Lesson 1: *The Mitten Problem*

Overview

In this introductory lesson, students are presented with a formative assessment probe, *The Mitten Problem*, to elicit their current thinking about sources of heat energy. Students then design and conduct a follow up investigation to further develop their conceptual understanding of heat as a form of energy.

Teacher Background

How are a cup of boiling water, an iceberg, a wool sweater, and a woodstove similar? How are they different? Perhaps the first thing that comes to mind when one thinks of these items is a particular temperature such as hot or cold. People often think of objects in terms of temperature, being "warm," "cool," "hot," or "cold." Does this thinking indicate a misconception? Likewise, through early experiences, students develop intuitive notions about energy, including heat. Children often think of heat as an intrinsic property of a material or object. In other words, students often think of materials as being inherently hot or cold or as containing a certain amount of "hotness" or "coldness." Although heat is a form of energy and not a substance, it is often described as one. "Put on a warm sweater!" and "If you're cold, wrap up in a warm blanket!" are phrases many caring adults have said to children. Is this language misleading? Could these sort of innocent reminders contribute to children thinking that the sweater and blanket themselves are warm? Or are they made of materials with effective insulating properties? Why does a wool sweater feel warmer than a cotton sweater? The sweater, like the mitten used in this lesson, is not in and of itself "warm." The sweater does not give off heat, it is not a heat source, and it does not have a higher starting temperature than its surroundings. Often what is overlooked in this situation is that the person wearing the sweater gives off heat. Wool has insulating properties that are more effective in slowing the transfer of heat energy than cotton so the wool "holds in" the body's warmth more effectively than the cotton, thus making the person feel warmer.

This lesson begins with *The Mitten Problem*, an engaging and motivating question posed as a formative assessment probe. *The Mitten Problem* is designed to elicit students' initial ideas about heat using a familiar experience. While this probe specifically targets ideas related to sources of heat, this simple investigation provides a

stimulating and familiar context for students to explore and express their developing understanding about heat sources and insulators.

So what do a cup of boiling water, an iceberg, a wool sweater, and a woodstove have in common? All of theses substances are examples of matter and all have thermal energy.

> **Note:** *Students will be using thermometers during this and subsequent investigations. Determine if students are skilled in using thermometers and if not, provide needed instruction.*

Key Idea

- Objects and substances are not inherently "warm" or "cold."

Lesson Goals

Students will:

- explore their current ideas about heat.
- be able to differentiate between a heat source and objects or substances affected by a heat source.

Vocabulary

heat: the flow of thermal energy from a warm area to a cooler one.

heat source: anything that produces heat.

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Preparation

- Gather an assortment of mittens.
- Inspect thermometers. Use thermometers with enough precision as to not confuse students. Consider borrowing laboratory quality thermometers or using temperature probes.
- Make overhead of thermometer diagram.

Assess students' prior experiences with reading and handling thermometers. If necessary, provide students with a mini-lesson on how to read thermometers. Discuss precision and limitations of the instruments being used. Simple lesson ideas can be found at: http://www.bbc.co.uk/schools/scienceclips/teachersresources/ages8_9/tr_keeping_warm_offlp.shtml

Safety

Ask students to use caution in handling thermometers. Use only thermometers that contain alcohol (not mercury) and those that cannot easily be broken. Many classroom thermometers are affixed to a metal or plastic backing to prevent breakage and laboratory thermometers often come with a plastic or rubber ring that prevents cylindrical thermometers from rolling off table tops. Give students instructions before the lesson about safe procedures to follow should a thermometer break. Have a dust pan and broom ready in case of breakage.

Materials

Item	Quantity
The Mitten by Jan Brett	1 per class
Student Handout 1.1: *The Mitten Problem*	1 per student
Thermometers	2 for initial demonstration 2 per student pairs (or 1 per student)
An assortment of mittens	1 pair minimally per student pair
Scientist's Notebook	1 per student
Teacher Resource 1.1: Thermometer diagram (optional)	1 per class

Time Required: 2 sessions

Session 1: Read book, do probe and mitten investigation demonstration

Session 2: Plan and carry out investigation, hold scientists' meeting

Connection to *National Science Education Standards (NSES) and Benchmarks for Science Literacy Standards (BSL)*

- Energy appears in different forms. Heat energy is the disorderly motion of molecules. BSL 4E(6-8)
- Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. NSES B(5-8) 8

Teaching The Lesson

Engage

1 Read *The Mitten*.

Open this lesson by initiating a discussion about mittens, using the children's story *The Mitten* by Jan Brett. Say something like: *How many of you have read the story "The Mitten" before? By looking at the cover, what do you think this story is going to be about?* This will get everyone involved and will not exclude those students who may not have heard the story before. (Several have undoubtedly heard this simple, classic story before.) Explain that this tale relates to a problem you will be asking students to investigate today. Read *The Mitten* to students. At the conclusion of the story, ask students why they thought the animals climbed into the mitten. (To keep warm.) Ask, *"Do you think their strategy would work? Why or why not?"*

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2 Administer *"The Mitten Problem"* probe.

Provide each student with a copy of Student Handout 1.1: *The Mitten Problem*. Ask students not to put their names on their papers. Either read the probe aloud to the class or instruct students to individually read the probe and select a response that best matches their thinking about the problem. Make certain that students complete the last portion of the probe by explaining their reasoning. Give appropriate support to students who need help with their writing.

> **Note:** *Make certain that students know why they are doing this activity. The probe allows everyone's ideas to be shared. Reinforce how important it is to consider all ideas and set the expectation that as ideas are shared it is done so respectfully.*

3 Collect, distribute and review student responses.

After all students have committed to a response based on their current ideas, ask them to crumple their papers into a ball and upon a given signal, toss the paper balls around the room until instructed to stop. (A few **seconds** of tossing is sufficient to "mix" papers around the room!) Have students pick up or hold on to one paper, and make certain all students have a paper. Facilitate a discussion about *The Mitten Problem* by asking students to share the ideas and thinking that are on the "caught" paper (as opposed to

sharing their own ideas). Model how to respectfully share the responses of others by giving students the following example: "This person selected Response A: The thermometer inside the mitten will have a lower temperature reading than the thermometer on the table. The reason the person gave was that mittens have large holes that let cold air in and make the thermometer reading drop."

> **Note:** ***Commit and Toss****, the strategy used above, is a technique used to get a quick sense of the different ideas students have about a particular idea. It is a safe, fun, and engaging way for all students to make their ideas known anonymously to the teacher and to other students in the class without individual students being identified as having correct or incorrect ideas. It also helps students recognize that there are a variety of ideas in the room and allows students to privately compare their ideas to those of others in the class. The* ***Commit and Toss*** *strategy "incorporates an essential component of conceptual change teaching and learning- committing to an outcome based on students' own ideas." This strategy comes from the resource Science Formative Assessment:* ***75 Practical Strategies for Linking Assessment, Instruction, and Learning****, pages 65-68 by Page Keeley.*

Explore

4 Initiate an investigation.

After various student responses have been discussed, ask students what they could do to find out if the temperature reading of a thermometer would increase, decrease, or remain the same inside the mitten. Students most likely will suggest how they would carry out an investigation.

Carry out this initial inquiry of the question above as a demonstration in a place visible to all students:

- Post the guiding question on a white board or chalk board for students to see and refer to: *How can we find out if the temperature reading of a thermometer will increase, decrease, or remain the same if the thermometer is placed inside a mitten?*
- Show students the materials available for the investigation: two thermometers and a mitten. Ask students if they can think of anything else that might be needed to carry out this investigation.
- Ask students what information is important to monitor and keep track of during the investigation. Ask students how they will determine if the mitten has an effect on the thermometer's temperature reading? This will remind students that they need to note and record in their scientists' notebooks the starting temperature of each thermometer (room temperature).

Note: *You may wish to use an overhead copy of the thermometer visual aid to record the starting temperature by coloring in the thermometer to the appropriate reading.*

- Put one thermometer in the mitten and leave the other thermometer uncovered on the table. Ask why they think two thermometers are needed. (The unwrapped thermometer is the "control" in the investigation and without that we would have no way to determine if the mitten was having an effect on the thermometer reading.
- Ask students to describe their thinking using diagrams or sketches to answer the following in their scientists' notebooks: *What do you think will happen to the temperature reading of this thermometer if we put the thermometer inside this mitten?*

  Note: *You may wish to note the start time and the end time of the investigation. Run the investigation for a fairly short period of time – about 3-5 minutes.*
- After students have been given the opportunity to record their thoughts, ask students to share with a partner.

5 Examine results.

Read the thermometers or ask a student volunteer to compare the temperature readings on the two thermometers. Ask students to record the temperatures in their scientists' notebooks. Students may be surprised to learn that the thermometer readings are the same. Ask students to record in their notebooks their thoughts and ideas about what they observed. Have students share some of their thoughts with the class.

Note: *Students commonly believe that some materials, such as blankets and sweaters, are intrinsically warm and that some, such as metals, are cold. (Driver et al. 1994). Students may suggest a variety of reasons for the temperature readings that they observed. Students may believe that the thermometer needed to be left wrapped up inside the mitten for a longer period of time; they may say the thermometer needed to be wrapped up in more layers or more snugly to "warm up" the thermometer; or they may suggest the thermometer is broken. Whatever reasons students give at this point should not be discounted or corrected.*

6 Plan student-designed investigation.

Tell students that they will be working in pairs to conduct their own investigation to further explore their ideas about why the temperature reading inside the mitten was the same as the temperature reading outside the mitten. Use the following guiding questions to help students focus and plan their own investigations:

- *What is the focus of your investigation?* Students should focus on one aspect to investigate, for example: length of time thermometer is left in mitten, number of layers (bundling or wrappings), using different types of mittens, or faulty equipment, etc. Student pairs in the class can choose to investigate different aspects of the problem, but each student pair should work together to investigate only one variable.

Note: *Pushing students to focus on one aspect of the thermometer problem will help them determine what information should be monitored and recorded during their investigation.*

- If students think the temperature will increase if it is left wrapped up in the mitten for a longer period of time, ask them to predict how long they think it will it take.
- If students think that the thermometer was not wrapped tightly enough or covered in enough layers, ask them to predict how many more layers or suggest how it could be wrapped differently.
- Ask students who think using different kinds of mittens will result in a higher temperature reading to predict how much hotter they think it will be in the different types of mittens.

Note: *Keep investigations simple. Students may want to take the mitten experiment outside, especially during the winter or place the mitten in a refrigerator or freezer. In doing so, students may inadvertently collect data that reinforces the misconception that mittens are a source of heat. Two potential problems arise: 1) students see a higher mitten temperature because the thermometers are not left long enough; 2) mittens are insulators and external factors such as wind and sunlight affect the readings. Advise students to design experiments that DO NOT involve putting the mitten in a new environment.*

Note: *It may be wise to give students a time limit for carrying out their investigations.*

Ask students to record their investigation question and prediction and to design a data table for their investigation in their scientists' notebooks. Students may include pictures of how the investigation is going to be carried out. Visit each student pair to make certain they have a clear plan in mind before providing materials for them to investigate their question. Remember that the purpose of this informal investigation is to explore initial ideas about heat rather than writing extremely detailed procedures or constructing complex data tables.

7 Provide materials for students' investigations.

Each pair of students will need two thermometers and a mitten. Allow students to carry out their investigation. Remind students to record their findings in their notebooks. Circulate among student pairs as they work. Ask guiding questions, make note of current thinking, and observe investigative behaviors.

Reflect And Discuss 

8 Consider results and draw conclusion.

Ask student pairs to:

- review their findings
- write a concluding statement supported with evidence for their investigation in their notebooks. Consider providing the following scaffold for this step:
  After 5 minutes in the mitten, the temperature of the mitten was _____
- record a least one new question they have as a result of their investigation.

9 Hold a scientists' meeting.

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Pair each student investigative team with another investigative team. Ask students to use the information in their notebooks to summarize how they carried out their investigation and share their findings and new questions with one another. Again, circulate among groups, listening to their conversations.

10 Debrief the experience as a large group.

Ask students to bring their notebooks and sit in a large circle for a science discussion. Start the discussion by summarizing students' experiences thus far: *We began investigating what would happen to the temperature reading of a thermometer that was placed inside a mitten. Our initial investigation showed that the thermometer placed inside the mitten had the same temperature as a thermometer that was not placed in a mitten. This seemed surprising! Each of you then conducted a follow up investigation to test your ideas and to find out more. The focus of this discussion will be to share your current ideas based on your findings from your investigations and to share your new questions.*

Invite students to share their current ideas but insist that they support what they say with evidence. Encourage students to cite evidence from their own investigation or from their peers. Use this

discussion to inquire more deeply about students' ideas concerning heat. Keep a list of the new questions students have about heat.

At this point, do not confirm that the mitten will not change the temperature reading of the thermometer because the mitten does not generate its own heat. This is an introductory lesson. It is not expected that students attribute the unchanged temperature readings to the mitten not being a generator or source of heat now. Heat is a very challenging concept and students will need numerous experiences to build an understanding of thermal energy.

11 Bring lesson to a close.

Acknowledge that this initial experience may bring forth more questions than answers and that the questions students have about heat will continue to be explored in the next few lessons.

> **Note:** *Some students may believe that certain objects and substances are intrinsically "warm" or "cold." Therefore, in spite of the first hand experiences with their own investigations, they may have great difficulty in recognizing that blankets, hats, and mittens are not generators of heat and that this explains the unchanged thermometer readings. While it is tempting to* ***tell*** *students that items generally thought of as "warm" (blankets, hats, and mittens) are not generators of heat and, therefore, are not capable of changing the temperature reading on a thermometer, it is best to bring the discussion to a point where students are able to agree on a tentative explanation as to why the temperature reading did not change. Students can revisit and reevaluate this thinking as they have more experiences with what heat is and how heat is transferred.*

Extensions

Student may:

- extend their mitten experiments by testing for a longer period of time.
- test other items they perceive as "warm." (Gloves, hats, scarves, jackets, blankets, etc.)
- visit WGBH's *Surviving Winter*. This media-rich activity explores the various physical and behavioral adaptations that animals rely on to help them survive changing environmental conditions, such as the arrival of winter. http://www.teachersdomain.org/resource/adlit08.sci.sawinter
- learn more about Chester Greenwood , a Maine inventor of Ear Muffs.

  http://www.visitmaine.com/article/at_chester_greenwood_day_its/?vm=l26qngdu6o8i22dr8lk4lnsrc3

  http://inventors.about.com/library/inventors/blgreenwood.htm

  http://www.ideafinder.com/history/inventions/earmuff.htm
- learn more about weather in Maine.

Connection to Maine Agencies

A Maine Energy Education Program (MEEP) representative and will come to interested schools, free of charge, to guide and support the concepts in lesson. For more information go to the MEEP website: http://www.meepnews.org/classroomactivities.

For schools in Aroostook County, a Maine Public Service (MPS) representative will come to interested schools, free of charge, to guide and support concepts developed in this lesson. A description of programs is available at www.mainepublicservice.com. Click on the education section of the site. To schedule a presentation contact Nancy Chandler at 207.760.2556 or nchandler@maine publicservice.com.

Online References and Resources

Annenberg Media. (1997-2009). Essential Science Series: Physical Science, Workshop 7
http://www.learner.org/resources/series200.html