Pedagogy Option 3: Ocean Lesson Plan

Amber Miller

SCED 530: Lessons from the Ocean: Science on the Water Planet

Adams State University

How does Temperature Affect a Substance

Physical Science Activity

Grade level: 8th grade (Middle school span 6-8)

Topic of Focus: Thermal Energy

Standards Addressed:

NGSS Standards

MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer

MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Common Core Standards

3.2.8.A3: Explain how changes in matter are accompanied by changes in energy.

3.2.8.B3: Explain how changes in temperature are accompanied by changes in kinetic energy.

3.3.8.A6: Explain changes in earth systems in terms of energy transformation and transport.

Time Needed: 2 class periods (45 minutes each)

Description of Resources:

(1) Fortner and Mayer (2009) provided a clear activity to middle school students on, "how bodies of water can affect the surrounding areas" (Fortner and Mayer, 2009, p. 2). Students use thermometers in the activity to determine the differences in heat absorption and release between water and soil. The Science Activity sheet from Fortner and Mayer (2009) provides objectives, material list, procedure, an option to use technology, and even a second activity to add to the first if desired. This second activity would be an extension to the first. For my lesson plan, I pulled ideas from the first activity as

described. The end of the activity sheet describes how the standards were met in the activity.

(2) FOSS (2019) or Full Option Science System is a program designed for science classes from kindergarten to 8th grade. It was developed at the Lawrence Hall of Science, University of California, Berkeley. The lessons used as a reference in this lesson plan is from the 8th grade Chemical Interactions unit. The first reference is from a lesson on thermal expansion where students create a device that has water contract when cold and expand when hot, otherwise known as a thermometer. This is not told to students and they must figure it out in the analysis. The lesson goes more into detail, but I will be incorporating this lab into this lesson plan. The other lesson is later in the unit and incorporates chemicals. Students create their own thermos and use different chemicals to try to lower the heat absorbed for the thermos, salt is one example of a substance used. I am going to take this method and apply it to the lesson here by having students add salt to change the chemical composition of the water. This will demonstrate the differences between salt and fresh water in their absorption and release of heat energy.

Objectives:

(Students will be able to- SWBAT)

- SWBAT define thermal energy in relation to the absorption and release of heat energy in varying substances.
- SWBAT construct a device using lab materials provided to measure the expansion and contraction of water in a system.
- SWBAT compare the absorption and release of heat energy in various substances that form the surface of Earth (soil and water).
- SWBAT compare their lab experience to the problems facing the Earth in regards to the effects of albedo on the oceans.
- SWBAT explain the rising sea levels using the terms expansion and contraction.
- SWBAT collaborate in a laboratory setting provided materials and a procedure.
- SWBAT analyze data at the conclusion of the lab given their own observations and measurements.

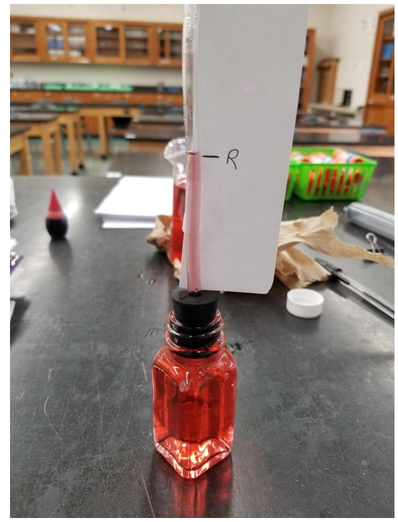
Assessment:

Students will be assessed on their ability to:

- Analyze the results of the experiment conducted in class and compare it to what they already know about matter and energy in the analysis questions and on the unit exam.
- Construct a conclusion using the terms contraction and expansion to describe the experiment taking place on day 1.
- Follow a procedure and complete the lab in the time given for days 1 and 2.
- Follow all safety rules in the lab.

- Compare their experiment to how a thermometer works in their analysis questions on day 1.
- Compare their experiment to the rising sea levels in their analysis questions.
- Describe, in their analysis questions on day 2, the differences between the absorption and release of heat between soil and water.

Materials for each pair in a lab group (Day 1):
(two devices will be created per lab group)



- 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 (Prep):

- Thermometer
- Bin of ice
- Hot plate or microwave

Materials for each lab group (Day 2):

- 2 Constructed thermometers from the previous lab
- Student Lab sheets (for both days)
- 1 container of dark soil and 1 container of water (Prepped by the instructor: The containers should hold equal amounts, and the soil and water should be left out overnight to come to room temperature.)
- 2 metric rulers- (Instructor prep- placed in the soil and water to give height of each)
- 1 Lamp (at least 150 W) with reflector
- 2 Ring stands (holding the thermometers in place)
- 1 Timer
- 2 glass thermometers
- Safety goggles for each group member

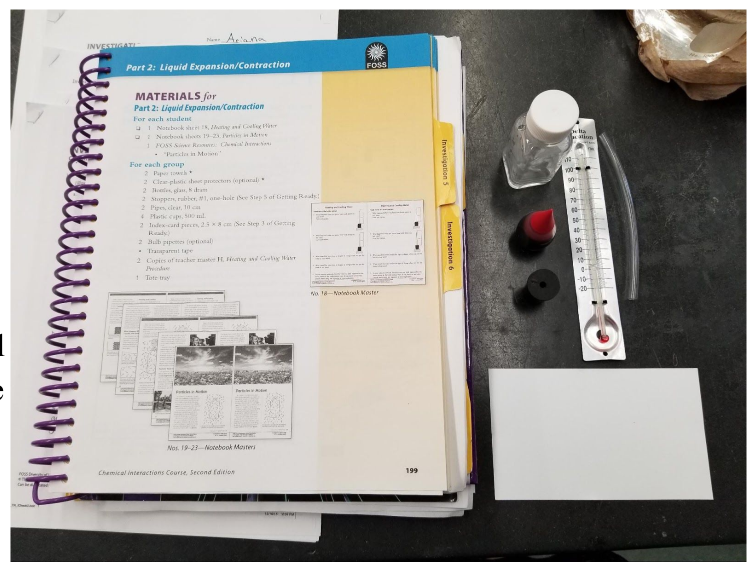
- Graph paper for each group member

For the Instructor (prep):
- 2 containers of equal volume
- Dark soil and water of equal volume
- 2 metric rulers

Instructor Information and Prep (Day 1):

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:

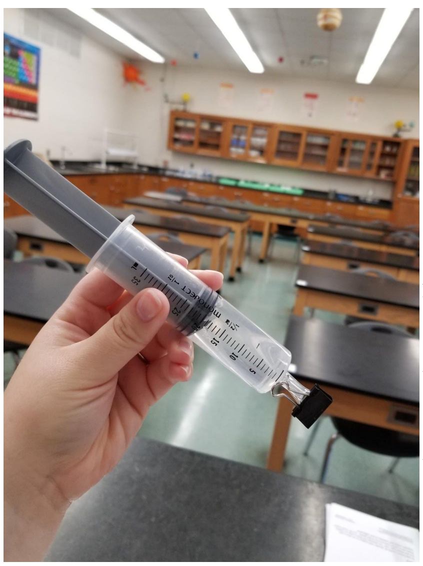
Global sea level has varied substantially throughout history, especially in response to the ice ages. In recent history, starting around 7,000 years ago, sea level became quite steady, but over the last century, it's been rising. Global tide measurements from tide gauges suggest that global sea level 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.

Procedure (Day 1):

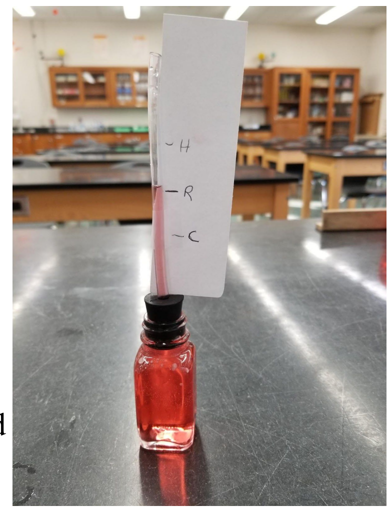
1. Start the class with a review of particles in a gas. Continue the review with students on kinetic and potential energy. A great way to do this is to throw a ball up into the air and have a student catch it, then ask the class, at what point is there kinetic energy? Do the same with potential energy. 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?
- Explain why the water level in the straw changed over time. What caused this?
- What happened to the water level as the device was placed into cold water?

Analysis Sheet:

1. What does the device remind you of that is a product mass produced and used in hospitals, schools, labs, and households:

A Thermometer

2. How does a thermometer work:

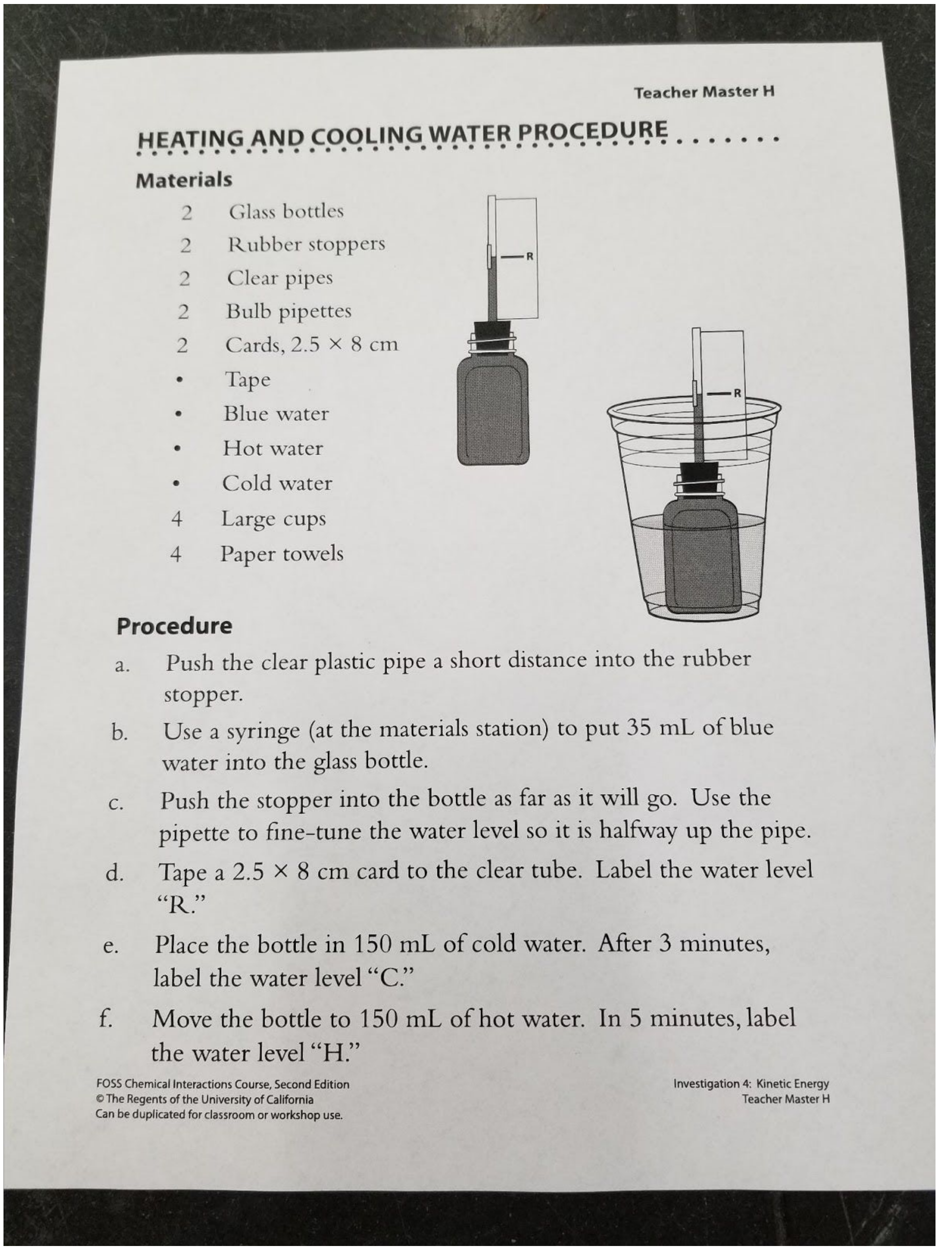
Thermal Expansion of water as it is heated and cooled.

3. 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 the 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.

4. How do 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 the particles of solid, and liquid.

Student Worksheet (Day 1):



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."

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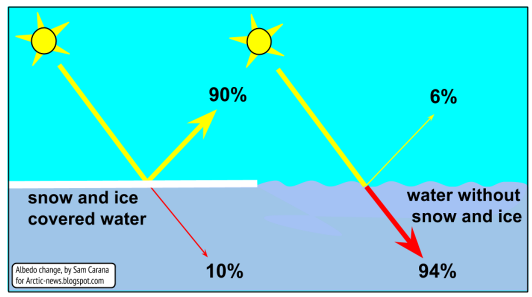
Investigation 4: Kinetic Energy
Teacher Master H

Instructor Information and Prep (Day 2):

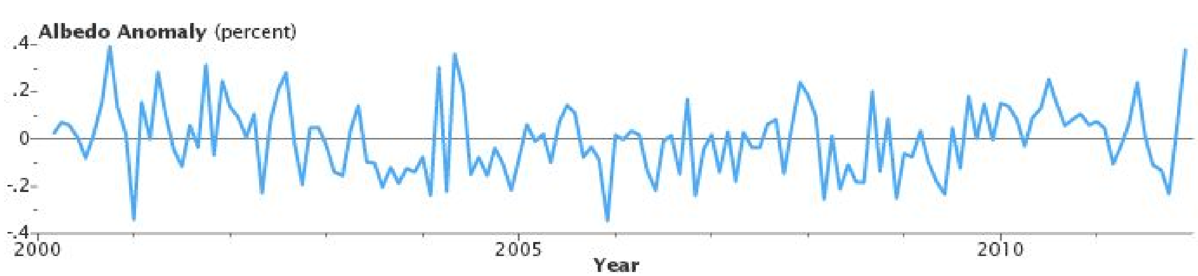
NSIDC or the National Snow and Ice Data Center (2019) defines albedo as, "a non-dimensional, unitless quantity that indicates how well a surface reflects solar energy" (NSIDC, 2019). Think about ice over top of a surface of water or going outside on a sunny day when there is snow on the ground. Sunlight is reflected off of the surface to its surroundings. Albedo, or the reflection of solar energy on a surface, is measured between zero and one. Black or absorption of solar energy is a zero and white or reflection of that solar energy is a one. "Sea ice has a much higher albedo compared to other earth surfaces, such as the surrounding ocean. A typical ocean albedo is approximately 0.06, while bare sea ice varies from approximately 0.5 to

0.7" (NSIDC, 2019). Ice on the surface of the ocean has a high albedo and therefore reflects a lot of the sun's energy. This energy is scattered to the surroundings of the sea water, land, and even back into the atmosphere. With the light before reflected, heat is also reflected back into the atmosphere and space.

As discussed, albedo is the reflection of the sun's energy. This affects the Earth in a variety of ways. Sea ice can reflect roughly 50 to 90 percent of the energy from the sun. That is 50 to 90 percent of radiation, heat, and light reflected back into the atmosphere and space. To compare, the ocean reflects 6 percent. That means the sea ice keeps the surface of the Earth cool (NSIDC, 2019). Earth Observatory (2011) from the EOS Project Science Office at NASA put these percentages into the amount of power reflected or absorbed from the sun. "Averaged over the entire planet, roughly 340 watts per square meter of energy from the Sun reach Earth. About one-third of that energy is reflected back into space, and the remaining 240 watts per square meter is absorbed by land, ocean, and atmosphere (Earth Observatory, 2011). This statement explains that one-third of the sun's energy is reflected back due to sea ice. That is a lot of heat and light energy entering the ocean. The ocean has an incredible capacity to absorb and hold heat. It takes a long time for the ocean to heat up and cool down due to water's specific heat capacity. On planet Earth, which is mainly water, that is a wonderous and helpful phenomenon for living things. It keeps the global temperature down to the levels that we are comfortable with today. Now what would happen if we were to have less of that ice or none at all?



It is not news to say that the ice is melting due to global warming, or otherwise known as climate change. As the ice melts there is less of the ocean surface covered in this layer of reflective substance. With less albedo the sun's energy is absorbed into the surrounding ocean more. This generates more heat, causing more melting, and the process continues. This causes positive feedback of this energy. The more energy we get from the Sun, the less albedo, and then the Earth absorbs even more energy from the Sun. "In the early 2000s, after the first few years of Terra-CERES measurements, it appeared that Earth's albedo was declining, a phenomenon that was widely reported in scientific journals and on NASA Earth Observatory"(Earth Observatory, 2011) . This caused panic in the science community and sparked many scientists, politicians, and citizens to recognize climate change. "But as more years of data accumulated, and as scientists began to better understand the data, they found that albedo was neither increasing nor declining over time. It was fluctuating a lot by year…" (Earth Observatory, 2011). There are times of higher albedo, which means more solar energy is being reflected and times of low albedo. The levels seem to fluctuate depending on the season and year. Earth Observatory has constructed data from their Terra-CERES from 2000 to 2011. This data is represented in Figure 2 (Data in this image is provided by Earth Observatory, 2011). The data expresses the fluctuation discussed.



Data has been collected over the years by multiple sources. The ice melting, causing less albedo, is an important topic to look into and assess. Michon Scott (2018) from NOAA has also conducted research and presented an analysis in 2018. “The 2018 minimum was nowhere near the record-low extent of 1.31 million square miles (3.39 million square kilometers) recorded on September 17, 2012, but it was nowhere near the 1981–2010 average, either. It was tied with 2008 and 2010 for the sixth-lowest extent in the nearly 40-year satellite record. The 12 lowest Arctic sea ice minimums have all occurred in the last 12 years” (Scott, Michon, 2018). What does this mean for our planet and climate change? As of now, the best way to address this rising issue is to advocate and educate. We need future scientists, engineers, and leaders to develop solutions to the problems of the past. This information on Albedo and thermal expansion is vital to our life on Earth. The ocean supplies resources, oxygen, and recreation to humans.

To examine albedo and the effect of the Sun’s energy, set up two bins for each lab group. One bin will be half filled with dark soil, while the other is of equal volume with fresh water. Each group should have two ring stands available at their lab station to set up their homemade thermometers from the previous lab. Be sure to have all materials listed at the lab stations for students to use or have them at a station for groups to collect.

Procedure for instructor:

1. Place the containers of soil and water about 3 cm apart.Lay one ruler across each container, resting it on the container’s rim.
2. Place one thermometer in the soil, with the bulb just barely covered. Use masking tape to attach the thermometer to the ruler to hold it upright. Place another thermometer close to the first one, with the bulb about 1 cm above the soil. Attach it to the ruler, too.
3. In the water container, position the remaining two thermometers in the same way, placing one just above and one just below the water surface. Attach both to the ruler above the water container.
4. Place the lamp on the ring stand, with the reflector pointing down. Position the lamp 30 cm above the containers and centered between them, being careful to shield the thermometer bulbs from the direct rays of the lamp. Containers may face each other for more even distribution of light, as long as the thermometers can be read. With this apparatus, one can simulate alternate periods of heating and cooling and observe how temperature changes in and above the water and land. The situation might represent either light and darkness on a single day or seasons of heating and cooling with annual changes in insolation.

Procedure (Day 2):

1. The class will begin with a review from the previous class on the expansion and contraction of water. The discussion should be calculated to end at thermal energy. Ask

the class where the thermal energy for our planet comes from. (*The Sun*) Then ask students how we measure the Sun's energy (*Temperature as one way, students may contribute more*). This will lead into today's activity.

2. Introduce students to the lab sheet and lab materials. The bins for the activity should already be set up with the dark soil in one and the water in the other.
3. Use the PowerPoints provided to explain albedo to students and how it will be used in today's lab.
4. Monitor students as they go through the lab sheet.
5. Students will begin by setting up their stations with the two bins and ring stands. Each group will have two thermometers from yesterday to mount onto the ring stand. Be sure each student has their device halfway in the way or soil just like what we did in the lab yesterday with the hot and cold water.
6. Lab group will then turn on the heat lamps at the same time at the same distance (10 cm) as a control. Group will record the temperature using their device and produced thermometers in the charts provided. The temperature will be recorded every 5 minutes for 20 minutes. The heat lamps will be shut off at the same time. The temperatures will be recorded again every 5 minutes for 20 minutes.
7. Students will clean up their stations and answer analysis questions. The analysis questions will also consist of a graph.

Discussion

- What can you conclude about the differences in absorption and reflection of soil versus water?
- Was there a difference between your thermometer and the manufactured one, according to the data?
- How does this experiment relate to real life?
- How would this freshwater compare to ocean water?

Extension: Have a container of each volume to the other containers ready in the front of the room with the same set up as the students, but this container has salt water in it. Conduct the same experiment as students if there is time in this class or the following class. Have students compare their data of the water to yours.

Analysis Sheet:

1. When the light is on, does air heat up faster over the soil or over the water?
   (Answer: over soil)

2. When the light is on, which changes more, the temperature of the soil or the temperature of the water?
   (Answer: The soil heats more rapidly. Soil has a lower specific heat, and it absorbs all radiation close to the surface. Specific heat is the amount of heat in calories required to raise the temperature of 1 g of substance by 1°C. The specific heat of water is 1. All other common liquids and solids have a specific heat of less than 1.)
3. Which absorbs more energy, soil or water?
   (Answer:water)
4. In the second 20-min intervals, when the light is off, which changes more, the temperature of the soil or the temperature of the water?
   (Answer: After the light is turned off, the soil cools more rapidly than the water because of its lower specific heat.)
5. Which loses heat faster, soil or water?
   (Answer: soil)
6. Which keeps heat energy longer, soil or water?
   (Answer: water)
7. After the light is turned off, is the soil a heat source? Is the water a heat source? Why?
   (Answer: After the light is turned off, soil functions briefly as a heat source. Because the air temperature above the water remains higher than that of the water itself, it continues to act as a heat source for the entire recording period, until the surface water is the same temperature as the air over it.)

(Fortner, Rosanne; Mayer, Victor., 2009)

Student Worksheet (Day 1):

How does Temperature Affect a Substance

Physical Science Activity

Materials for Each Lab Group

• Four thermometers
• One container of dark soil and one container of water (The containers should hold equal amounts, and the soil and water should be left out overnight to come to room temperature.)
• Two 30-cm rulers
• Masking tape
• Ring stand

• Lamp (at least 150 W) with reflector
• Safety goggles for each group member
• Graph paper

Procedure

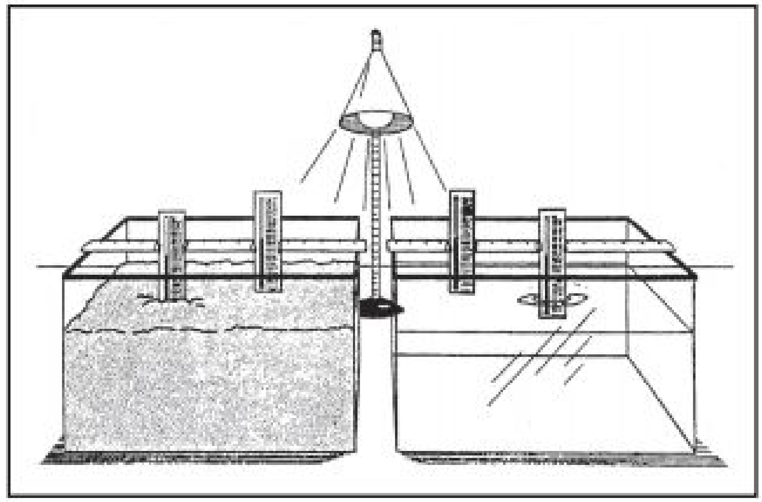


FIGURE 1. Setup for activity 1 investigation. Source: V. J. Mayer et al. 1996.

1. Use the data tables provided to show the temperatures of the four thermometers every 5 minutes for at least 20 minutes.
2. Wear safety goggles for this investigation.
3. The teacher should examine the setup before the lamp is turned on.
4. Turn on the lamp. At 5-min intervals, record the temperatures on each of the four thermometers. Continue for 20 minutes.
5. After 20 min, turn off the lamp. Continue recording temperatures at 5-min intervals for 20 min more.
6. Plot the data on a time–temperature graph. Use a different color for the data from each thermometer. Use the data to answer the analysis questions.

Data:

Heat Lamp On

Time (minutes)	Temperature (Lab made)	Temperature (Manufactured)
5		
10		
15		
20		

Heat Lamp Off

Time (minutes)	Temperature (Lab made)	Temperature (Manufactured)
5		
10		
15		
20		

7. Generate a graph using the graph paper provided for each data table. Use two different colors for the Lab made thermometer and the manufactured.
8. Clean up your station
9. Answer the analysis questions in your science notebook once completed

Grading Rubric:

	5pts	3pts	2pts	1pt
Introduction	• Name, Date, Lab Partner • Writes a statement of the purpose of the lab. • States a hypothesis that is based on research and/or sound reasoning • Hypothesis (prediction) is testable.	One of the "excellent" conditions is not met	Two of the "excellent" conditions is not met	Three of the "excellent" conditions is not met
Procedure			Procedure is followed as written in a timely manner.	Procedure not followed and lab uncomplete
Observations	Graphs and tables are	Results are clear	Results are	Results are

/ Results (data)	present • Labeled correctly • Results and data are clearly recorded, organized so it is easy for the reader to see trends. • Written description present	and labeled, trends are not obvious,	unclear, missing labels, trends are not obvious at all	present, though too disorganized or poorly recorded to make sense of
Conclusions	• Summarizes the essential data used to draw conclusions • Conclusions follow data (not wild guesses or leaps of logic), • Discusses applications of experiment ("real world" connections) • Hypothesis is restated and rejected or accepted based on the data.	One of the "excellent" conditions is not met	Two of the "excellent" conditions is not met	Three of the "excellent" conditions is not met
Format	• Followed instructions • Proofread • Neat/legible		Neat, organized with headings, few spelling/grammar errors	Somewhat lacking in organization, multiple spelling/grammar errors, not neat
Total Points:				

Resources:

Fortner, Rosanne; Mayer, Victor. (2009). "How is Coastal Temperature Influenced by the Great Lakes and the Ocean?". Heldref Publications. Vol. 46, No. 3; Pages 20-26.

FOSS. (2019). "FOSS: Full Option Science System". The Regents of the University of California. Received from: https://www.fossweb.com