Description of the resource:

The resource I chose from this lesson came from the NASA website https://www.jpl.nasa.gov/edu/teach/. I chose to incorporate the thermal expansion model lesson into a lesson I have already created and used in the past. This lesson in particular can be found at https://www.jpl.nasa.gov/edu/teach/activity/thermal-expansion-model/. The lesson is a way to teach students about rising sea levels and climate change. Students are supposed to consider causes for the rising sea level and figure out what they could be as they conduct the lab. The lab is set up using water bottles, thermometers, and hand tools. Students create the device and then test it in different temperatures. The purpose is to show students that when the device gets hotter the water level rises. The lesson I already had in place was the same set up for students except I was teaching them about thermal expansion with a thermometer. Instead of giving students a thermometer to record the temperature they had to create one. The purpose was for students to see how liquid particles reacted compared to the gas particles we looked at before. For students to realize the heat ws causing the particles to have an increase in kinetic energy. I took both of these concepts and put them together for students in the lesson.

Lesson Plan:

Thermal Expansion Model
Chemical Interaction Unit: Investigation 4

Grade: 8
Class size: 18-27
Sections: 4

Objectives:

- SWBAT explain the differences in solids, liquids, and gases on a particle level.
- SWBAT understand that the particles are always in motion no matter the state of matter.
- SWBAT define matter, kinetic energy, and potential energy.
- SWBAT explain that particles in a substance gain kinetic energy as they warm, and lose as they cool.
- SWBAT define contraction and expansion of a particle in a substance.
- SWBAT carry out an investigation heating and cooling a liquid to observe expansion and contraction.
- SWBAT construct an explanation of how a thermometer works.
- SWBAT compare the experiment they conduct to the rising sea levels.

SWBAT (Students Will Be Able To)

Assessment:
Students will be assessed on their ability to:

- Describe, orally, the movement of particles in a solid, liquid, and gas on a particle level.
- Analyze the results of the experiment conducted in class and compare it to what they already know about matter and energy.
- Construct a conclusion using the terms contraction and expansion to describe the experiment taking place.
- Follow a procedure and complete the lab in the time given.
- Follow all safety rules in the lab.
- Compare their experiment to how a thermometer works in their analysis questions.
- Compare their experiment to the rising sea levels in their analysis questions.

Standards:
Next Generation Science Standards: 4-PS3-2 , 5-ESS2-1 , MS-ESS2-6 , MS-PS1-4 , MS-PS3-3 , HS-ESS2-4
Common Core Standards: CCSS.ELA-LITERACY.RST.6-8.1, CCSS.ELA-LITERACY.RST.6-8.9

Procedure:
(Time Required: 30 mins - 1 hr)

1. Students will enter the room with some directions on the board to start.
    - Place all books off of your desk except your composition book.
    - Turn in any late homework.
    - Reminder: Notebook check at the end of the investigation.
2. The instructor will begin the class with a review of vocabulary and knowledge gained thus far on chemical reactions and particles. The class will discuss the differences between compression and contraction, vocabulary terms (Kinetic Energy, Physical Properties, Particles, Matter, Expansion…), and what happened to air when it was heated and cooled. Students will answer questions posed to them by the instructor and discuss.
3. On the next slide, Students will record and answer the focus question in their composition books given 2 minutes. “What happens to particles in a sample of liquid when the liquid is heated and cooled?”.
4. The class has demonstrated the ability to compress a gas, could we do the same with a liquid? In a previous lesson, students used syringes to compress and expand air in a closed system. The instructor will set up a syringe in the same way as that activity, but have liquid inside of the syringe. The instructor will try to compress and expand the liquid and allow other students to try as well.

5. The instructor will then introduce the investigation for the day. Students will be creating their own thermometer (without knowledge of what it is). The instructor will have warm water available for the homemade device to be placed into. Students will record their findings and describe the device and its uses. (A complete layout of the lab is given in the instructor lab sheet).
6. Students will conduct the lab as the instructor monitors. The instructor will also be around the room to ask students questions as they create the device.
7. Once finished, students will clean up the lab and answer analysis questions.
8. If there is enough time in class, the class will discuss their responses together, if not, the class will go over it at the start of class next time.

Modifications/Accommodations:
All modifications and accommodations are based on the records kept of IEPs and GIEPs. The instructor will monitor the lab and give assistance when needed. The instructor will also assist students in keeping them on task by posing questions to different group members and asking them what they are contributing.

Lab sheet for Instructor Use:

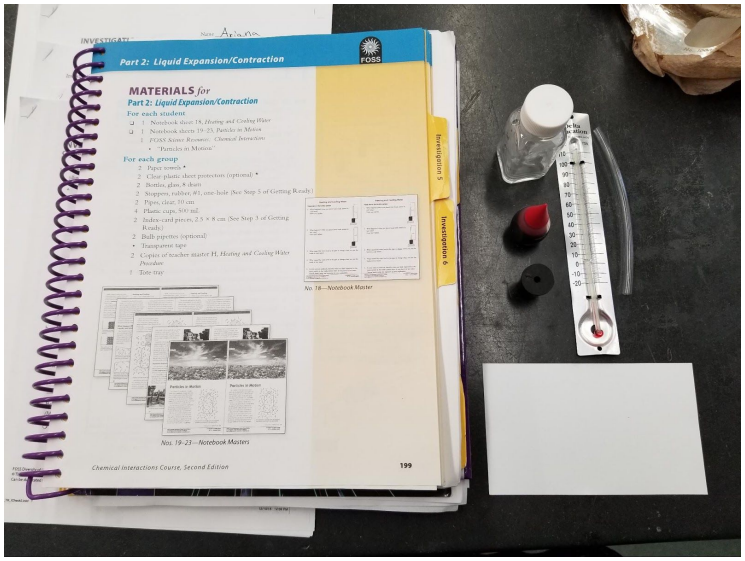
Background (Why am I learning this?)

In this investigation, students will start to think critically about what it means to cool and heat substances. The really big idea in this investigation is that matter as its fundamental level, particles, is in motion. Increasing the particle's motion heats a substance, while decreasing the particle's motion cools the substance. So how can we apply this to our lives? This could be cooling down your drink or heating up your dinner. Os something more complex like global sea levels rising. Here is some information on Global sea levels to add to the lesson for students:

Global sea level has varied substantially throughout history, especially in response to the ice ages. In recent history, starting around 7,000 years ago, sea level became quite steady, but over the last century, it's been rising. Global tide measurements from tide gauges suggest that global sea level rose approximately 3.4 millimeters (0.13 inches) per year over the past century. Sea level is measured by monitoring stations on the shoreline and at sea. Satellites such as NASA's JASON-3 satellite also collect data on sea level. There are over 120 sea level monitoring stations in the U.S. and 240 additional stations worldwide. By looking at data from these stations over periods of 30 years or more, trends can be identified at individual stations and compared with other stations. This gives scientists useful information about local conditions. Those data can also be used to calculate the global, average sea level and study it over time, giving scientists a

picture of what's happening to the ocean on a planet-wide scale. Sea level has been measured at some stations for more than a century, providing sea level data going back to 1880.

The total amount of water on Earth isn't increasing, but the volume of liquid that fills the ocean basins is growing, raising the elevation of the sea's surface and spilling ocean water onto low-lying land. The extra volume of seawater comes from two places: Clearly, the melting of ice sheets and glaciers on land adds water to the sea. The second, and less obvious cause for rising sea level, has to do with water expanding as it warms, so the more heat energy the ocean absorbs, the more space its water requires. Water has the ability to absorb a lot of heat, a property known as heat capacity. As a result, when air temperature increases, so does ocean temperature. We see this playing out in the data returned from satellites, weather stations, weather balloons, ships and buoys. They show that the temperature of the water at the ocean's surface is rising along with temperatures at the lowest layer of the atmosphere and the average air temperatures at the surface of land and water.



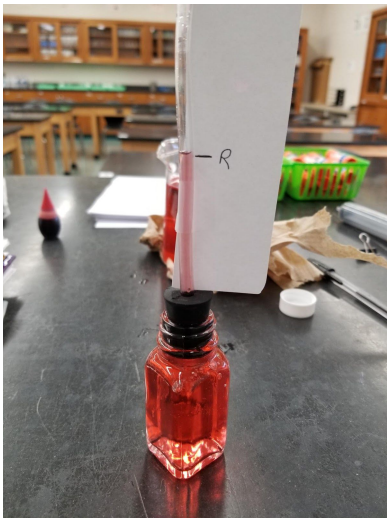
Materials

Per group of 3-4 students:

- 8 oz glass bottle
- 10 cm plastic tubing
- Food coloring
- Index card
- Scissors
- Dark felt-tip pen
- 2 Plastic cups for hot (60 C) and cold (5 C) water- marked to 100mL
- Hole #1 rubber stopper
- Syringe
- Bin/Tray

For the instructor:

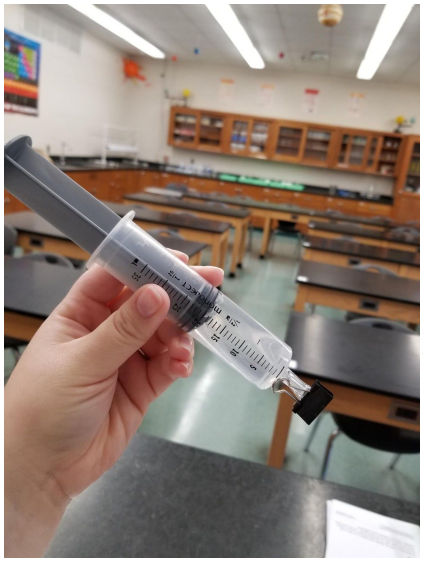
- Thermometer
- Bin of ice
- Hot plate or microwave



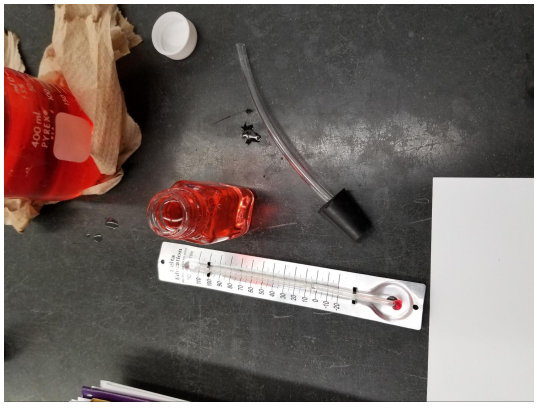
Example of Bottle Assembled

Procedure

1. Start the class with a review of particles in a gas. Continue the review with students on kinetic and potential energy. A great way to do this is to throw a ball up into the air and have a student catch it, then ask the class, at what point is there kinetic energy? Do the same with potential energy. Once the review is over give students 3 minutes to record and answer the focus question of the day. "What happens to particle in a sample of liquid when the liquid is heated and cooled?". Pose examples in real life to students of the effects seen of a substance heating and cooling. Some of these examples could be heating up water for hot chocolate, cooling down a drink with ice, humidity in a room causing a wooden door to be unable to shut, massive amounts of ice melting in the ocean causing sea levels to rise. This will lead into a discussion on climate change. Ask students to identify causes of sea-level rise. If students identify melting ice as a cause of sea-level rise, ask them which type of ice, land ice or sea ice, contributes more to sea-level rise. If students do not mention thermal expansion, explain that in addition to ice melt, there is another phenomenon that contributes to sea-level rise. The following activity will demonstrate that phenomenon.

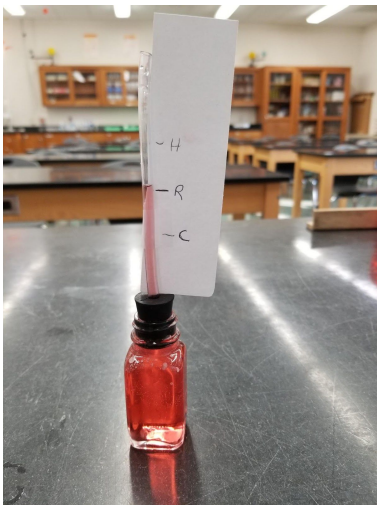


2. In the previous lesson students compressed and expanded air in a syringe. This was how the class discussed particles in air, so to demonstrate the difference in a liquid the instructor should place water into a syringe and again have students attempt to compress and expand the air. Students will be instructed to think of the solution to why it does not.
3. At this point the instructor will introduce students to the activity for today to figure out what happens to a liquid when it is heated and cooled. Students will have the lab sheet taped down to their lab station upon arrival into the class. The instructor will also hand out the worksheet to go with the lab for the day. Students will begin by gathering their materials. Once gathered students will assemble their apparatus. This will involve putting the 10 cm tubing into the stopper and 35 mL of dyed water into the glass bottle. CAUTION: The water will overflow when the stopped is put into the glass bottle. Students



should do this part in their trays for easy clean up. Students will then move the stopper until the water line is roughly in the middle of the tube. Lab groups will tape half of the index card (cut card in half using scissors). The water line will be marked with an R (the instructor is not to give a reason for the lettering used that is for students to figure out that this is a thermometer).

4. Now that the apparatus is set up students will test it out.
5. The testing will involve students placing the device into hot and cold water. There should be a station for students to gather this water somewhere in the room. The hot water should be kept around 60 C and the cold water at 5 C.
6. Students will mark the new places on their index cards as "H" and "C" for hot and cold. Students will use a timer or clock to keep track of time. Each time the device is tested it should have 5 minutes to settle prior to students marking it.
7. The finished device should look like the image provided.
8. Once the lab is finished instruct students to clean up their stations and work on the analysis questions given to them.
9. When students are finished with the lab and all clean up hold a discussion with them with the questions below.
10. If there is time in class or the next class time your have with them, go over the analysis questions and have students write a conclusion.



Discussion

Ask students to observe the data and discuss the following questions:

- What happened to the water level as heat energy was added?
- **Answer:** The water level rose as the temperature increased.

- Explain why the water level in the straw changed over time. What caused this?
- **Answer:** Water increases in volume when heated. The added energy that came in the form of heat caused the water molecules to move around more. As they moved and bounced off of each other, they took up more space, thereby increasing in volume. As the temperature of the water in the bottle increased, the volume of water in the bottle increased (expanded), which caused the water level in the straw to rise. This process is called thermal expansion.

- What happened to the water level as the device was placed into cold water?
- Answer: The water level fell as the temperature decreased.

Assessment

Ask students what the device reminds them of that is a product mass produced and used in hospitals, schools, labs, and households:

- A Thermometer

Ask students how thermometers work:

- Thermal Expansion of water as it is heated and cooled.

Ask students to identify causes of sea-level rise with sufficient detail to demonstrate understanding:

- Melting ice is contributing to the rise of sea level. As land ice melts, it runs into the ocean and increases the amount of water in ocean basins. Sea-ice melt does not contribute to sea-level rise, as the melted ice fills the space previously occupied by the frozen sea ice.

- The ocean's heat capacity allows it to absorb a lot of energy in the form of heat as land and air temperatures rise. When water is warmed, it expands and takes up more space, a phenomenon known as thermal expansion. Thermal expansion increases the volume that ocean water takes up, leading to sea-level rise.

Ask students how particles move in a solid, liquid, and gas using the terms: particles, kinetic energy, and matter.

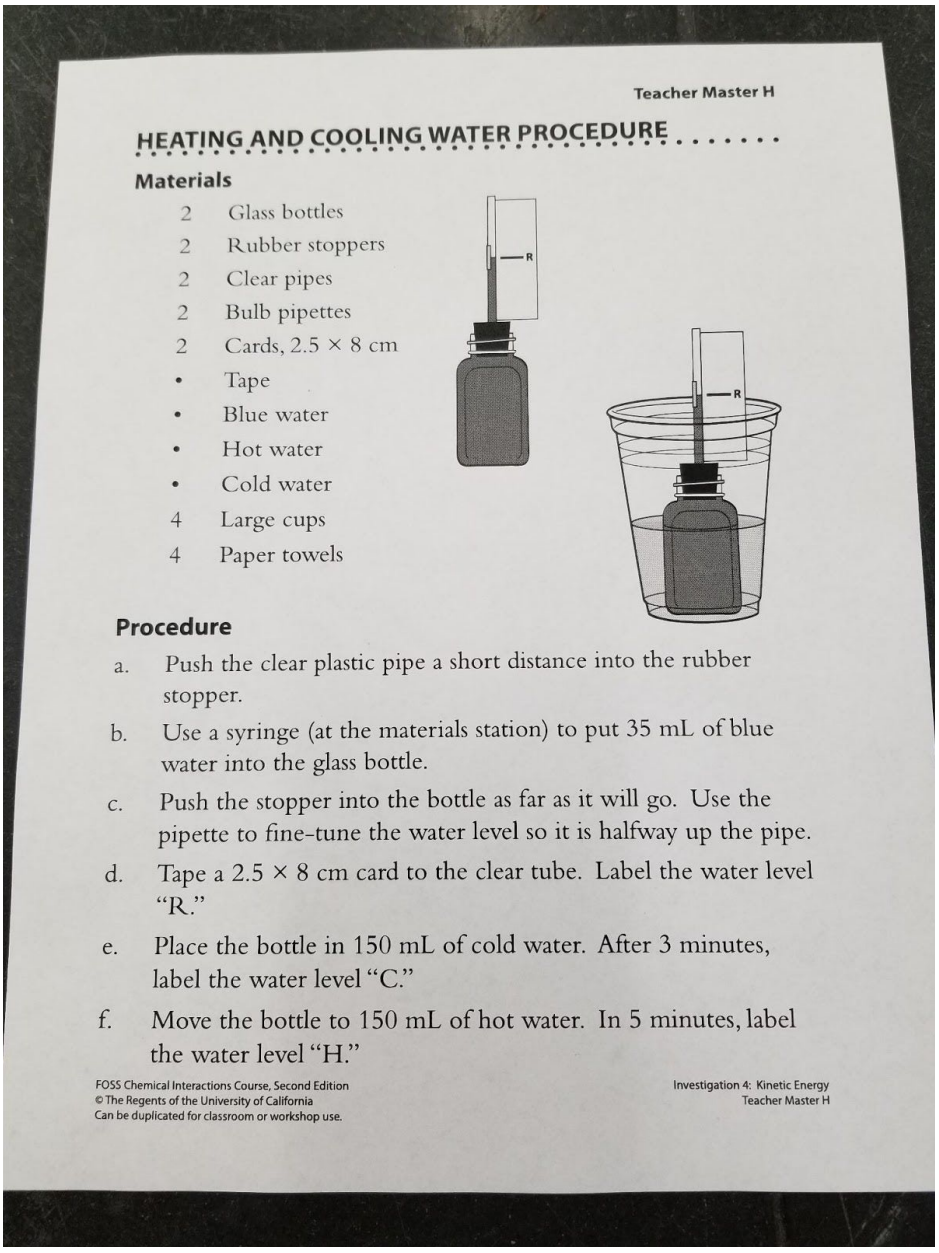
- In a solid the particles move with less kinetic energy and vibrate as movement. In a liquid the particles roll past each other with more energy. The last state of matter discussed in class, gas, has high kinetic energy and moves around whatever container they are in freely. There is a lot of space between particles in a gas, where there is little space between particles of solid, and liquid.

Resources:

FOSS (Full Option Science System). (2018). "Liquid Expansion/Contraction". Investigation 4 in the Chemical Interactions Unit. Teacher's Manual Textbook. Received from: https://www.fossweb.com/

Jet Propulsion Laboratory. "Thermal Expansion Model". California Institute of Technology. NASA. Received from: https://www.jpl.nasa.gov/edu/teach/activity/thermal-expansion-model/

Lab sheet for Student Use:



Teacher Master H

HEATING AND COOLING WATER PROCEDURE

Materials

- 2 Glass bottles
- 2 Rubber stoppers
- 2 Clear pipes
- 2 Bulb pipettes
- 2 Cards, 2.5 × 8 cm
- • Tape
- • Blue water
- • Hot water
- • Cold water
- 4 Large cups
- 4 Paper towels

Procedure

a. Push the clear plastic pipe a short distance into the rubber stopper.

b. Use a syringe (at the materials station) to put 35 mL of blue water into the glass bottle.

c. Push the stopper into the bottle as far as it will go. Use the pipette to fine-tune the water level so it is halfway up the pipe.

d. Tape a 2.5 × 8 cm card to the clear tube. Label the water level "R."

e. Place the bottle in 150 mL of cold water. After 3 minutes, label the water level "C."

f. Move the bottle to 150 mL of hot water. In 5 minutes, label the water level "H."

Analysis Sheet for students:

Thermal Expansion Analysis Sheet

1. What happened to the water in the device when it was placed in hot water?
2. What happened to the water in the device when it was placed in cold water?
3. How do particles move in a solid, liquid, and gas?
   (Use the terms: particles, kinetic energy, and matter in your answer)

4. What does the device remind you of that is a product mass produced and used in hospitals, schools, labs, and households?
5. How does a thermometer work?
6. How does this device represent the rising sea levels of our oceans?

Ask students how thermometers work:

- Thermal Expansion of water as it is heated and cooled.

Ask students to identify causes of sea-level rise with sufficient detail to demonstrate understanding:

- Melting ice is contributing to the rise of sea level. As land ice melts, it runs into the ocean and increases the amount of water in ocean basins. Sea-ice melt does not contribute to sea-level rise, as the melted ice fills the space previously occupied by the frozen sea ice.

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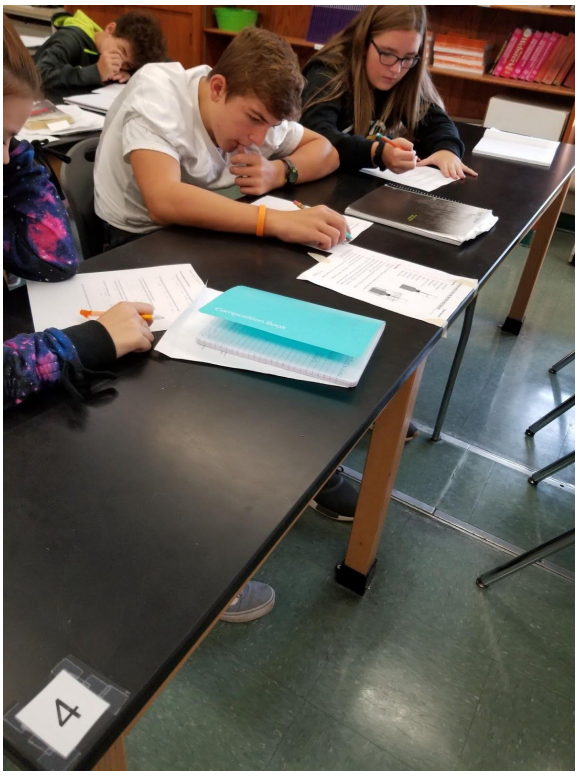
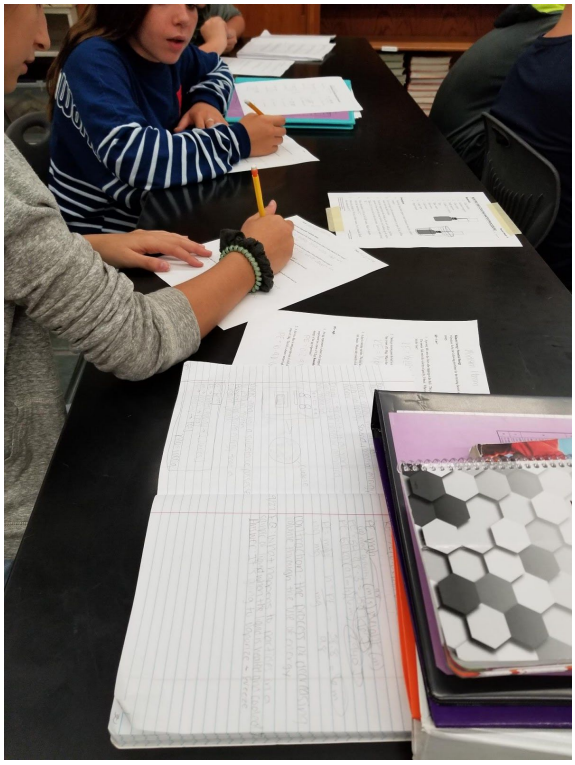
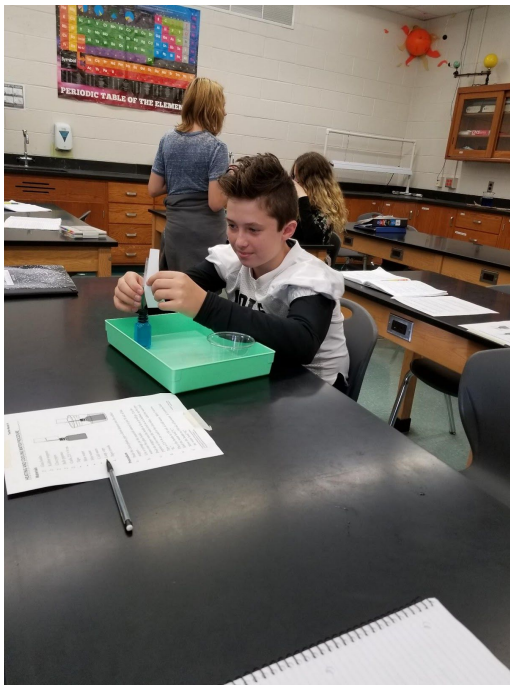
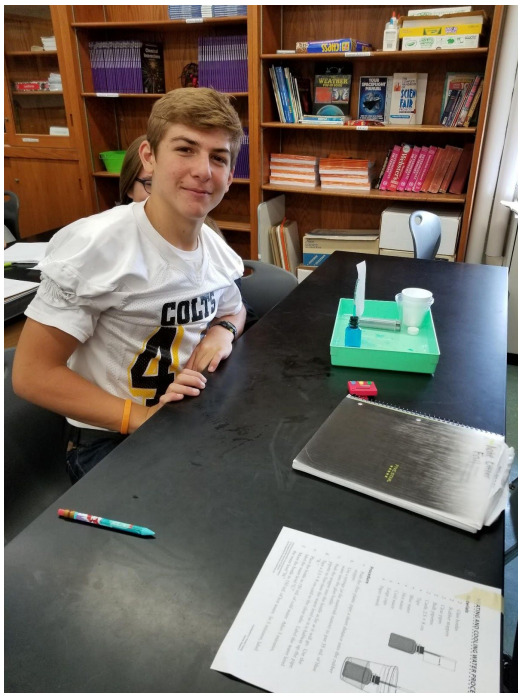
Lab Conducted 9/27/18



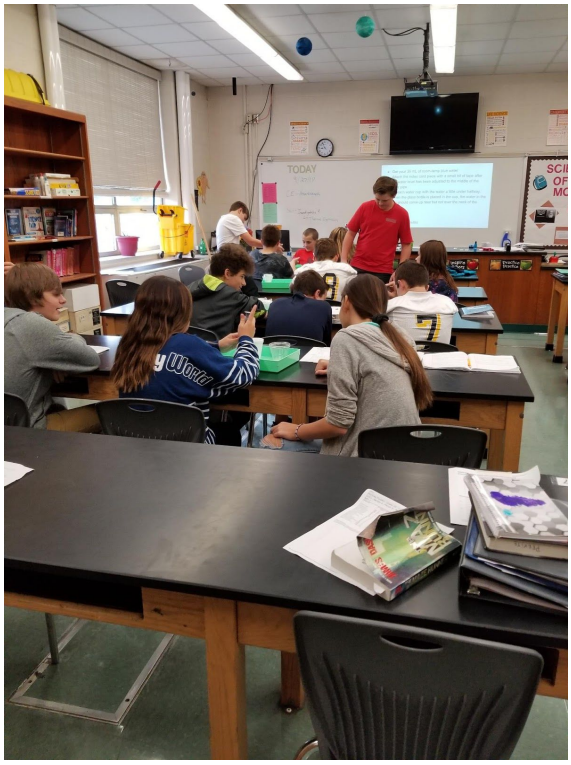


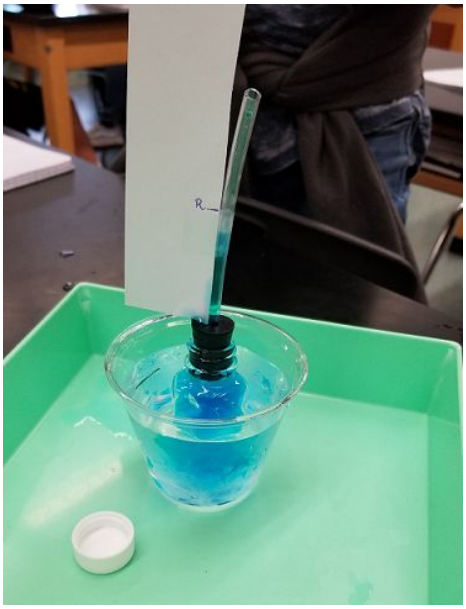
Artifact 1: Lab groups working on their analysis questions after completing and cleaning up the lab.





Artifact 2: Students constructing the Liquid Device (Thermometer) and testing it in hot and cold water.





Artifact 3: Students conducting the lab.

Reflection:

After teaching this investigation and this lab I feel as though students were able to understand particles and how they are affected by kinetic energy. Students were able to conduct the lab on their own with little to no assistance from myself, the instructor. Students were also able to answer analysis questions in their groups. I have conducted this lab before for my 8th grade students. This lab is a part of investigation four in our unit on Chemical Interactions. The materials and lesson are from the FOSS program mentioned in the resources. I take their lessons, read through them, and then shape them into my own teaching style. This resonates very well with students and they seem to take a lot away from each investigation.

When I taught the lesson this time I pulled from another source, NASA. I read through this lesson and took information and pieces of the lesson, that I thought would mesh well with my formed lesson, and combined them together. I have more gifted students this year and wanted to have them think beyond the movement of the particles and apply it to a real life situation. NASA provided that situation through climate change. With the introduction to climate change and presenting the lesson in that way students were able to think about our own oceans and how the sea levels are rising just like the water in the device rose when placed in hot water.

The students in this class and my other classes really enjoyed the lessons. Students in general tend to enjoy science because it isn't just sitting in your seat taking notes. Students are active using their hands and engaging in problem solving. Towards the end of class I asked these

students if they enjoyed the lesson and how was the lesson different. They said they liked it because they were able to work and figure out things on their own. This lesson is sort of a hands off lesson for me. I coach my class instead of teach it in some of the lessons in this unit. The students tend to struggle a bit more at first, but I personally think they get more out of the lesson. I got to hear that confirmation in my students response.

In reflecting on the lesson, I believe it was a success and I plan on conducting the lab in this way in the future. I believe it could be improved by making the lesson into a two day scenario. In the future, take one day to discuss climate change and teach about it and then conduct the lab or maybe do that in reverse. Have students conduct the lab and then discuss climate change and the rising sea levels the following class. This way students can compare to the lab that they conducted. All I know is after this lesson I plan on researching the NASA lesson plans even more to add some new ideas to my planning.