NSF RET Lesson Plan

Lesson Title: Heat Transfer of Various Substances	**Grade Level/Subject:** 8th and 9th Grade Science
Maximum # of Students: Students in classroom	**Total Time Required:** 2 x 45 min class periods

Prior Knowledge Needed:
https://www.covington.kyschools.us/userfiles/15/My%20Files/7th%20gr%20add%20chg/Design%20an%20energy%20efficient%20house%207-ps3-3.pdf?id=4494

Materials:

- Insulator Examples (thermometers, a tub of ice water, heat packs, bottles)
- Phase Change House: For each group: one reusable hand warmer for a demo, three orange hand warmers (for some groups, all three in solid phase; for some groups, all three in liquid phase)
- Calorimeter composed of a 250-milliliter plastic bottle with ⅛ inch hole for temperature probe of digital thermometer.

Performance Objectives/Learning Targets:

- Students will define insulators and recall how they are related to energy flow.
- Students will discern the best insulator to use in a building and describe why it is the best insulator.

Standards:

Energy (PS3)		
PH.PS3.3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*		
Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints placed on a device could include the cost of materials, types of materials available, having to use renewable energy, an efficiency threshold, and time to build and/or operate the device. **Assessment Boundary:** Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.		
Science and Engineering Practice	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Designing Solutions: • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**Energy and Matter:** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

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<tr><th colspan="2">Lesson Procedure</th></tr>
<tr><td>Before:</td><td>
Ask engaging questions: “If you put a coat on a carton of ice cream, would it affect it?”
Ask students if they want to share personal stories that relate to the heat transfer qualities of different structures they are familiar with (Their attics, their family homes (old and new), barns, sheds, etc.) Also, ask students about the direction of heat transfer.
Give out pre-test (inserted below)
Students will be provided plastic bottles for a “house”. Re-emphasize the ways to calculate heat transfer by defining calories, mass, change in temperature, and specific heat.
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<tr><td>During:</td><td>Phase Change Material “House” Procedure:
Get ice water in 2.5-gallon tub
Wrap the three orange hand warmers around the calorimeter, taping with masking tape
If the hand warmers are liquid, trigger all three (maybe have to do this before taping?)
Hold the wrapped calorimeter in the ice bath so “walls” are touching ice water (almost submerged), record temperature every minute for 8 to 10 minutes starting at t = 0 using the data table below. Use minutes for time and Celsius for temperature.
Students will fill in a data table. (inserted below)
Students will follow the instructions above, but use heat materials that have already “frozen” (already spent their heat).
If time permits, place the plastic bottle in the water without anything around it and record for
Students will put the data table on a paper and turn it in.
Next, students are asked if this gives them ideas about how the heat transfer could be limited in their own homes.
Students will graph data from the table with time on the x axis
A question to ask about the graphed data: “Which calorimeter “house” would you prefer to be in during the winter?” or “Why do you choose this?
Students will answer questions and put in their graph.
Further exploration could be putting different types of insulation in the house to see their effects.
Do you think this would be a high R value or a low R value? Why do you think this?

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After:	To close the lesson, review the objectives and content. ● In chemistry we measure heat using two different units: calories and joules. A calorie is defined as the amount of energy needed to raise the temperature of one gram of water one degree Celsius. ... The other unit used to measure heat is the joule. The joule is the SI (System International) unit, but they represent different quantities. (Just like inches and meters are both units of length) ● A calorie is used to be defined in terms of the specific heat of water. ● It is now defined precisely in terms of joules: 1 calorie = 4.184 joules ● The heat into and out of your house can be expressed in terms of calories or joules. Either way, the temperature change is the important factor. Your insulation is intended to limit temperature change (or heat flow). The R value of insulation describes its ability to limit the transfer of heat. ● Follow up with a post-test worksheet. (attached below)

5E Model: *(Engage, Explore, Explain, Evaluate, Elaborate)*

- Engage: Personal Story
- Explore: House Experiment
- Explain: Class Discussion
- Evaluate: Research and Short Essay over R values
- Elaborate: Quiz and Data Table

Extensions:

To extend the lesson, students can further explore by putting different types of insulation in the house to see their effects. Also, they can answer the question of “Do you think this would be a high R value or a low R value? Why do you think this?”

Pre-Test: PS Energy Transfer Worksheet (Use the equation $\Delta heat = mc\Delta T$) (Show ALL Work)

1. The air in a room has a mass of 100 kg and a specific heat (c) of 1000 J/kg C. What is the change in thermal energy of the air when it warms from 20 to 30 degrees C?

2. The temperature of a 4 kg block increases by 5 degrees C when 2000 J of thermal energy are added to the block. What is the specific heat of the block?

3. Describe the energy transfer that occurs when you touch a block of ice with your hand.

4. When one object heats another, does the temperature increase of one object always equal the temperature decrease of the other object? Explain your answer.

5. Explain why water is often used as a coolant.

6. Calculate the change in thermal energy of water in a pond with a mass of 2000 kg and a specific heat of 4200 j/kg C if the water cools by 1 degree C.

7. Fiberglass insulation is made from molten glass that is spun or blown into fibers. Most manufacturers use up to 40% to 60% recycled glass content (Dept of Energy website). Predict which of the following would be the best insulator and explain.

Data Table

Time	Temperature (activated warmer)	Temperature (spent warmer)	Temperature (without anything)

PS Energy Transfer Worksheet (Use the equation Δheat = mcΔT) (Show ALL Work)

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4. When one object heats another, does the temperature increase of one object always equal the temperature decrease of the other object? Explain.

5. Explain why water is often used as a coolant.

6. Calculate the change in thermal energy of water in a pond with a mass of 2000 kg and a specific heat of 4200 j/kg C if the water cools by 1 degree C.

7. Explain whether the following statement is true: For any two objects, the one with the higher temperature always has more thermal energy.

8. Calculate the specific heat of a metal if 0.3 kg of the metal absorbs 9000 J of heat as the metal warms by 20 degrees C.

9. With a 50 word statement describe the effect that extra material has on energy transfer into or out of the house. Include the words: heat, transfer, calories, joules, temperature, and change.