be using water.

How will you investigate this question? Use words and/or pictures to show how you can start your investigation.

What data will you collect? Make a table where you can record your data:
<table>
<thead>
<tr>
<th>Question: What causes the water to cool at different rates?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim:</td>
</tr>
<tr>
<td>Evidence:</td>
</tr>
<tr>
<td>Class discussion notes:</td>
</tr>
</tbody>
</table>