Bay Area Scientists in Schools Presentation Plan

Lesson Name_____ Heat Transfer: It's So Cool!
Presenter(s)_____ Kevin Metcalf, Sarika Goel, David Ojala, Melanie Drake, Carly Anderson
Grade Level____ 3 ____ **Standards Connection(s)**_____ Physical Science: Energy and Matter

Next Generation Science Standards:

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.

Science & Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. ▪ Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (**4-PS3-3**) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. ▪ Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (**4-PS3-2**)	**PS3.A: Definitions of Energy** ▪ The faster a given object is moving, the more energy it possesses. (**4-PS3-1**) ▪ Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (**4-PS3-2**),(**4-PS3-3**) **PS3.B: Conservation of Energy and Energy Transfer** ▪ Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (**4-PS3-2**),(**4-PS3-3**) Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (**4-PS3-2**),(**4-PS3-4**)	**Cause and Effect** ▪ Cause and effect relationships are routinely identified and used to explain change. (**4-ESS3-1**) **Energy and Matter** ▪ Energy can be transferred in various ways and between objects. (**4-PS3-1**), (**4-PS3-2**),(**4-PS3-3**),(**4-PS3-4**)

Common Core Standards:

ELA/Literacy:

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Mathematics:

MP.2 Reason abstractly and quantitatively.
MP.5 Use appropriate tools strategically.

FOSS Connections:

Grade 3 Module: *Matter and Energy*
Investigation 1: *Energy*

Teaser: Heat conduction is experienced by everyone, every day. We find this effect when we cook our dinner, store food in a cooler, and keep our bodies warm during winter. Yet, many of us are unaware of these phenomena. So what is heat conduction, how does it change with material types, and how can we manipulate it in our favor? This lesson is designed to introduce key concepts of heat conduction and the difference between conductors and insulators. We will show you that heat is both cold and hot! At the end of the lesson, students will solve a problem using their new knowledge of heat conduction.

Objective: *As a result of your lesson, what will students learn? What will they be able to do?*
Students will be able to describe heat conduction on a molecular basis. They will be able to describe conductors and insulators and explain why each material has a different conductivity determined by the material composition.

Vocabulary/Definitions: *3 – 6 important (new) words*

- **Temperature** – a measure of how hot an object is or how much energy it has.
- **Thermometer** –an instrument used to measure the temperature of an object.
- **Heat** – exchange of energy between two objects. When objects are different temperatures, heating and cooling occurs.
- **Conduction** – the transfer of heat by moving molecules.
- **Conductor** – a material the transfers heat well.
- **Insulator** - a material that does not transfer heat well.

Materials:

What should students have ready (pencils, paper, scissors)?
Students should have pencils for data recording.

What will you bring with you?

Materials for Heating and Cooling Experiments

- Rods (3x 6 groups)
  a. Metal
  b. Wood
  c. Styrofoam
- Water boiler (electric)
- Ice
- Infrared thermometer
- Data table worksheets
- Styrofoam cups with lids
- Materials for Liquid Nitrogen Ice Cream
- Liquid nitrogen in portable dewar
- Styrofoam bowls and plastic spoons
- Large bowl for mixing and wooden spoon
- Milk, heavy cream, vanilla, sugar
- Gloves

Classroom Set-up: *Student grouping, Power/Water, A/V, Light/Dark, set-up/clean-up time needed.*
A demonstration table is needed in the front and center of the classroom, preferably adjacent to a black/white board with chalk or markers. Access to water or a sink would also be helpful.

Classroom Visit

1. Personal Introduction: _____5___ Minutes

Explain that we are graduate students in chemical engineering at UC Berkeley, but come from all over the country. Give name and hometown and discuss how each town climate is different from the Bay Area. What is chemical engineering? Why did we choose to become engineers? What kinds of problems do engineers work on?

2. Topic Introduction: _____5___ Minutes

What is heat? Is heat hot? Cold? Heat is energy transferred from one object to another because of a temperature difference between them. Given enough time, the temperatures of the two objects will become equal. What are some everyday examples of heat transfer? Coffee in a mug, a glass of lemonade, a chicken on the grill, and a car's engine are all examples of heat transfer.

In front of the class, have several student volunteers (5-6) demonstrate heat conduction in solids on a molecular level. For metals, have students crosslink at elbows and show how heat (motion starting with one student) would make them all move together quickly. This is a conductor. For wood, have the students stand fingertip to fingertip and show how heat (motion starting with one student) would move more slowly between them. This is an insulator. Now students will be able to understand how different materials have different arrangement of molecules and thus show different conductive properties.

3. Learning Experience(s): ____30___ Minutes

<u>Experiment 1</u>: Heating

Student groups will be given Styrofoam cups and a rod of each different material. While we are describing the concepts, we will start heating water using an electric kettle. If we put the rod into hot water, what will happen? The rod will warm up. But how fast does this happen? We have to use our knowledge of heat transfer to answer this question. Each material has its own set of unique properties. The transfer of heat by conduction depends on the molecular properties of the material that are transporting the heat. How do the molecules look for each material? Remind the students of the difference in molecular arrangement between Styrofoam, wood, and metal with the students acting as the materials or actually print out pictures of the structure of each material. Each of the materials that we will be studying in this experiment has different molecular configurations, and this makes the cups warm up at different rates.
The students will divide into groups of 4-5, with a volunteer helping each group to prevent burns. The students will be given time to look at each of the rods and will hypothesize the order of thermal conductivity of the materials. They will record their hypotheses in the data table. Volunteers will begin the experiment by pouring the hot water into the cups. The students will use their hands to feel the temperature change on the rod 6 inches above the water level. They will also take a temperature reading of the rod after 5 minutes. They will be asked to record this data and determine if their hypotheses is true.
Results/Conclusion: On the board write "Coldest/Warmest (at 5 minutes)" and tally each group's results. [Styrofoam should be coldest, wood should be in the middle, and metal warmest].
We will then segue into the cooling experiment by discussing how heating and cooling are both governed by the same law.

<u>Experiment 2</u>: Cooling

Divide the class into groups of 4-5 and hand out the materials listed above. Ask the students to assign each member a task: (1) time keeper, (2) temperature recorder for the metal rod, (3) wood rod, and (4) Styrofoam rod. While students are sorting tasks divvy out the materials to the groups, including the ice bath, that is approximately 4 inches deep.
Explain how to insert the thermometer carefully into the bore hole at the top of each rod. Next, instruct the class that the temperature of the rod will be recorded over 5 minutes to observe how fast each material conducts heat. Based on the first experiment, ask the class which one is expected to cool the fastest.
Perform experiment: Before starting the experiment record the initial temperature on the table worksheet for time=0. When the time keeper starts the clock, the other 3 students submerge their respective rod into the batch.
Results/Conclusion: On the board write "Coldest/Warmest (at 5 minutes)" and tally each group's results. [Metal should be coldest and Styrofoam warmest]. Explain that coffee cups are made of Styrofoam and are great for keeping coffee hot and water cold for longer than in a metal cup. Now, compare these results with that of the heating experiment. It should be seen that metal rod was the warmest at 5 min for the heating experiment and the coldest at 5 min for the cooling experiment. Reinforce that heat conduction explains energy transfer for both hot and cold instances. We can conclude that metal is the best conductor of heat and Styrofoam is the best insulator.

4. Wrap-up: Sharing Experiences ____15____ Minutes

After conducting the individual heating and cooling experiments we will reconvene for a final experiment making ice cream with liquid nitrogen. We will make the ice cream in a large bowl in front of the classroom and then distribute portions to the students. We will ask students to reflect on what they have learned and hypothesize what type of bowl would keep the ice cream from melting the longest. We will explain why Styrofoam would be the best choice (example: milkshakes served in Styrofoam cups), and we will be using Styrofoam bowls for each student's portion of ice cream. We will explain why liquid nitrogen can be used to make ice cream as a fun example of heat transfer in action.

5. Connections & Close: ____5____ Minutes

Why did the metal rod get hotter faster and colder faster?
Why does each material behave differently?

Conduction is the transfer of heat through molecular motion. Molecules are very tiny and are very difficult to see. In a solid such as our rods, molecules are very close together and packed in tight. When a solid is heated, the molecules move faster. When these molecules move faster, they bump into each other more often, causing the temperature to increase.

Heat is the transfer of energy from one object to another. As heat transfers, the temperature of the object changes. We can measure temperature change using a thermometer. The transfer of heat occurs through several ways. Today, we talked about conduction, or heat transfer by molecules. There are other ways of heat transfer as well, for example- convection and radiation. Convection is caused by motion, like a fan or the wind. Radiation is caused by light, like the sun. In a solid, heat transfer by conduction is very important. This is because the molecules in a solid are more closely spaced than in a liquid or a gas.

What are some more examples of heat transfer by conduction?

Total 50 – 60 Minutes

Differentiated Instruction:

English Learners: Repeat directions, if necessary, and physically model how to perform heat transfer experiment. Write vocabulary, e.g. temperature, heat, on the board and read words aloud. Vocabulary words can also be visually demonstrated, e.g. using an illustration, and/or redefined in very simplistic terms.

Advanced Learners: Have students hypothesize what other materials would be good heat conductors. Students should explain their reasoning.

Follow-up Possibilities

ELA Activity:
Suggest students write a letter explaining "How we learned about heat conduction…."

Reading Connections:
- Heat by Darlene Lauw - Simple text and experiments describe and demonstrate the principles of heat and how heat energy is produced. Reveals topics such as steam power, sun power, how heat travels, heat capacity, and other uses of this form of energy. http://www.amazon.com/Heat-Science-Alive-Darlene-Lauw/dp/0778705595

Mathematics Activity:
Repeat the activity and have students record the actual degrees of the different objects (wood, metal, Styrofoam). Graph the hot water and cold water objects' degrees and compare the two groups.

Other:
Think about examples of heating and cooling in every-day life. The clothes you wear, the materials your house is built out of, what you cook with.

Cool It: Reading a Thermometer - In this fun hands-on activity, learners use simple materials to investigate evaporation. How can the evaporation of water on a hot day be used to cool an object? Find out the experimental way! The activity is based on an episode of Cyberchase called "Digit's B-Day Surprise" and was developed to capture kids' interest in math using the appeal of the popular PBS series.
http://pbskids.org/cyberchase/parentsteachers/lessons/themes/weather/pdf/Act5_Cool_It_Teacher.pdf