Heat -- It's as Easy as ONE, TWO, THREE!

Summary

Students will learn the difference between conduction, convention, and radiation.

Materials

- *Heat Partner Practice*
- Literary Reading -- Heat
- HEATO Bingo sheet
- HEATO Definition Strips

Amazing Ice Melting Blocks (set)
Ice cubes
Large sheet of drawing paper
Small Three Musketeers bar

Activity #2

Transparent container (small fish aquarium)
Baby food jars
Ice water dyed blue
Boiling water dyed red
Aluminum foil
Rubber bands

- *When Hot and Cold Meet Warm*

Activity #3

Gooseneck lamp
Aluminum foil
White and black construction paper
Glue stick
Small rectangular box (5"x7")
Thermometers

- *The Tale of Three Colors*

Heat cluster cards

- Heat tri-fold brochure

Background for Teachers

Everything is made up of small particles or molecules. Heat energy is the random movement of these molecules. The molecules in matter are constantly moving, but the hotter something is the faster the molecules move. When fast-moving molecules touch slow-moving molecules energy is transferred. The slow molecules speed up and the fast molecules slow down until the molecules eventually move at the same speed. Heat always travels from hotter to cooler objects. If you were to step barefooted onto a tile floor it might seem as though the "coldness" of the tile transferred into your foot making it cold. The heat energy, however, is actually transferring into the tile from your warm foot making the tile warmer and leaving your foot feeling colder. Heat energy can move from one object to another in three ways: conduction, convection, and radiation.

Conduction is when heat energy travels from one object to another by direct contact between the molecules. Heat is transferred from one molecule to another without the movement of matter itself. Think of a time you may have burned your hand by touching a hot spoon in a pot of hot water on the stove. The heat transfer actually started with the hot burner on the stove. The fast-moving particles of the burner transferred energy by contact into the slower-moving molecules of the cool pan, making

the pan's particles move faster and become hotter. The fast-moving particles in the pan then transferred into the slower-moving particles in the cool water making it hot. The hot water then transferred its heat energy into and up the metal spoon, making it hot to the touch of your hand.
Convection is the transfer of heat by movement of currents within fluids, such as a liquid or gas, causing the fluid matter to move. When heat is transferred by convection, slow-moving molecules in the fluid began to move faster, and they also move farther apart. As a result, the heated fluid becomes less dense and floats to the top. The more dense (cooler) fluid then sinks to the bottom. Many students are under the misconception that heat rises, but it is actually hot fluids (gas and liquids) that rise. Convection produces global winds that form Earth's weather when air is heated by the Sun. It also produces the ocean currents when warm water meets the cold.
Radiation is the transfer of heat energy by electromagnetic waves and (unlike conduction and convection) does not require a medium in which the energy is transmitted. Students often incorrectly think that radiation radiates only downward because heat radiated from the Sun appears to radiate down. Heat energy actually radiates out in all directions from the energy source, such as radiated heat from a fire moving up to cook a marshmallow held above it. Any object that has more heat energy than another radiates heat to the cooler object. This is the reason a room heats up quickly when it is filled with hot student bodies. Since heat and light travel by electromagnetic waves and do not require a medium, heat and light travel through space to Earth, while sound can not.

Intended Learning Outcomes

1. Use Science Process and Thinking Skills.
3. Understand Science Concepts and Principles.
4. Communicate Effectively Using Science Language and Reasoning.

Instructional Procedures

Invitation to Learn
Discuss with the students the common occurrence of items coming in three's. List the ideas the students generate on the board. Examples are: the three bears, three little pigs, three billy goats Gruff, three Stooges, Three Musketeers, three blind mice, etc. Discuss how heat also comes in threes and illustrate by mapping their brainstorms on the board. (Transferred three ways, creates three states of matter, measured in three temperature scales, etc.) Divide the class into groups of three and tell them that you expect them to perform together as the Three Musketeers, not the three blind mice or Three Stooges. Tell the students that during the next three days they are to work together to discover how heat is transferred in three ways.
Instructional Procedures
The Three Sponges -- These three heat sponge activities keep students actively engaged during common time wasters, such as class changes, teacher set-up, students finishing early, etc. (These simple strategies can be used by the teacher for any science topic or content area.)

- Partner Practice Procedure (two minute timed bell work, students work together to learn the big ideas)
  - As you enter the room, get your *Partner Practice* (PP) sheet & begin.
  - Face your partner & hold the PP sheet between the two partners, so the practicing partner sees the question side.
  - The practicing partners ask themselves the questions and then answer the questions.
  - The other partner corrects from the answer side as needed.
  - Repeat steps b-d with the second partner.
- Literary Readings (one minute timed read to gain information while increasing reading fluency)
  - Read the Literary Reading orally but quietly to yourself.
  - Read as fast as you can and try to beat your previous speed.

Record your gain in words per minute each time.

Vocabulary "Bingo" Games (students review critical vocabulary in a fun way)

Write the targeted vocabulary words randomly in the squares on your "Bingo" sheet.

Listen to the description of the word and place a marker on the correct word.

Call out if you have five markers horizontally, vertically, or diagonally.

Activity #1 -- The Three Ring Circus -- Conduction

Pass around the two amazing ice melting blocks, allowing the students to discover that one block seems somewhat cold to the touch, while the other seems warm.

Tell the students that today they are going to witness a disappearing act where 3 ice cubes will disappear in a three-ring circus act. Their mission as the Three Musketeers is to predict correctly how much time it will take for each ice cube to melt. One will be placed on the cold block, one on the warm block, and one on a black square of construction paper placed on the desk. They are to work together as a group and record their predictions in their journals.

Place an ice cube inside each rubber ring on the three black surfaces and wait as the students observe. (The ice cube on the aluminum completely melts within two minutes, and the students are always surprised and curious as to why.)

Tell the students to compare the actual results with their predictions. They are also to discuss among themselves as to why the ice cube could have disappeared so quickly and record their reasons.

Have each group share their explanations with the class and encourage class-wide debate. With guidance the students should discover that because the aluminum block conducts so well, its heat (room temperature) is transferred quickly into the ice cube (0 C). Discuss other forms of heat transfer by conduction and how some materials allow this transfer and others do not.

Follow the activity by discussing other examples of heat conduction. Give each group a large sheet of drawing paper and have them illustrate as many examples as they can. The group with the most examples wins the prize (a Three Musketeers candy bar, of course).

Activity #2 -- Three Temperatures, When Hot and Cold Meet Warm -- Convection

Ask the students what happens when hot and cold meet warm. Tell them they are to work together as the Three Musketeers to discover what will happen when hot water and cold water are introduced into warm water. They are to discuss and come up with a prediction of what will happen. Pass each group a copy of the *When Hot and Cold Meet Warm worksheet*.

Fill the transparent container with room temperature water.

Fill one baby food jar with boiling water and add three drops of red food coloring. Cover the jar with aluminum foil and put a rubber band around the neck.

Gently lower it into the container, turning it on its side.

Puncture the aluminum foil in the middle and again near the edge with a pencil point so the colored hot water can flow out. If the water doesn't flow out, you may need to put the pencil into one of the holes to release any trapped air bubbles. (The hot red water will float to the top of the room temperature water.) Have the students observe and draw what is happening on their worksheet.

Fill the other baby food jar with ice water and add three drops of blue food coloring. Cover the bottle with aluminum foil and put a rubber band around the neck.

Repeat steps four and five with this jar.

Have the students discuss within their groups what happened, compare it to their predictions, and determine why it happened. Have them share their thoughts with the class and discuss how convection works. Discuss other examples of convection. Have each group list as many examples of convection (completely described) as they can on the back of their worksheet. They may use textbooks and other sources, and the group with the most examples wins the prize.

Activity #3 -- The Tale of Three Colors-- Radiation

Previous to the activity make the three colored flat surfaces, the three colored envelopes, and the three-chambered box. To make three chambered box, find a small rectangular box (approximately 5" by 7") and cut two pieces of heavy paper (oak tag, poster paper, etc.) as long as the inside of the box (lengthwise) and as tall as the box. Place the two pieces in the box and tape them so that they divide the box into three equal chambers.

Use the aluminum foil to cover the bottom and all sides of the center section and glue the foil in place. Cover one section with the white paper and the third section with the black paper. When finished, the box will have three chambers: one black, one white, and one silver.

Cut 6 pieces of construction paper, four white and two black, that are 6" x 4". Cover one side of two of the white squares with tin foil and glue in place.

Fold one of the black pieces, one of the white pieces, and one of the silver pieces in half. The three folded pieces should now be 6" x 2". Tape the bottom and long side of each piece to form three envelopes. (Set the remaining three pieces aside.) Now you are ready for the activity. Tell the students that as the Three Musketeers, they have a special mission to discover how color affects radiated heat. Pass out the worksheets and remind them they will need to be precise in the data they keep.

Lay a thermometer on top of each of three squares of paper: a white piece, a black piece, and a silver foil piece. Have the students write down the starting temperature (C) of each thermometer on the worksheet. (Select one Musketeer from each group to witness each experiment and verify the temperatures.) Place the pieces evenly under the lamp so they will all get the same amount of light and turn it on. While waiting for the time to pass they are to predict the outcome.

WARNING: Do not touch the lamp after you have turned it on, as it gets very hot!

Check and record the temperature after five minutes and again after 10 minutes.

Cool the three thermometers to room temperature and then place them inside each of the three envelopes. Write down the starting temperature (C) of each thermometer on the worksheet. Place the envelopes evenly under the lamp so they will all get the same amount of light and then turn it on.

Watch the clock and allow the lamp to shine on the envelopes for five minutes. While waiting for the time to pass have the students predict which envelope will get the hottest. Check the thermometers quickly and have the students record the temperatures of each envelope on the worksheet after five minutes and again after 10 minutes.

Take the thermometers out of the envelopes and allow them to cool again to room temperature.

Now place the thermometers in the three-chambered box. Place the box under the light so each chamber gets the same amount of light and then check the clock and time the box for five minutes. Have the students record their predictions. Record the temperatures after five minutes and then after 10 minutes.

After the students have gathered the data, have them compare the results with their predictions. After they have filled out their worksheets discuss why they think there was a difference between the three placements. Discuss possible applications of the results.

On the back of their worksheets have them demonstrate what they have learned and come up with as many applications to life situations as they can that show an understanding of heat and color. (You wouldn't wear a dark shirt on a hot, Sunny day. You could put a silver lining on your windows to keep the heat out. You could wrap yourself in a silver survival blanket to keep the heat in on a cold day or place it above your head as a canopy to keep cooler on a hot day. You could line a solar oven with silver to heat better and add black to help absorb the heat.) The group with the most heat applications wins the prize.

Extensions

Curriculum Extensions/Adaptations/Integration

Have students test to see which spoon (wooden, plastic, or metal) conducts heat best by gluing a marshmallow with a dab of butter on each spoon handle and pouring boiling water on the bottom of the spoon to see which marshmallow drops first.

Have students fly a hot air balloon by filling plastic bags with hot air from a blow dryer or floating a solar bag heated by the Sun's radiation.

Have students design and construct an Ice House that will prevent an ice cube from melting and have a class-wide Great Ice Race.

Have a Three Musketeers conduction race. Tie three small candy bars with a string and attach each string to a long copper rod or hanger suspended on two blocks of wood. Attach each string to the rod with a piece of wax, making sure they are at least two inches apart. Have the kids predict what time each musketeer will drop from the rod when a flame is held on the end of the rod.

Have students predict what will happen when hot water is placed over cold water and cold water over hot water and experiment with the baby food jars and colored water.

Family Connections

Students could design and construct solar ovens and test their effectiveness by cooking in them.

Have students keep a log and document examples of conduction, convection, and radiation they observe at home for a week.

Have students keep a weather log for a week and explain how convection creates weather patterns.

Have students conduct a home energy assessment to determine where heat energy is being lost in their homes and how heat loss can be lessened.

Assessment Plan

The Great Heat Race, a fun cluster activity where students compete in groups to be the first to place the cluster pieces under the correct method of transfer: conduction, convection, or radiation. Through informal observation the teacher is able to discover many student misconceptions.

The Heat Brochure: Students make a tri-fold brochure. On the front they write the thee ways heat is transferred and illustrate an example of each. On another side they write and illustrate the three states of matter. On one page they draw the three temperature scales and write the freezing and boiling points for each.

Bibliography

Stahl, S., & Hayes, D. (1997). *Instructional models in reading*. New Jersey : Lawrence Erlbaum Associates, Inc.

"Studies have shown that when students work cooperatively, as opposed to competitively or individually, student achievement is increased, attitudes toward learning are better, social bonds between students are more positive, and students' self-esteem is higher (Johnson & Johnson, 1991: Johnson, Johnson, & Holubec, 1990; Slavin, 1990)."

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