The Best Sock for the Job

Goal: To determine the sock material that is best at keeping heat close to the body (feet in particular) when the material is both dry and wet.

Grade Level: 9th (but can be adapted for 10th-12th)

Class: Physical Science, Earth Science, can be adapted for Physics.

Objectives:

Students will be able to:

1. Identify patterns in the data and explain these patterns based on evidence gathered in the experiment.
2. Explain the transfer of heat through a material, based on the materials insulating/conducting ability due to its make-up.
3. Explain why heat transfer is affected because the insulating or conducting abilities differ between materials when they are dry or wet.
4. Determine the best sock material (wet or dry) that a person would want to wear on a cold winter day, from empirical data.

Background Information:

Weather is a part of everyday life and can affect little things such as your choice of clothes or activities. Several factors contribute to how well your body maintains its normal temperature – air temperature, wind, clothing, intensity of activity and the body's ability to adapt to compensate for the cold environment. The extremities lose heat quickly because they have a greater surface-to-volume ratio. Extremities do generate their own heat; it must come from the core body areas. So any heat lost through clothing must be replaced from the core. Losing heat at a faster rate than replacement can put the extremities into dangerous situations.

Winter weather emergencies can include hypothermia and frostbite. The air temperature does not have to be below freezing for someone to experience cold emergencies. Wind speed can create dangerously cold conditions even when the temperature is not that low.

If you must go out in inclement weather, the Red Cross offers the following guidelines to help prevent weather-related illnesses and emergencies:

- Dress appropriately for the environment and your activity level.
    - Dress in layers so you can adjust to changing conditions, and avoid overdressing.
    - Put on a hat, preferably one that covers your ears, since most body heat is lost through your head.
    - Choose mittens over gloves, if possible, as they provide more warmth to your hands.
    - Wear waterproof, insulated boots to help avoid hypothermia or frostbite by **keeping your feet warm and dry** and to maintain your footing in ice and snow.
    - **Remove wet clothes immediately** and warm the core body temperature using a blanket and/or by drinking warm fluids like hot cider or soup.
- Avoid being outdoors during the coldest part of the day.
- Reduce the intensity of outside activities and take frequent breaks.
- During breaks, drink warm fluids to help your body stay hydrated and maintain a normal temperature. Avoid beverages containing caffeine or alcohol as they hinder the body's temperature-regulating mechanism. Dehydration is dangerous and, unfortunately, is less noticeable in cooler temperatures.

Keeping dry is very important. You want to change wet clothing frequently to prevent loss of body heat. Wet clothing loses all of its **insulating** value and transmits heat rapidly. Insulation is the name of the

game! Insulation is a material which slows down the movement of heat. Your home and school are insulated. It's usually in the attic and behind the wall. It helps keep the heat in during winter. Some materials make better insulators than others. This experiment can tell you what materials will keep our bodies warm in the winter. For example, would a jacket made of wool be better than a jacket made from cotton? Will wool socks keep your feet warmer than cotton socks in the winter? If you get your socks wet how much heat will you lose? If you know you are going to get wet, which type of sock would be the best insulator while wet?

Materials List: (for a class of 28 working in pairs)

14 glass bottles ~ 20 oz. (old coke bottles work best)

15 thermometers

14 one-hole stopper

Large pan w/lid (big enough to fit all bottles into and cover)

Metal trivet (for bottom of pan)

14 different pairs of socks (must have wool, synthetic cold weather socks, cotton, fleece, synthetic dress, others can be class choices).

Stopwatches or other timing device

Procedure:

1. Place trivet into large pan and add water until it is about an inch over the trivet (~ 3 inches deep).
2. Place pan on a large hot plate or on a stove.
3. Fill bottles with water to ~1 inch from top.
4. Place 1 thermometer in pot with bottles (prop up on bottles).
5. Cover and heat until water is ~90ºC (ASSUMPTION: water temperature in bottle is same as temperature of water outside bottle).
6. Meanwhile: take 14 thermometers and carefully work them through the 1-hole stoppers so that about 1/3 of thermometer is below the stopper and 2/3 is above the stopper (so you can read the scale clearly above the stopper).
7. Divide the sock pairs into two piles; get one pile completely wet, slightly wring out.
8. When bottles have reached desired temperature, have student pairs pick up a dry and wet sock pair.
9. QUICKLY take bottle out of pan, securely place stopper-thermometer into the bottle, carefully drop into one of the socks.
10. Students take sock outside and start the data collection. Repeat with all socks.
11. Data collection: Students take baseline temperature of each sock (record in data table); another temperature is taken each minute for the next 20 minutes (record in data table).
12. When all groups are finished, data is exchanged and a class data set is constructed (if time limits exist, teacher can collect all data and construct a class data set to be handed out on a subsequent date).

Graphing:

1. Using the class data set construct 2 graphs; one for the dry socks and one for the wet socks.
2. Place Temperature (ºC) on the y-axis and Time (minutes) on the x-axis.
3. Make sure a key is included and label the graphs and the axes.

Analysis Questions:

1. Which dry sock was the best insulator? Explain why in terms of the data.

2. Which wet sock was the best insulator? Explain why in terms of the data.
3. In terms of clothing, what makes a good insulator?
4. Describe at least three sources of error encountered in this lab.
5. Explain the transfer of the heat energy in the water through the bottle and then through the sock into the surrounding air in terms of conduction, convection, and radiation.

Assessment:

Students will be graded on their participation in the laboratory (10%); the accuracy and completeness of their graphs (40%), the completeness, accuracy, logical interpretation of the data, in answering the analysis questions (50%).

Benchmarks:

P4.1B Explain instances of energy transfer by waves and objects in everyday activities (e.g., why the ground gets warm during the day, how you hear a distant sound, why it hurts when you are hit by a baseball).

P3.p1A Explain that the amount of energy necessary to heat a substance will be the same as the amount of energy released when the substance is cooled to the original temperature.

P1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity–length, volume, weight, time interval, temperature–with the appropriate level of precision).

P1.1E Describe a reason for a given conclusion using evidence from an investigation.

P4.3A Identify the form of energy in given situations (e.g., moving objects, stretched springs, rocks on cliffs, energy in food).

E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.

Sources Used:

Halfpenny, J.C. and R.D. Ozanne 1989 ***Winter: an ecological handbook.*** 1st edition. Johnson Publishing Company, Boulder, Colorado. 273 pages.

http://www.camse.org/scienceonthemove/documents/LAB%20ACTIVITIES%20-%20Middle%20School.doc

http://www.redcross.org/article/0,1072,0_312_6213,00.html

http://www.nema.ne.gov/index_html?page=content/disaster_recovery/winterweatherawareness.html

Class Data Table (need one for dry socks and one for wet socks; use abbreviations for sock types)

	Type of Sock:													
Time (min)														
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