Hot Cans

Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

In this 3-day activity, teams of 3 students design a system for keeping a can hot. All cans get hot water at once, and teams are challenged to keep their can as hot as they can. Students have learned about conductors and insulators in grade 4 and explored conduction, convection and radiation in earlier activities. On the first day, teams decide on materials and draw a few designs to try during the next class period. During the next class, they try out and analyze designs. On the third day, they choose their best design, run it, look at other designs around the class, and predict which ones they think will work best. In the process, they explore data from the whole class to draw conclusions about practical applications of materials with regard to heating and cooling.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- How heating and cooling affect different materials,
- How materials can be used as thermal conductors and insulators.

Students demonstrate this knowledge and understanding by:

- Designing and building a device to keep a can warm,
- Evaluating the usefulness and characteristics of materials used as thermal insulators.

Correlations to NC Science Standards

5.P.3.2 Explain how heating and cooling affect some materials and how this relates to their purpose and practical applications.

Brief Science Background

A hot teapot sitting on a table in a cool room eventually cools to room temperature, even with a tea cozy on it. Things that are hotter than their surroundings and have no source of energy eventually cool down. However, a tea cozy does slow the rate of cooling. Common devices for keeping things warm include thermos bottles, foam cups, and insulated lunch boxes. Insulators are often nonmetallic and lightweight for their size. To stop heat loss, they are fashioned to surround the thing they are meant to keep warm. Similarly, a metal handle on a pot on the stove conducts heat from the pot to your hand, and can burn a person. To prevent this, pot handles are often made of insulators, which conduct heat slowly.

Materials

Materials for the whole class all 3 days

- Newspaper*
- 1 box sandwich bags
- 2 rolls masking tape
- 1 roll box tape
- 1 thermos
- 1 Hot Pot
- 1 Funnel
- wash cloths to use as hot pads
- 2 cans per team
- 1 can lid per team
- 1 digital thermometer per team
- 1 roll aluminum foil

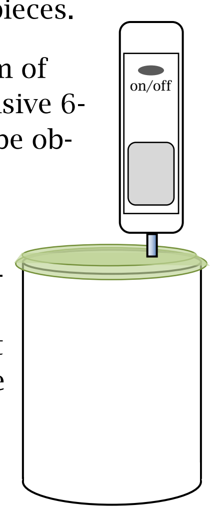
Materials for groups of 3 students all 3 days

- 1 empty 6-oz aluminum can
- 1 can topper
- 1 digital thermometer
- wash cloth to use as a hot pad
- access to insulating and building materials such as newspaper, fabric, foam, sandwich bags, tape, etc.
- science notebooks (1 per student)

Part 1 — Hot Can Warmer Designs

Preparation

1. About a week before the activity, send home a note requesting clean scrap fabric, such as T-shirts, socks, sheets, flannel, wool, etc. for students to use as insulating material.
2. A few days before this activity, collect newsprint (5-6 old newspapers from the library) and cardboard for students to use as structural pieces.
3. You will need a rinsed 6-oz aluminum soda can for each team of three. All teams must use this same small-sized can. Inexpensive 6-oz 6-packs of soda are available from WalMart, or these can be obtained from home.



Procedure

1. Explain that teams of three will work on an engineering challenge to keep a can hot. Teams will get a sealed can of hot water with a thermometer in it. **Show an example.** Teams must design a system to keep the can hot using materials from the classroom and from home. The best designs will show the least temperature change after 10 minutes.

Procedure

2. Show tape, sandwich bags, foam, newsprint, cardboard, and all other items available for designs. Explain that teams can bring teacher-approved items from home if they follow these rules:
   - Raw materials only, no commercial products designed to keep things warm such as soda koozies, insulated lunchboxes, etc.
   - Things that can be destroyed as part of the activity (nothing of value).

3. Set up teams of three and give each a copy of BLM 1. Ask them to use the rest of the class period to draw designs and list materials on BLM 1 in the "Draw and Describe Design" column. Remind them that designs must be simple and assembled quickly. At the end of class, each team will show the teacher BLM 1 with their designs and lists of items to bring from home (also listed on BLM 1). Students can only bring in things that the teacher approves.

Part 2 — Hot Can Warmer Trials

Preparation

1. Have cans, tape, wash cloths to use as hot pads, and all other materials available.

2. Starting about 20 minutes before class, heat pots of water twice, one after the next. Store these in the thermos for the first trial and adjust to 130-140 ˚F. Before class, pour the hot cans, snap on plastic covers, and insert the thermometer probes. To keep them warm, bunch them and cover with a small blanket or coat. Give them out with rags to use as hot pads.

3. Have a hot can for your "control" for both trials (a new one for each trial). This can sits out on a table with no insulation. The teacher records its temperature when each trial starts and again when the trial ends. After each trial, calculate its temperature drop and give this number as the example of what happens when nothing is done to keep it warm.

4. <u>Second Trial Hot Cans</u> The second trial requires another full thermos of 130-140 ˚F water. Heat more water right after filling the thermos with the first two pots for the first trial. When you have emptied the thermos into the first trial cans, this third pot will be hot and can be poured into the thermos. Heat a fourth pot while students work on the first trial, add it to the thermos, and adjust temperature. Treat the second trial hot cans just as in step 2 above.

Procedure

1. Explain that teams will try out two ideas today in two 10-minute trials. The goal for each trial is for the temperature of the can to drop as little as possible. Give out BLM 1 and ask teams to enter first trial data in the "Trial 1" section. Show teams how to turn thermometers on and read 140 ˚F (if a thermometer times out, they can turn it on again).

2. Ask everyone to get their materials and say that they will get a hot can in 3 minutes. After 3 minutes, with materials gathered, give out the hot cans with a rag to use as a hot pad. Set out the control can and record it's starting temperature. Ask teams to record their starting temperatures on BLM 1. Say that

Procedure Cont.

everyone now has 10 minutes to build a design they made during the last class, with the hot can.

3. After 10 minutes, ask everyone to record the final temperature of their can and temperature loss (subtract final temperature from starting temperature) on BLM 1 under Trial 1.

4. Let everyone know the temperature loss of the control can. Designate a "refill depot" in the room. Ask teams to return their cans there then fill in the analysis section of BLM 1. While teams do this, empty the trial 1 cans and refill them with hot water for trial 2.

5. Conduct trial 2 by repeating steps 1-4.

6. Ask teams to use the back of their record sheet to sketch and describe a plan for the final challenge. Remind them to have these plans ready for the next class period. If a team wants to bring in more materials, ask them to list them. As before, they can bring in only things that you approve.

Part 3 — Hot Can Warmer Challenge

Preparation

Preparation is the same as for the previous class period except that you will need to make copies of BLM 2, 1 per team.

Procedure

1. Be sure that everyone has their design drawings and descriptions and a science notebook. Explain that teams will try designs made using lessons learned from the two trials. Ask them to be prepared to record the starting and final temperatures of their can and the control can. Assign each team a number and ask them to write that number next to their Hot Can Warmer.

2. Say that this time, teams have 3-5 minutes to get ready. After that, nearly everything will go as with the previous 2 trials. The best design is the hottest after 10 minutes.

3. Give each team a copy of BLM 2. Give access to building materials and allow 3-5 minutes to build the Hot Can Warmers.

4. After 3-5 minutes, give out hot cans and set aside a control as before. Call "start." Take the temperature of the control. Remind teams to record their starting temperature. The teacher takes the starting temperature of the control can, <u>then turn their thermometers OFF</u>.

5. When all thermometers are off, tell students that they have nearly 7 minutes to circulate around the room and find the three set-ups that they think will be most successful. Ask them to write those 3 numbers in their notebooks, and beside each number, include a reason why they think that particular Hot Can Warmer will be one of the top 3.

6. After nearly 10 minutes, tell teams to turn their thermometers back on. At 10 minutes, call "stop" and ask everyone to record their final temperature. At this time, the teacher records the final temperature of the control can.

Procedure

7. Ask each team to call out their team number, their final temperature and the temperature loss. When they finish doing this, the teacher calls out and records the starting and final temperatures of the control can. Ask students to write these numbers by each team number on BLM 2, and the control can numbers in the appropriate blank. These will be used in the wrap-up in the next class period.

8. If possible, maintain all of the setups with the cans in them, or if this is not possible, take pictures of them. The setups are useful in the wrap-up during the next class period.

Wrap-Up

1. Take a poll of predictions: "Which team numbers did you predict would be in the top 3?" and record the results on the board as a frequency table.

2. Show the results taken on the previous day by team number. Ask: "Which Designs Worked Best?"

3. Ask: "If you could do yours over, what would you try?"

4. Discuss the materials that people used and how they worked.

5. Discuss characteristics of materials that worked well and those that did not work well.

6. Introduce the terms "heat conductor" and "heat insulator" and relate these to students' designs and other elements of the activity (e.g. the aluminum in the can is a heat conductor).

Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions before an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write responses in notebooks.

1. Four cups made of different materials were filled with a hot drink 30 minutes ago. One cup is glass, one is metal, one is Styrofoam™, and one is plastic. Circle the following choice that places the cups in the correct order of how hot they would keep the drink.

	Cool	**Lukewarm**	**Warm**	**Hot**
A.	Glass	Metal	Styrofoam	Plastic
B.	Metal	Glass	Hard plastic	Styrofoam
C.	Styrofoam	Metal	Glass	Hard Plastic
D.	Styrofoam	Plastic	Glass	Metal

2. Race car engines get very hot during races. An engineer wants to put a material between the engine and the driver to protect the driver from the heat. The engineer is choosing based characteristics of the material. Circle the choice below that you think would work best. The thing that would work best:
   A. is very heavy and thin
   B. allows air to pass through it
   C. is flexible and heavy
   D. is lightweight and thick
3. Circle the choice below that best completes the following sentence. A cup of hot liquid that you can hold your hand is made of a material that has the property of being a good...
   A. ...heat conductor.
   B. ...heat trap.
   C. ...heat insulator.
   D. ...heat filter.

Answer Key

1. **B**
2. **D**
3. **C**

Extensions

1. Try the reverse of this activity with cans of cold water (not ice water). The object is to keep the water warmest.

2. Pose the question: What would happen to the temperature of two cans if we put no water into a control can, and no water in another can placed inside a really good Hot Can Warmer setup? Try it. Wait 10 minutes, and read the thermometers. **The thermometers will read the same.**

3. Ask: What is the Hot Can Warmer doing to the can? Discuss this with students. **A good hot can warmer slows heat from leaving the can, but it does not make heat. Insulation does not warm things. If the two cans start out at the same temperature, and no source of energy heats either one, insulation will make no difference in temperature.**

BLM 1 Design Record Sheet

Trial 1

temperatures	labeled drawing and description of the design	analysis of results
YOUR CAN Starting temperature________°F Final temperature__________°F Temperature loss__________°F **CONTROL CAN** Starting temperature________°F Final temperature__________°F Temperature loss__________°F	Items needed from home: ______________________ ______________________ ______________________	

Trial 2

temperatures	labeled drawing and description of the design	analysis of results
YOUR CAN Starting temperature________°F Final temperature__________°F Temperature loss__________°F **CONTROL CAN** Starting temperature________°F Final temperature__________°F Temperature loss__________°F	Items needed from home: ______________________ ______________________ ______________________	

On the back of this page, draw your final design and list all materials needed.

BLM 2 Hot Can Warmer Predicted Results

In the left column, circle the 3 Hot Can Challenge Teams that you predict will have the best results. In the right column, describe features of these designs that you think make it work well. Record actual results for the Control Can *and* your 3 choices in the columns labeled "Final Temperature" and "Temperature Loss."

Team #	Final Temperature	Temperature Loss	Features of the circled team's Hot Can Warmer that you think will give good results.
CONTROL CAN			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Appendix

Common Student Preconceptions About This Topic

Many 5th graders think of heat as a substance that can flow into and out of objects, rather than as energy that can be transferred. They also think that cold is the opposite of heat, a substance that flows in the same way, like a fluid. With regard to the effects of heat insulators, many children predict that a thermometer placed in a mitten will give a higher reading than one placed outside the mitten. It seems only natural to them that the mitten makes warmth.