More on Conduction and Convection (5-E model)

Purpose

The purpose of this lesson plan is to use the 5-E model to address common preconceptions about the transfer of heat via conduction and convection. This lesson assumes the previous introduction to heat transfer, thermal energy, and temperature. The student will be able to identify heat transfer via conduction and convection in a system, identify the direction of heat flow in a system, compare different thermal conductivities, and understand natural convections role in the generation of wind.

Safety Issues

Safety has been considered, but because the instructor will be the one working with the boiling water and hot plate, the concerns are minimal.

Relevant Virginia SOL's

PS.7 c & d) conduction, convection, and radiation; and applications of thermal energy transfer
PS.2) d) physical properties (thermal conductivity)

Material and Resources

- Hot Plate
- Ice
- 1 large glass beaker per 4 students
- 1 insulator (e.a. Styrofoam cup) preferably different per 4 students
- 2 standard lab thermometers per 4 students
- 1 inferred thermometer
- 1 set of melting blocks (1 aluminum, 1 rigid plastic foam)
- 1 color dyed ice cube
- 1 color dyed ice cube with paper clips frozen inside
- 2 tall clear glasses
- Red and Blue Food Dye
- 1 clear large water tank

Engagement

This lesson begins with a discrepant event involving thermal conductivity and temperature. The instructor allows the student to hand two blocks of nearly the same appearance, but composed of different materials. The blocks are labeled so the students can keep track. One block made of aluminum feels cold to the touch, while the other block, made of rigid plastic foam, and feels much warmer. An infrared thermometer is also introduced. The instructor uses it to measure the temperature of several different objects to demonstrate its accuracy. (Most of the students have only experience a standard laboratory thermometer and may doubt the validity of the infrared one.) The students then are prompted to guess the temperature of the blocks. The infrared thermometer is used to show that both blocks are at the same "room" temperature as many of the other objects in the room. The instructor will then have the students predict what will happen to two equally sized pieces of ice left on the two blocks. It should take approximately two minutes of time to pass for the ice on the aluminum block to completely melt. At the same time the ice on the plastic block will have just barely begun to melt. While the students observe the ice melting the instructor asks question about the temperatures of the melting ice and of the blocks. (15 min)

Exploration

Students perform the "Comparing the Thermal Conductivity of Different Materials" lab. Groups of 4 are assigned an "insulator." Hot water, provided by the instructor just before the experiment, is placed inside the container and colder (not ice) temperature water is placed outside in a larger beaker. Thermometers are placed in each that students first make predictions and then record the two temperatures and calculate the temperature differences over time. Before the experiment students make predictions as to what container will be the best at keeping the inside temperature high. If time permits, groups can be rotated and the experiment can be repeated. The class comes back together and compares the different group's results. As a class students decide which material made for the best insulator, and which one made for the best conductor of heat. Materials are left out so that students can see the thermal equilibrium in all of the containers later during the explanation of the event. (20 min)

Explanation

A power point will summarize the heat transfer via conduction that the observed in the lab and in the heat activity. The difference between heat and temperature will be emphasized. Other misconceptions such as "cold" energy will also be addressed and corrected. Examples of conductors and insulators will be given and asked for from the class. Thermal conductivity will also be put into the context in the particle level. Students will be asked to identify thermal conductivity as either a chemical or physical property. (20 min)

Elaboration

Students are reminded of other types of heat transfer, specifically convection. The "Weighted Ice" demo is performed after students make predictions about what will happen. Ice, dyed with color and weighted with paper clips frozen in the middle, drops to the bottom of a glass and the dye does not dissipate upwards. However ice that is only dyed with color and left to float on the top of the water allows the dye to spread throughout the glass. The difference between conduction and convection are emphasized and the actions of both are discussed in the demonstration. An emphasis on the comparative strengths of conduction and convection is made. A second demo involving the mixture of blue ice water with red heated water serves as a lead in for a discussion about wind as a process of natural conduction, air density as related to Charles' Law and the recent hurricane. (20 min)

Evaluation

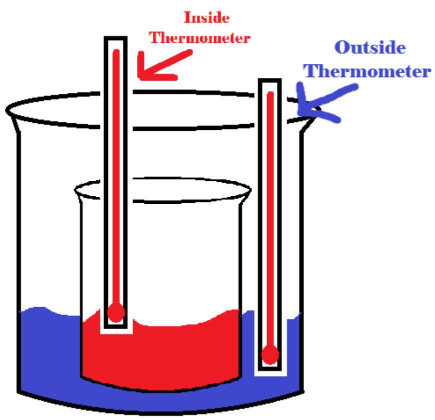
Name: __________
Block: __________

Students will complete a short question sheet about conduction, thermal conductivity, and convection that will be turned in for a grade at the end of class. (10 min)

Name: ___________
Block: ___________

Comparing the Thermal Conductivity of Different Materials

You will be recording the temperature reading of the thermometer at several points in time. This will serve as a rough way to measure the relative "Thermal Conductivity." Roughly speaking, **THERMAL CONDUCTIVITY** is the **ABILITY TO CONDUCT HEAT.**



Temperature Difference =

Inside Thermometer Reading **–**

Outside Thermometer Reading

Prediction: What do you think will happen to the two thermometers as the time passes?

1. **Mr. Merrill will tell you what type of container your table will be using. Write it next to the ★.**
2. **Decide on roles for your group. One person needs to record. One person needs to read the Outside Thermometer. One person needs to read the inside Thermometer. One person needs to calculate the Temperature differences.**
3. **Mr. Merrill will keep time with a stop watch. He will call out 60 seconds, 120 seconds, and 180 seconds as they pass. When he does the people watch the thermometers will tell the recorder what to write in the table below and the other person can begin calculating the temperature difference.**
4. **After the final measurement, take time to make sure every person in your group has filled out the table.**

★My container is:

Time (s)	Inside Temperature (°C)	Outside Temperature (°C)	Temperature Difference (°C)
90 s			
180s			
270s			

Name: ___________
Block: ___________

Name: __________
Block: __________

Conduction and Convection

1. Good insulators of heat have __________ thermal Conductivity.
2. One example of a good insulator of heat is:

3. Good conductors of heat have ___________thermal Conductivity.
4. One example of a good conductor of heat is:

5. Why did the aluminum block feel “colder”?

6. Say we repeated the insulator experiment using a tin can. Would the **TEMPERATURE DIFFERENCE** at the end of the experiment be **BIGGER** or **SMALLER** compared to the Styrofoam cup? Explain why. (Use the words “thermal conductivity” and “heat” in your explanation.)

7. Charles’ Law says that as **Temperature** of a gas **increases**, **Volume** of a Gas __________.
8. What is the formula for density?

9. The formula for density says that if the mass stays the same, but the **volume increases**, the **density** of a gas __________.
10. Why does warm air rise?

11. Explain in your own words what causes the wind.

Name: __________
Block: __________

Reflection

I think my lesson plan addressed some of the common misconceptions in thermal physics as well as underlined some of the problems almost all physics lessons encounter. Heat and temperature are some of the most difficult to understand topics encountered in a middle school science classroom (Dale & Piburn, 1997). I think much of the confusion in physics stems from the subject's shared vocabulary with the everyday language we use. It is not surprising to see students interchange and confuse the definitions of heat and temperature in the classroom when the words are used outside the classroom interchangeably. Our language also seems to separate the properties of hot and cold objects for purposes of description. This causes a challenge when trying to explain something like an ice cube of higher temperature, the thermal energy of a desk, or in my lesson where two objects shared the same temperature yet one felt 'colder.' Our everyday references are not always applicable in the physics classroom.

It is one thing to recognize there are difficulties in learning and teaching science concepts, but it is another to identify a specific misconception and address it as part of a lesson. For example one study showed that 75% of students would pick aluminum foil over Styrofoam to keep a soda cold (Lewis, Linn, 1994). Another underlined that temperature was simply a measure of heat and vice versa (Tanahoung, Chitaree, & Soankwan, 2010). I used this research to progress my interviews and to frame my lesson. By researching common misconceptions in the subject I was able to think about what to ask during interviews with my students. The interviews themselves provided me with a sense of the specific prior knowledge my students would be bringing into the classroom the day of the lesson.

I observed some students make significant progress in their understanding of the content, especially considering that the post interviews were performed a full week after the lesson. As a challenge I asked a student the hypothetical, "If I hold my finger on both blocks (referring to the aluminum and plastic foam block used in the lesson) for 10 seconds, which block will be at the higher temperature?" The student was able to respond, "The metal one because it got more of your heat because it's a better conductor." This shows an understanding of the relation between heat and temperature, as well as the direction that the heat must be transferred. However gaps were still evident. Many responses were simply the regurgitating of what I had said without the contextual understanding. For example a student could tell me that wind was caused by "the uneven heating of the Earth's surface," but could not explain further.

I came to a realization while teaching my lesson on how pacing is important when addressing misconceptions and difficult material. If I were to remake my lesson, I would start by splitting it over a two day period by giving an equal amount of time to conduction and convection. Though I am usually opposed to multiple choice question in science, I can see their purpose if the misconceptions are used as distractors.

Name: __________
Block: __________

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Works Cited

Dale, B. R., & Piburn, M. D. (1997). *Constructing Science in Middle and Secondary Classrooms.* Boston: Allyn and Bacon.

Lewis, E., & Linn, M. C. (1994). Heat and temperature concepts of adolescents, adults, and experts: Implications for curricular improvements. *Journal of Research in Science Teaching*, 657-677.

Tanahoung, C., Chitaree, R., & Soankwan, C. (2010). Probing Thai freshmen Science Students' Conceptions of Heat and Temperature Using Open-ended questions: A case study. *Eurasian Journal of Physics and Chemistry Education*, 82-94.