Groundwork Education in Mathematics and Science

A collaborative project between the University of Louisville
and the Jefferson County Public Schools
visit at: www.math.louisville.edu/gems

Prepared by Fellow Jessica Koehler and Teacher Cindy Plappert

Module: No JCPS-adopted module (a curricular 'gap')
Investigation/Lesson: Elementary Concepts in Heat, Temperature and Conduction (Level: Elementary, Grade 3)
Sessions 2-3 class periods (including assessment)

Content Vocabulary:
heat (thermal energy)
temperature
thermal equilibrium
heat conductor
heat insulator

Concepts:
1) heat is a form of energy (thermal energy[kinetic energy])
2) the transfer (flow) of heat is directional: heat flows from a hotter object to a cooler object until thermal equil. is established
3) materials that absorb and conduct heat well are called conductors Metals are usually good heat (and electrical) conductors.
4) Insulators do not conduct heat (or electricity) well. Wood, styrofoam, and plastic are examples of insulators
5) A thermometer is a tool for measuring how hot/cold a substance is (relative to an accepted standard)

Skills:
1) read a thermometer with accuracy
2) record observations & data and infer conceptual meaning
3) integrate mathematical charting and graphing skills to organize data

KY **Core Content bullets addressed by this lesson: 1.1.1 & 1.3.2** (deals with how heat can be produced; conductors, insulators & their properties

Materials:
Station 1: "Your hand is not a thermometer"
one flat piece of each: metal, wood, insulating foam;
Station 2: "Keep it Cool"
3 identical cans of soda (diet works best); 3 alcohol thermometers, watch, tape (to secure thermometers; paper toweling, a can 'cozie', and rubber bands.
Station 3: "Conductor or Insulator?"
1-2" X 6" strips of metal sheeting (Al and Cu work well), plastic, wood, etc. A cup of hot water, multimeter (for making the heat/electrical conductor connection)
Station 4: "The Balloon Expansion"
mini-hot plate; long, narrow party balloons, ruler, string
Station 5: "Visualizing Heat Transfer"
Liquid crystal sheets (20-25°C and 25-30°C) and commercially available 'fever strips'

Classroom/Materials Management:

Groups of 4-6 rotate through the stations. Stations 3 and 4 are manned by the teacher and fellow. Directions & guiding questions were provided at the unmanned stations.
Stations can be readied by the team well before class. Things to remember:
*sodas should be cooled to 0-5°C for measurable results within a class period (provide data recording chart)

Student Notes/Notebooks:

Where and how will students record important classroom information? How will students know what to record?
During the lesson introduction, have students title a separate page for each Station in their science notebooks. Tell them that they will record all observations and data on the pages and reserve space on the bottom of each for their conclusion/wrap-up
Initial observations at 'unmanned' stations should be minimally-guided; allow students to describe and interpret without rushing to clear misconceptions. Discussions at manned stations can be guided by the teacher and fellow.
Wrap-up discussions should be conducted for each station. The data for Station 2 can be graphed and interpreted by the class at this time. Discussions should focus on addressing any misconceptions that arise and final emphasis should be on the 'take-home' message illustrated by each activity.
Students should be given ample time to write and reflect on their conclusions in their science notebooks.

How will you provide feedback to your students about their notes/notebooks and their organization?
Fellow and teacher will review notebooks and enter comments, kudos, and corrections.

Procedures & Ties to Content

Station 1: The students take turns placing their hands on the various objects and 'rank' them from hottest to coldest to their touch. Guiding questions: Are these materials really at different temperatures? Haven't they all been sitting here in the room long enough to have the same temperature as the room (reached thermal equilibrium)? Why might your hand not be a reliable thermometer in this case? If you could measure the temperature of each with a thermometer, would the readings be the same or different?

Station 2: Secure a thermometer in each of the 3 cans (one without any wrapping, one wrapped in paper toweling, and one seated in a 'cozie'. Record the initial time and temperature. Instruct students that each group is to record time and temperature when they visit the station. Ask them to make a prediction for which of the cans will stay cold the longest and why they think so.

Station 3: Introduce the multi-meter and explain what it can be used for. Have students touch the multi-meter to each of the objects and record their results in their notebook charts (see sample entry). After establishing that conductors of electricity often are conductors of heat also, ask students to preduct which objects will evidence warming (conduction) when one end is placed in hot water. Students can then test their predictions and record their results.

Station 4: Have students measure a long party balloon's circumference and/or length using the string/ruler approach. The teacher or fellow then rotates the balloon a few inches above the surface of a hot plate. Ask students to record their observations (expansion is usually visible). After 1-2 minutes, remove from the heat and measure the balloon again. Discuss the results and draw a conclusion (heat is a form of energy; when the gas in the balloon absorbed heat energy, it moved around faster and expanded).

Station 5: Tell students that the liquid crystal sheets are 'sensors' and will change colors according to changes in temperature. Allow students to explore what happens when they touch/use the liquid crystal and fever strips. They should record their observations and see if they can explain why the color changes are observed (evidence of heat transfer).

Thinking Through the Lesson:

Introduction-How will you introduce the lesson and connect it to prior student learning?

Before visiting stations, question students about conceptual ideas they already have: **probe 'prior knowledge'** and help students make connections (eg, electrical conductors/insulators)

Pose guiding questions such as "What is the difference between heat and temperature?", "Why does a marble floor feel colder on your bare feet than a carpeted floor?", "What happens to the temperature of a cold drink if you let it sit out on the table?"

Facilitation-How will you facilitate learning and move all students to higher order thinking?

At 'manned' stations, teacher and fellow will use questioning to lead them. At 'unmanned' stations, there will be questions to both guide their inquiry and to help them make sense of what they observe.

Closure-How will you know what each student has learned/is able to do?

Teacher and fellow will lead a circle discussion where students share-out what they have written in their notebooks about what they have observed/learned. Included in this wrap-up is the plotting of the data from Station 2.

Informal Assessment can be worked into the share-out by using student markerboards to answer concept questions. A more formal assessment with open response questions can also be administered during the next class session.

Background Information and Interesting Web sites:

*students can reinforce what they have learned in Station 2 by visiting the following interactive website: http://www.bbc.co.uk/schools/scienceclips/ages/8_9/science_8_9.shtml

Heat "Snacks" mostly middle school level: http://www.exploratorium.edu/sncks/iconheat.html

Misconception alert!: http://www.exploratorium.edu/snacks/cold_metal..html

More on misconceptions: http://www.physlink.com/education/AskExperts/ae680.cfm

Mathematical graphing experiment that is equally useful for science students: http://mtl.math.uicu.edu/projects/5/heating-cooling/