Heat vs. Temperature: What's the Difference?

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Overview

Topic: Physical Science, Temperature, Heat. In this lesson, students will explore the difference between heat and temperature through the use of the ***Eureka!*** ITV series and simple experiments. Students will measure temperature and analyze data using a Calculator Based Laboratory (CBL) and a graphing calculator.

Length of Lesson

Two 45-minute class periods

Video/Technology Hardware & Software

Eureka! #20, Measuring Temperature
Eureka! #21, Temperature vs. Heat
Calculator Based Laboratory (CBL)
TI-80, 82, or 83 Graphing Calculator
CBL temperature probes
PHYSICS program for graphing calculator
Website: Sprocket Works www.sprocketworks.com

Learning Objectives

The student will be able to:
- define heat and temperature
- understand that heat and temperature are not the same
- distinguish between heat and temperature
- demonstrate the indirect measurement of heat by measuring temperature change
- compare the amount of heat given off by various objects
- collect, record, and interpret data

(This lesson addresses Va. SOLs Science 6.1, LS.1, PS.1, PS.5, PS.7; Math 6.9, 6.18, 7.20, 8.13; Computer/Technology 8.4)

Materials and Teacher Preparations

Per class:
- 3 beakers
- access to hot and cold water
- 2 large containers (gallon jars or plastic pails)
- 1 1000 ml beaker
- hot plate
- 2 tongs
- thermometers (Celsius scale)

Per group of 4-6 students:
- 2 beakers
- 2 bolts (1 large and 1 small)
- room temperature water
- CBL, graphing calculator, and 2 temperature probes

Per student:
- "Turn Up the Heat" worksheet
- "Temperature vs. Heat" worksheet

Preparatory/Pre-Viewing Activities

1. Before the class: Label three beakers as Beaker A, Beaker B, and Beaker C. Fill beakers with water: Beaker A — cold water (from water fountain or refrigerator), Beaker B — room temperature water, and Beaker C — warm water (from faucet). Caution: Students are going to put their fingers in the

water so make sure that the water is not hot enough to burn students. Put the three beakers in the front of the classroom.

2. Say: Welcome to the exciting new game show—The Temperature Is Right! We need two contestants from the audience. Select two students. Tell the "contestants" that they must determine whether the water in the beakers is hot or cold.

3. Have the first contestant put a finger in Beaker A and hold for 15 seconds. He/she should then tell whether the water is hot or cold. Repeat with Beaker B, then Beaker C. Record the answers on a board.

4. Have the second contestant repeat the procedure, only begin with Beaker C then go to Beaker B, then Beaker A. Record the answers. Students should note that the first contestant responded that the water in Beaker B was "hot or warm," but the second contestant responded that the water was "cold." Ask: Why the two students gave different responses to Beaker B? Students should realize that it was because their finger was hot or cold to begin with.

5. Say: "Let's try a little different approach." Have each of the contestants put their left finger into Beaker A and the right finger into Beaker C for 15 seconds at the same time, then put both fingers into Beaker B. (The students will notice that the same water feels different to the different fingers.) Ask: What difference does it make that the finger was hot or cold to begin with? Develop the idea that the terms "hot" and "cold" are subjective. Solicit other examples, such as a person from Florida may think 50 degrees is cold, while a person from Minnesota would consider 50 degrees warm.

6. Put the terms "heat" and "temperature" on the board. Explain to the students that people often use these terms incorrectly. Ask students for the definitions. Discuss students' responses, then say: Today we are going to investigate to determine just what is the different between heat and temperature.

7. Say: Before we begin this investigation, we need a brief review. Bring up the website www.sprocketworks.com on a projection device, click on Topics: Chemistry, then Gas Behavior. Ask students: What do molecules have to do with heat and temperature? (Students should know that molecules move faster in warmer objects). Use the sliding bar on the computer screen to add the molecules to the container. Ask: What will happen if we increase the temperature in our container? (The molecules will move faster.) Slowly slide the bar to increase the temperature. Ask: What is happening to the molecules when we add temperature? (They move faster.) Ask: What must I do to slow the molecules down? (Lower the temperature). Slide the bar to the left to lower the temperature. Ask: What happened? (Molecules moved slower.)

Focus for Viewing/Other Technology

1. Say: Let's review what we know so far: molecules move faster when the temperature is increased and slower when the temperature is decreased; the terms hot and cold are subjective; and people often use the terms heat and temperature incorrectly. Refer back to the two words on the board.

2. Say: Earlier, we discussed our thoughts on the meaning of these two terms, now we want to make sure we understand their meanings, as well how the two terms are different so we can use them correctly. Hand out the "Turn Up the Heat" worksheet. Have students read the definitions of temperature and heat at the top of the page. Discuss those definitions, then say: These definitions do not help us to really understand heat and temperature. We will be watching two programs from the **Eureka!** series. Look for important points about heat and temperature. You'll notice that the narrator may not use those specific terms until later in the video, so pay close attention. If you hear an important point, raise your hand and I will pause the video so you can write it down in Chart 1 on your worksheet. Remember, we want to find out how heat and temperature are different.

Note to the Teacher

It is important that students do not write while the video is playing, so emphasize to the students that you will pause the video so they can write down the important points.

Time Cues

To synchronize your VCR with the time cues that are included with this lesson, zero/reset your time counter at the very beginning of the program, before the introduction and titles. Time cues are expressed as "minutes:seconds;" for example, 3:15 means three minutes and fifteen seconds.

Pause vs. Stop

When using a video interactively with students, teachers need to decide when to use **PAUSE** and when to use **STOP**. **PAUSE** the video when the anticipated discussion or activity will take less than two minutes. **STOP** for longer periods. Pausing for too long at one time can cause video heads on the VCR to become clogged which may require cleaning to correct.

Viewing and/or Online Activities

1. FOCUS: Let's begin by listening for the term that is used for how hot or cold something is. **START *Eureka! #20*** right after one toe sticks out its tongue at the other and you hear the narrator saying: There must be a better way to measure degree of hotness? (1:33) **PAUSE** after the narrator says: How can we measure their speed? (2:12) Ask: What is the term that the narrator used for degree of hotness? (temperature) If students can not answer, **REWIND** and **REPLAY** the segment. Ask: What do we know about hotness? (Molecules move faster in hot, slower in cold) Is there a way that we can measure the speed of molecules? Discuss students' responses.

2. FOCUS: It seems like we need more information. Watch the video to find out another important fact about hotness that will help us to measure the degree of hotness of a substance. **RESUME. PAUSE** after the narrator says, " . . . so we could measure molecule speed indirectly by measuring the effects of the speed—the expansion itself." (2:36) Ask: What else do we know about hotness? (Increasing the temperature causes the molecules to move faster and the substance to expand.) How does knowing that fact help us to measure the speed of molecules? Accept student responses.

3. FOCUS: Let's continue watching the video to find out how a certain scientist used the fact that substances expand when they are heated. **RESUME. PAUSE** after the narrator says, "He decided to label the freezing point of water." (3:03) Ask: What was our scientist's name? (Celsius) What did he label the freezing point? (0 degrees) If students say 32, remind them of the name of the scientist! How did Celsius use the fact that substances expand and contract? (He made a thermometer.) What do you think he is going to do next? (Put the thermometer in boiling water.) Accept student predictions.

4. FOCUS: Let's check our prediction. **RESUME. PAUSE** after the narrator says, "He marked this boiling point of water." (3:17) Ask: What did he mark the boiling point? (100 degrees) So how can we use expansion to measure the speed of molecules? (When matter is heated, it expands and mercury moves up the thermometer—higher temperature. When matter is cooled, it contracts and mercury moves down the thermometer—lower temperature.) Why was it important for Celsius to mark the freezing point and the boiling point of water? (This is the way that we calibrate thermometers.)

5. FOCUS: What is your body temperature? (Students will most likely answer in 98.6 degree F.) Do you know what it is in degrees Celsius? Accept students' responses, then say: Let's see how close our guesses are. **RESUME** video to the end of the program. **STOP.** Ask: What is body temperature in degrees Celsius? (37 degrees) Say: Let's review the important points that we marked down for temperature. Discuss the items that students have on their charts. (degree of hotness, molecules move faster and matter expands when heated, etc.) Stress the point that temperature is the movement of molecules.

6. FOCUS: Now that we have a good idea what temperature is, let's examine heat. Again, as we play the video raise your hand so I can pause the video for you to jot down important ideas. **START *Eureka! #21*** on the title screen "Temperature vs. Heat" (4.5 seconds after the opening screen).

PAUSE after narrator says, "In which one of these two containers are the molecules moving faster, the bucket or the cup?" (1:03) Ask: In which of the two containers are the molecules moving faster? (Cup) How do you know? (Temperature is higher.) We know that the temperature is higher and the molecules are moving faster, but does that mean that there is more hotness in the cup than in the bucket? Accept students' responses.

7. FOCUS: Watch this next segment to see how we can find out whether there is more hotness in the cup that in the bucket. **RESUME. STOP** after the narrator says, ". . . you'd be better off emptying the cupful of boiling water into it rather than the bucketful of water at the lower temperature, wouldn't you? Or would you?" (1:22). Ask: Do you still think that there's more heat in the cup than the bucket? ***Eureka!*** is doing an experiment to find out. Let's try our own.

8. Have two large containers filled 3/4 full with room temperature water. Ask: How can we test to see which has more hotness—a small amount of boiling water or a larger amount of warm water? Put a beaker of 100 ml of water on a hot plate and bring to a boil. Draw 1000 ml of water from the hot water tap. It should measure around 50 degrees. Have student volunteers measure the temperature of the water in the buckets, the temperature of the boiling water, and the temperature of the warm tap water. Record temperature in Chart 2 on the worksheet. Add the boiling water to one bucket and the hot tap water to the other. Measure the temperature of the two containers again. Record and compare. Discuss the differences.

9. FOCUS: What did we find out from our experiment. (The large amount of warm water had more ability to heat the water than the smaller amount of boiling water) Let's see if ***Eureka*** came to the same conclusion. **RESUME** the video. **PAUSE** after narrator says, " . . . the 50 degree bucket water is much better at heating up swimming pools than the 100 degree cup water. Why is it?" (2:42). Ask: Did his findings agree with ours? (Yes) Why do you think the bucket of water heated the water in the swimming pool better than the cup of water did? Discuss students' responses. Students should infer that the bucket contains more water (more molecules) than the cup.

10. FOCUS: So heat actually involves two things. Continue watching to find out what those two things are. **RESUME. PAUSE** after narrator says, "So now it's time to introduce the word for the quantity of hotness — heat" (4:14). Ask: Heat actually involves what two things? (Speed and quantity of molecules) Why is the bucket of cooler water actually able to heat the swimming pool better? (It has more heat) Review what affects temperature (speed) and what affects heat (speed and mass).

11. FOCUS: What is the difference between heat and temperature? **RESUME. STOP** at the end of the video. Ask: What is the difference between heat and temperature? (Temperature: speed of molecules; Heat: speed and quantity of molecules)

12. Discuss the items that the students have listed for heat (quantity of hotness, involves speed and mass, etc.). Hand out the "Heat vs. Temperature" worksheet. Have students complete the worksheet, illustrating the difference between heat and temperature.

Post-Viewing and/or Online Activities

1. Reinforce the fact that temperature is the speed of the molecules, while heat involves speed and mass. Have students complete the back page of the worksheet, comparing the heat given off by two objects. After students have completed, discuss answers.

2. Ask: How do we measure temperature? (Thermometer) How do we measure heat? Discuss students' responses, then say: That was a trick question. There is no direct way to measure heat. So how do we know which object gives off more heat? How did we evaluate whether the 100 ml of boiling water or the 1000 ml of warm water had more heat content? (By measuring the temperature change in the large containers of water) Say: We can indirectly measure heat by measuring its affect on the temperature.

3. Divide class into groups of 4-5 students. Each group should have a CBL, graphing calculator with

PHYSICS program loaded, two temperature probes, and 2 beakers with 200 ml of room temperature water.

4. Put a beaker of water on the hot plate. Place all of the bolts into the beaker. Boil for two minutes. Have a student volunteer measure the temperature of the boiling water. Make sure students understand that the bolts would be heated to the same temperature. Ask: What is the temperature of the boiling water? (100 degrees Celsius) Are both bolts at that same temperature? (Yes)

5. Set up the CBL and graphing calculator. Connect the CBL to the graphing calculator. Attach the temperature probes. Select the PHYSICS program, set for 2 probes, select temperature, collect data, and use time graph. Enter time between samples as 30 seconds for 10 samples.

6. Place the probes in the two beakers and press enter to begin collecting data. Use two sets of tongs to carefully place a small bolt in the water of one beaker and a large bolt in the other at the same time.

7. When the graphing calculator has finished collecting data, press enter to graph the data. Discuss the results with the students. What was the temperature of the water at the start of the experiment? (Around 20 degrees Celsius) What happened to the temperature of the water when the bolts were added? (Increased) Did the two beakers have the same increase? (No, the one with the large bolt increased more) Why? (The large bolt released more heat because of its mass) Reinforce again that temperature relates only to speed of molecules, while heat relates to speed and mass.

Assessment

Evaluate students based on class participation, completion of the worksheets, and observation of the post-viewing activity.

Action Plan

1. Invite an HVAC (heating/ventilation/air conditioning) technician to discuss how they calculate the amount of radiators or ducts that are needed to heat a room.

2. Invite a health care professional to speak on the how your body maintains temperature and why you might run a fever when you are sick.

Extensions

Language Arts: Have students write a expository paragraph explaining the difference between heat and temperature. (English SOLs 6.7, 7.8, 8.5)

Science/Technology:

- Have students enter the data collected by the graphing calculator/CBL into a spreadsheet, then graph and print results. (Science SOLs 6.1, LS.1, PS.1; Computer/Technology SOLs 8.1)

- Have student convert temperature measurements from Celsius to Fahrenheit and vice versa using the website: Online Metric Conversion www.sciencemadesimple.com/conversions.html

Social Studies/Technology: Use the website World Temperature Extreme members.iinet.net.au/~jacob/worldtp.html to find extreme temperatures for various parts of the world. (Computer/Technology SOL 8.4)

Special Needs Students: Provide appropriate modifications for the special needs students based on the IEP. Students may work in groups to facilitate understanding. The use of video supports visual and auditory learning. Hands-on activities promote understanding.

About the Author

Karen K. Campbell
Karen has been a Master Teacher for the NTTI since 1994. After teaching science for 16 years, Karen moved out of the classroom when she became the Technology Resource Teacher for Page County Schools. In this capacity, she works with the teachers in all of the county schools to assist them in the integration of technology into the curriculum. Karen has been involved with technology in Page County since the early days of Apple II computers. She serves on the division-wide technology committee and has served as technology trainer. Karen was named Page County Teacher of the Year in 1996. She received her B.S. degree from JMU. She is a member of the NEA, VEA, PC (Page County) EA, and VSTE. In her spare time, Karen enjoys hiking and camping.

March 2001

Turn Up the Heat!!

Heat - form of energy caused by the internal motion of molecules of matter

Temperature - measure of the motion of molecules

Chart 1: Heat and Temperature

Heat	Temperature

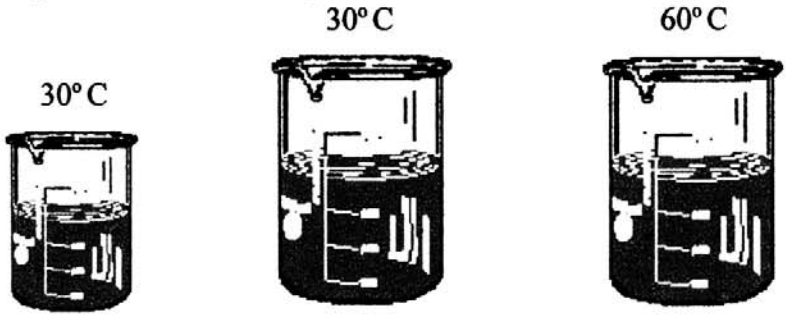
Chart 2: Record the temperatures in the chart below:

Beginning temperature of water in containers		
Temperature of 100 ml boiling water		
Temperature of 1000 ml warm tap water		
Temperature in containers after heated water		

Temperature vs. Heat

Term	Meaning	Depends on:
	Degree of Hotness	
	Quantity of Hotness	

Use the Diagram to Answer the Questions:



1. In which container is the heat content greatest? _____
2. In which 2 containers is the motion of molecules the same? _____
3. Compare the motion of molecules from beaker A to beaker C.

Circle the item in each pair that gives off more heat.

1. 50 ml of 60° water — 100 ml of 60° water
2. A stick burning at 70° — A log burning at 70°
3. A 95 lb. person with normal body temperature — A 200 lb. person with normal body temperature