The Cold, Hard Truth

Flow of Heat Energy

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Grade Level	9th – 12th Grade	**Time Frame**	2-3 class period(s)
Subject	Science	**Duration**	150 minutes
Course	Chemistry, Physical Science, Physics		

Essential Question

What factors affect heat energy transfer?

Summary

In this lesson, students observe the movement of heat energy by measuring the rise in water temperature after placing hot metal washers in the water. Students also calculate the amount of heat energy transferred between the washers and water. Lastly, students cite specific evidence to refute or agree with two claims.

Snapshot

Engage

Students engage in a hands-on demonstration of perceived hot and cold using three pans of water of different temperatures. Students use the Magnetic Statements strategy to discuss the demonstration.

Explore

Students watch a short clip of heat transfer and make a hypothesis. Students design their own experiments to observe the transfer of heat between two types of matter, thus testing their hypotheses.

Explain

Students explain their procedures, share data, and state their conclusions.

Extend

Students create extensions of their experiments and perform the experiments again.

Evaluate

Students complete Two-Minute Papers in which they refute or agree with a statement, citing specific evidence from their experiments.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.
HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Oklahoma Academic Standards (Physical Science)

CH.PS1.8.1: Nuclear processes, including fusion, fission, and radioactive decay of unstable nuclei, involve release or absorption of energy.
PH.PS1: Plan and conduct an investigation to provide evidence that the transfer of thermal energy between components in a closed system involves changes in energy dispersal and heat content and results in a more uniform energy distribution among the components in the system(second law of thermodynamics).
CH.PS3.4.1: Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

Oklahoma Academic Standards (Physical Science)

PS.PS2.5.1: Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space.
PS.PS3.1.4: Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

Oklahoma Academic Standards (Physical Science)

PH.PS2.5.DCI.1: Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space.

Attachments

- Heat Transfer Activity Lab Sheet—The Cold, Hard Truth - Spanish.docx
- Heat Transfer Activity Lab Sheet—The Cold, Hard Truth - Spanish.pdf
- Heat Transfer Activity Lab Sheet—The Cold, Hard Truth.docx
- Heat Transfer Activity Lab Sheet—The Cold, Hard Truth.pdf
- Lesson Slides—The Cold, Hard Truth.pptx

Materials

- Lesson Slides (attached)
- Three pans
- Water
- Heat Transfer Activity Lab Sheet (attached; one per student; optional)
- Coffee cups w/lids
- Thermometers
- Scientific calculators
- Metal washers
- Twine/Pipe cleaners
- Lab composition book/Graphing Paper
- Hot plate
- Timers or stopwatches
- Sticky easel pad paper
- Markers

- Colored pencils
- Pencils/Pens
- Sticky notes
- Computer with internet access

Engage

Pre-Class Setup

Prior to class, set up one pan of ice water, one pan of room-temperature water, and one pan of hot water. Put the pans in that order.

Call on a student to place a hand in the cold water and a hand in the hot water. After 30 seconds, ask the student to submerge both hands in the lukewarm water. Ask the student to share some observations with the class. Allow other students to participate in the demonstration. If possible, set up enough stations for every student (or small groups of students) to participate.

Teacher's Note: Safety

Be careful that the hot water is not too hot. Get it ready before class starts or during the break between classes and let it sit out until you are ready. This will allow it to begin cooling. Leaving the hand in the cold water will be uncomfortable as well, so test your own hands first. The same results may be observed with less submersion time.

Teacher's Note: Explanation

Even if students did this at a younger age, they probably didn't truly understand what was happening. Because of the temperature difference, the hand in cold water will feel hot in the room-temperature water, and the hand in the hot water will feel cold in the room-temperature water. We only perceive hot and cold because of temperature differences and that heat flows from high to low. Students will be curious about how this happened.

Say to students: The water in the middle is room temperature. To your hand, under normal circumstances, you may describe it as lukewarm or neither hot nor cold. What happened?

Allow the students to share their ideas.

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to read aloud the essential question. Display **slide 4** to go over the lesson objectives. Review these slides with students to the extent you feel necessary.

Go to **slide 5**. Ask students to think about the following two statements:

- **Statement 1:** Heat energy is transferred from objects with low temperatures to objects with higher temperatures.
- **Statement 2:** Heat energy is transferred from objects with high temperatures to objects with lower temperatures.

Move to **slide 6**, and introduce students to the Magnetic Statements strategy. Divide the room into two groups. Those who agree with statement one will stand on one side of the room while those who agree with statement two will stand on the other side. Make sure they agree with the same statement. Feel free to divide the group further for larger groups. Have students first discuss and justify their belief, and then ask the entire group to devise one statement, justifying the class's reason for agreeing with the scenario.

Teacher's Note: Construct Their Own Knowledge

Do not give anything away at this point. Allow for healthy discussion, but also give students a chance to discover for themselves how heat flows. Keep students in their groups for the next section.

Explore

Keep the previous groups together.

Display **slide 7**. Show the YouTube video, Red Hot Nickel Ball in Water. It is very short, so be prepared to replay it at least once.

Embedded video
https://youtube.com/watch?v=9qSEfcIfYbw

Have the groups reevaluate their statement choice after watching the video. Give them a few minutes for discussion. Instruct the students to make a hypothesis about the transfer of heat between the metal and the water. They must understand that this hypothesis will be tested in an experiment.

Go to **slide 8** and lay out all the materials on a table (washers, twine/pipe cleaners, thermometers, and coffee cups). Instruct each group to devise a procedure that will test their hypothesis. They will record their procedure in their lab notebooks.

Optional Lab Set Up

Whether or not the students will be comfortable designing their own procedure will depend on their academic level and the setup of your own classroom. If designing their own procedure is too advanced, give them the attached **Heat Transfer Activity Lab Sheet** and have them forego their own lab notebooks.

Teacher's Note: Safety

Set up your own station. Heat the water to boiling and add the washer systems (which are pipe cleaners with different amounts of washers attached to each). Instruct each group to come up one at a time to get their system. The first temperature reading is after 1 minute, so this will be perfect for students returning to their seats.

Explain

Before the students share their data, move to **slide 9** and instruct them to calculate the amount of heat energy actually transferred. The students will have the temperature difference of the water, and the mass of water will be equal to the amount of water they used.

Teacher's Note: Calculations

They can do this by using the equation: $Q = cm\Delta T$ (where Q is the heat transferred in joules, c is the specific heat of water (4186 J/kg°C), m is the mass of the water, and ΔT is the temperature change of the water).

Move to **slide 10**. Give each group a poster board. Instruct them to create a poster that displays their experiment. Have the class participate in the Gallery Walk strategy to view and give feedback on one another's posters.

Extend

Display **slide 11**. Ask students: What are ways to change this experiment so that heat transfer is shown more broadly? Then have students create their own extensions of their experiment, write a new hypothesis and procedure, and perform it again.

Optional

There are many ways to extend this lab: using a different liquid, like alcohol with a larger heat capacity; using a different number of washers; using a different amount of water; using a different metal; varying the temperature of the water; making the washers cold instead of hot; using an object that doesn't conduct well, like wood, in place of the washers; etc.

If this is too advanced for your students, have the whole class come up with their own extension. Let them brainstorm together and create a new procedure for everyone to carry out. Each class could have an entirely different perspective on how to extend this experiment.

Upon completion of the extensions, lead a class discussion of all the factors that will affect heat transfer.

Teacher's Note: Reinforce

Students need to know that amount of substance, heat capacity, ability to conduct, and temperature difference are all factors that affect the amount of heat that is transferred from one object to another.

Evaluate

Display to **slide 12** to revisit the following statements:

- **Statement 1:** Heat energy is transferred from objects with low temperatures to objects with higher temperatures.
- **Statement 2:** Heat energy is transferred from objects with high temperatures to objects with lower temperatures.

Pair the students. Inform students to write a Two-Minute Paper that refutes statement one, citing specific evidence from both of their experiments, *or* a Two-Minute Paper that supports statement two, citing specific evidence from the experiments.

Lastly move to **slide 13** to post the statement: Heat transfer is not just about temperature difference. Again, the students will write another Two-Minute Paper that cites specific evidence from their extensions to support this claim.

Resources

- carsandwater. (2012, November 25). Red hot nickel ball in water (nice reaction) [Video]. https://www.youtube.com/watch?v=9qSEfcIfYbw
- K20 Center. (n.d.). Gallery Walk / Carousel. Strategies. https://learn.k20center.ou.edu/strategy/118
- K20 Center. (n.d.). Magnetic Statements. Strategies. https://learn.k20center.ou.edu/strategy/166
- K20 Center. (n.d.). Two-Minute Paper. Strategies. https://learn.k20center.ou.edu/strategy/152