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**Title:**Heating things up **Grade Level:**4

**Benchmarks:**  
**P.EN.04.41** Demonstrate how temperature can be increased in a substance by adding energy.

**S.IP.04.14** Manipulate simple tools (for example, thermometer, and stop watch/timer) to measure temperature.

**Objectives: (do these match your evaluate activity?)**

* The learner will identify heat as a form of energy.
* The learner will identify temperature as a measure of relative hotness or coldness of a substance.
* The learner will perform experiments to show that heat can add energy to a substance and increase its temperature.
* The learner will use a thermometer to measure the heat added to a substance and observe the resulting temperature.

**Misconceptions:**

* Energy is a thing.
* **Energy gets used up.**
* Temperature is used to measure heat and heat is “hot”.
* **There is no difference between heat and temperature.**
* Temperature is heat.
* Heat is a substance which could be added to or removed from an object.

One misconception that students may have prior to this lesson is that energy gets used up. Students may think this for many reasons. One reason may be because they watch their windup toy eventually stop moving, so they think that all of the energy has been used up. This lesson will help with this thinking because students will be able to see that the energy is just being transferred by noticing an increase in the temperature of a substance. For example, they will notice that the heat energy from a candle is being transferred to the water by seeing the increase in temperature with a thermometer.

A second misconception that students may have is that there is no difference between heat and temperature. They may think this because they associate temperature with how it feels outside or the amount of heat that there is around them. This lesson will help with this misconception because students will be able to see that a thermometer is used to measure how hot or cold something is, and that heat is a form of energy that can cause an increase of temperature for a particular substance.

**Materials and Setup:**

Explore:

Each of the following per group of 6 students

* An aluminum or other metal can with one open end
* A candle
* Matches
* Hot pads or barbeque tongs for holding hot cans
* Thermometer
* 50 mL of water per container
* Sandpaper attached to a block
* Block of wood that can be sanded
* An aluminum or metal can with one end open
* 50 mL of water per container
* String sunlight or a lamp with an incandescent bulb (60 W or higher) or other type of bulb that heats up when turned on
* Thermometer
* A science journal for each student

Elaborate:

Each of the following per group of 2-3 students. Note that these are the same materials as the first group of “explore” materials, with the addition of stopwatches or a projected clock

* An aluminum or other metal can with one open end
* A candle
* Matches
* An empty metal can for collecting used matches
* Hot pads or barbeque tongs for holding hot cans
* Thermometer
* Water
* Stopwatches or digital clock projected on to a screen for the class to see
* A worksheet for each student. (This worksheet needs to be designed).

**Safety:**

* Basic fire safety: keep all objects, materials and yourself far enough away from heat and flame so nothing catches on fire or burns.
  + In case of an emergency, the students will immediately alert the teacher. The teacher will take care of any necessary procedures (teacher should know how to properly use a fire extinguisher prior to these labs).
  + Teacher and all students should know correct procedures for a fire drill (what to do, where to go, etc.).

**Requisite Knowledge/skills for students:**

Students should have already developed somewhat of an understanding that energy comes in many forms (such as heat, light, sound, and electrical) and that energy is transferable by convection, conduction, or radiation. This knowledge gets more developed in further grades. Students should know that as the temperature increases, more energy has been added to a system. Students should know what a thermometer is and that it is used to measure the temperature of a substance.

**Procedure:**

Engage: (3-5 minutes)

Ask students if their hands feel warm or cool. Have students vigorously rub their hand together for 30-60 seconds. Ask students to describe any changes in the warmth of their hands. Ask students why their hands warmed up; guide them to the role of energy (where did the energy come from?).

* When asked if their hands are warm or cold some student’s responses may be as follows:
  + **My hands are warm or my hand are cold**
  + **The students whose first response what that their hands were warm may now say that after rubbing their hands vigorously together their hands got warmer. The students whose first response was that their hands were cold may now say that after rubbing their hands vigorously together their hands became warm.**
* When asked why their hands warmed up after rubbing them together some student’s responses may be as follows:
  + **My hands became warm because I was rubbing them together really hard**
  + **When I rubbed my hands vigorously together my hands produced energy**
  + **The energy of my hands rubbing together caused my hands to get warmer**

Explore: (10-15 minutes)

Break students into groups of 6 and pair them up within each group. Provide them with their materials. One pair of students will use the candle/metal can/water materials. Model how to hold the container over the lit candle so that nothing (pot holder, people, paper or other supplies) burns. Model how to read the thermometer if students are not familiar with how to do this. Have students record the temperature of the water;heat the water for 5 minutes over the candle, then record the temperature again. Students should record all observations and answer the question, “how is energy added to this system”?

* When students are asked the question how is energy being added to this system some student’s responses may be as follows:
  + **Energy is being added to the system from the heat of the candle**

The second pair of students will touch the block to determine its relative temperature. They will rub the block with sandpaper over the wood as quickly as they can for 1 minute, then record all observations and answer the question, “how is energy added to this system”?

* When students first touch the wood block their responses of its relative temperature may be as follows:
  + **The wood block feels warm**
  + **The wood block feels like room temperature**
* When students are asked the question how is energy being added to this system some student’s responses may be as follows:
  + **Energy is being added to the system by rubbing the wood block with sandpaper**
  + **The students will say that the wood block is now warmer than it was before**

The third pair of students will record the temperature of the water, and thenshine the light onto the water, keeping it there for 5 minutes. They will record the final temperature, all observations, and answer the question, “how is energy added to this system”?

* When students take the first temperature of the water, their responses may be as follows:
  + **The temperature is not very warm or not very cold**
  + **The temperature is room temperature water**
* When students are asked the question how is energy being added to this system some student’s responses may be as follows:
  + **Energy is being added to the system by shining the light onto the water**
  + **The students will say that the warmth from the light made the water to heat up**

After each pair has finished their experiment, each pair will share their results with the rest of their group. Each pair will briefly share their results and answer the question, “how is energy added to this system”? There is no need to create a worksheet for this section, assume students record results in a science journal, and that assessment will simply be a check to see that something is recorded.

Explain: (10-15 minutes)

Bring the class together. The pair of students in each group who did the experiment should report their data to the class. Ask students how energy was added to the water in each case and to the blocks. Ask them to describe the relationship between the energy added and the temperature change. Ask students what form(s) of energy were involved in changing the temperature of the water or block.

* When the pairs of students are asked to describe the relationship between the energy added and the temperature change, their responses may be as follows:
  + **The students would say that as the temperature increased, more energy was being added to the system.**

Elaborate (Apply, Extend): (15-20 minutes)

Have all students, in groups of 2-3, heat water with a candle in a cup. They should record the temperature every minute for 7 minutes. The class should determine how to make a “fair test” out of this experiment—how much water, how many candles, what distance to hold the cup from the flame, etc. Graph the results, have students determine if energy seems to be added at a constant rate to the water (why or why not). Students will record a description of the (class-determined) procedure on this sheet, along with a table of the temperature every minute for 7 minutes, a graph, and answers to the question about heating rate.

Evaluate:

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| --- | --- | --- | --- |
| **GLCE** | **Learning Objective** | **Instructional Activity** | **Assessment** |
| **P.EN.04.41** Demonstrate how temperature can be increased in a substance by adding energy. | **•**The learner will identify heat as a form of energy.  •The learner will identify temperature as a measure of relative hotness or coldness of a substance.  •The learner will perform experiments to show that heat can add energy to a substance and increase its temperature. | In the engage portion where they are rubbing their hands together.  In the explore portion when they are heating the water over candles, heating the wooden block with sandpaper, and heating the water with light.  In the elaborate section when students are heating water in a cup over candles. | The teacher will check the work in the student’s science journals and on the worksheet/graph. |
| **S.IP.04.14** Manipulate simple tools (for example, thermometer, and stop watch/timer) to measure temperature. | •The learner will use a thermometer to measure the heat added to a substance and observe the resulting temperature. | In the explore portion when they are heating the water over candles, and heating the water with light and measuring the temperature.  In the elaborate section when students are measuring the change in water temperature each minute for seven minutes. | The teacher will check in their science journals and on the worksheet to see the temperature readings they got from a thermometer. |

**Scientific Background:**

In many everyday experiences, a common misconception is that when you add heat to a substance such as water, the temperature of the water will increase as well. When heat is added to a substance it is not necessarily true that the substance will increase in temperature. Temperature is a number that is related to energy, but is not energy itself. Temperature is a number that is related to the average kinetic energy (energy of motion) of the molecules of a substance. It is a measurement of how hot or cold a something is. Heat is not a number; it is a form of energy that can be transferred from one substance to another substance. Heat comes from friction, when particles are moving around and smacking into each other. When heat is added to a substance, energy is being added to the substance as well. When heat is added to a substance the substance will increase in temperature if it is not during a phase change (solid to liquid or liquid to gas). The temperature of a substance is directionally proportional to the heat of a substance; as heat is added and increases in a substance the temperature of a substance increases. When there is an increase in temperature the average speed of molecules increases. Particles tend to move faster and hit one another when the temperature of a substance is warmer. The temperature of a substance will increase when energy has been added and the substance has gone through a phase change. It is only when a substance has increased in energy that that substance goes through a phase change. When a substance is in between phase changes, the substance remains at a constant temperature.

**References:**

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Zobel, E. A. (2011). Heat and Temperature.In *Zona Land Education*.N.p.: SciLinks by NSTA. Retrieved September 14, 2012, from <http://www.zonalandeducation.com/mstm/physics/mechanics/energy/heatAndTemperature/heatAndTemperature.html#animations>

**Student Materials:**

Attach assessment materials with keys as specified in the activity (one worksheet for elaborate activity).

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hearting Things up Worksheet

Materials needed:

* Cup
* Water
* (5) candles
* Thermometer
* Graph paper

As a class, it is up to you to come up with a “fair test” experiment. Everyone will start with 50 milliliters of water. With the materials provided for you, it is up to you (as a class) to determine how many candles should be used to heat the water and how far away to hold the cup of water from the candles. Record the “fair test” experiment in the space below.

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Temperature (taken over one minute intervals)

|  |  |
| --- | --- |
| Minutes | Temperature (Celsius) |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |

Describe what happened to the temperature based on the recordings every minute for seven minutes. What is happening to cause the water to have this change in temperature?

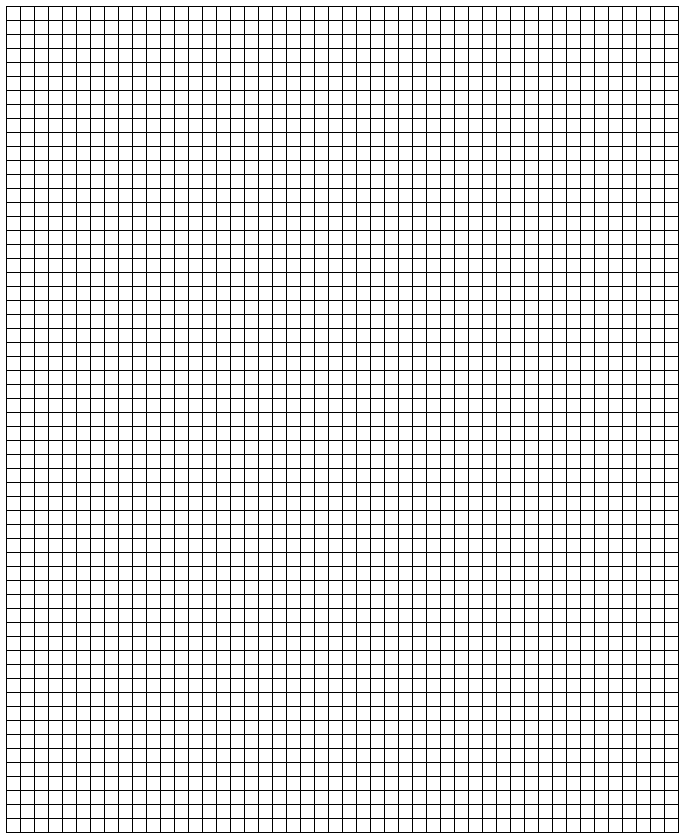
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Does energy seem to be added at a constant rate to the water? Why or why not?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Graphing Directions:

Each student will create their own graph. The type of graph should be a line plot and must include a creative title. The X axis needs to be labeled in minutes and the Y axis needs to be labeled in temperature (Celsius). There needs to be a line of best fit included after all of the points are plotted. There is a graph paper for you to use on the back of this worksheet.



**Answer Key/Scoring Rubric(total of 20 points)**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hearting Things up Worksheet

Materials needed:

* Cup
* Water
* (5) candles
* Thermometer
* Graph paper

As a class, it is up to you to come up with a “fair test” experiment. Everyone will start with 50 milliliters of water. With the materials provided for you, it is up to you (as a class) to determine how many candles should be used to heat the water and how far away to hold the cup of water from the candles. Record the “fair test” experiment in the space below.

**This should include the class “fair test” experiment-amount of water (must start with 50 milliliters), number of candles used, and how far away the cup was held- answers\_ may vary depending on what the class comes up with (4 points). \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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Temperature (taken over one minute intervals)**(7 points for completion of table-answers will vary).**

|  |  |
| --- | --- |
| Minutes | Temperature (Celsius) |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |

Describe what happened to the temperature based on the recordings every minute for seven minutes. What is happening to cause the water to have this change in temperature?

**Students should have noticed an increase in temperature. Answer should include\_\_\_\_ something similar to the understanding that: the heat energy from the candle is being transferred to the water, I know this because of the increase in temperature.(2\_\_\_\_\_\_ points).**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Does energy seem to be added at a constant rate to the water? Why or why not?

**Answer should be something similar to: Yes, because there is a constant flame of heat from thecandle to the water. There is no more or less energy being added; it is a\_\_\_\_ constant amount of energy from the candle. (2 points).\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_**

Graphing Directions:

Each student will create their own graph. The type of graph should be a line plot and must include a creative title. The X axis needs to be labeled in minutes and the Y axis needs to be labeled in temperature (Celsius). There needs to be a line of best fit included after all of the points are plotted. There is a graph paper for you to use on the back of this worksheet.

**Graph is worth 5 points:**

* **1 point-type of graph is a line plot**
* **1 point-title is labeled**
* **1 point-X axis is labeled as minutes**
* **1 point-Y axis is labeled as temperature (Celsius)**
* **1 point-line of best fit.**