Introduction to the Scientific Method

Overview:

After watching the teacher demonstrate an experiment, students generate a list of ideas describing why they believe the experiment worked as it did. This list of questions is revised to create a testable hypothesis. During the second part of the activity, students use the scientific method to conduct their own experiment.

Objectives:

The student will:

- understand the steps in the scientific method;
- write a testable hypothesis;
- write a conclusion based on experimental data;
- understand the importance of a control in an experiment;
- read a Celsius thermometer; and
- record and analyze data.

Materials:

- 2-liter bottle, with lid (for Cartesian diver)
- Eye dropper (for Cartesian diver)
- Brass nuts (only if plastic eye dropper is used)
- Hot plate (one per group of students)
- Thermometer (one per group of students)
- Two 250 ml beakers (per group of students)
- Water (distilled if available)
- 30% salt water solution
- Student Worksheet: "Testing a Hypothesis"

The plastic eye dropper above has been weighted with two brass nuts to provide the added weight needed to sink the Cartesian diver.

Answers to Student Worksheet:

Data: Boiling point of water: answers should be close to 100 ˚C.
Boiling point of salt water solution: answers should be higher than 100 ˚C and below 115 ˚C.

Data Analysis: salt water

Conclusion: Answers will vary depending on student's hypothesis.

Questions:

1. a) Non-salted water acted as the control in the experiment.
2. a) Yes. A 30% salt solution caused water to boil at a higher temperature than non-salted water, so we can assume that more salt (solute) will further increase the boiling point.

Introduction to the Scientific Method

Activity Preparation:

Before teaching this lesson, the teacher should make a Cartesian diver by following these steps:

1. Fill a 2-liter bottle with water, leaving a small amount of air space at the top of the bottle.
2. Fill an eyedropper with water so that it barely floats. (It is easier to test this in a beaker before putting it in the 2-liter bottle.)

Note: If a plastic eye dropper is used, weight the eye dropper with brass nuts as shown on the Teacher Instructions page of this lesson.

3. Place the eyedropper in the 2-liter bottle and twist on the cap.
4. Squeeze the bottle. The eyedropper should go to the bottom of the bottle and rise again when the bottle is no longer being squeezed.
5. Prepare the 30% salt solution required for the experiment part of this lesson. A 30% salt solution (by mass) is made by adding 30 grams of salt to 70 ml of water.

Activity Procedure:

1. Demonstrate the Cartesian diver. Ask students how it works. Write the ideas on the board. Have students phrase their ideas as a hypothesis, then ask how each could be tested. Try some of the ideas. For example: Does the Cartesian diver experiment work upside down, with the bottle 1/2 full of water? Does the experiment work with the lid off? Ask students to test each hypothesis.
2. Discuss terms related to the scientific method using the Teacher Information Sheet: "Lesson Terminology" as a resource.
3. Divide students into groups and distribute two beakers, a hot plate and a thermometer to each group, and the Student Worksheet: "Testing a Hypothesis" to each student. Explain that students will do an experiment to compare the boiling point of tap water to a 30% salt water solution to determine if the salt water solution will boil at the same, greater or lower temperature.
4. Ask students to follow the instructions on the Student Worksheet: "Testing a Hypothesis" to perform the experiment. Remind students how to read a thermometer.
5. Explain that this experiment demonstrates the importance of a control. If students didn't know the boiling point of water they would not be able to determine if salt had any effect on the boiling point of the salt water solution. In this experiment, water is the control (the standard for comparison) and the salt water solution is the variable or experimental set up.
6. Ask students how salt affected the boiling point. Explain that adding a solute to a solvent will generally increase the boiling point and decrease the freezing point. The salt solution should boil at a higher temperature.

Inquiry Extension: Ask students to determine if there is a relationship between the amount of salt in a salt water solution and its boiling point. Have students determine the boiling point of a 5%, 10%, 20% and 30% salt solution, then graph the results.

Lesson Terminology

Other definitions for the terms listed on this page exist, depending on the source of the information. These may not be exactly the same as definitions provided in the class textbook.

A ***hypothesis*** is usually a first, testable guess at the answer to a question. It should be based on available data.

A ***theory*** is an idea that explains why something happens or how something works. The ideas that make up a theory can be tested by conducting repeated experiments under controlled conditions. New information can discredit theories that people once held as true. For example, people believed the theory that Earth was flat, until new evidence demonstrated that Earth was round.

A ***law*** is a well-tested theory that is thought to express a fundamental principle of nature. Laws are commonly expressed as mathematical equations, such as the law of gravitation. It is important for students to realize that laws and theories can be changed. As more information is learned theories and laws can change to reflect current understanding.

The ***scientific method*** is a series of steps used to test a hypothesis.

A ***procedure*** is the method used to answer or test a hypothesis. In an experiment, there should be a *control* setup and an *experimental* setup. The control is used as a standard for comparison. For example, to find out if a particular fertilizer helped plants grow taller several plants would need to receive the fertilizer and several would not. All other conditions (light, water, soil, etc.) should be the same. The plants that did not receive fertilizer are the control group. Those that did receive fertilizer (the variable) are the experimental group.

Data is information collected during an experiment. Height of the fertilized and unfertilized plants, recorded over a period of time, could be one example.

A ***conclusion*** is the statement formed after analyzing the data. The conclusion should accept the hypothesis as true or reject it if it is not true.

Sometimes it is not possible to conduct an experiment to test a hypothesis. This is often the case in geology where events happened in the past. In these cases, scientists must use ***deductive reasoning*** to test the hypothesis.

Deductive reasoning example:
Moe, Larry and Curly barbecue hamburgers for dinner. They cook them thoroughly and each put their own "fixings" on their burgers. Moe puts lettuce, onion, mustard and ketchup on his hamburger; Larry puts lettuce, tomato, onion, mustard, mayonnaise and relish on his; Curly put tomato, onion, mustard, ketchup and relish on his. They also had some BBQ chips and lemonade. Two hours later Larry starts getting sick. Moe and Curly take him to the doctor, who examines Larry then asks what he had for dinner. Larry tells him exactly what he had. Next, the doctor asks Moe and Curly what

Lesson Terminology

they ate for dinner. Based on this information, he tells Larry what he thinks is wrong. What did the doctor tell Larry?

Answer: Larry probably had food poisoning from eating the mayonnaise.

In this case the doctor did not do an experiment to make a conclusion. By examining the data (what each one ate) he isolated one item that neither Moe nor Curly ate (mayonnaise, a common source of food poisoning). The doctor used deductive reasoning to solve the problem.

Mo'olelo are historical stories that have been passed on from generation to generation. Historical stories are an important part of Hawaiian culture. The knowledge gained through observations was passed along in the form of mo'olelo. They often provided important survival information, such as where to fish or find shelter. The scientific method and mo'olelo are methods of gaining knowledge through careful observations.

A ***control*** is a standard of comparison for checking or verifying the results of an experiment.

A ***variable*** is the part of an experiment that is likely to change.

Name:_____ **Student Worksheet**

Testing a Hypothesis

Directions: Complete the lab by finishing the hypothesis, performing the experiment using the materials provided, then recording the data and answering the questions.

Testable Question: How does salt affect the boiling point of water?

Hypothesis (fill in the correct word):

When compared to water, I think a 30% saltwater solution will boil at the/a _____ (same / higher / lower) temperature.

Procedure:

1. Put 150 ml of water in one beaker.
2. Place the beaker with water on the hot plate.
3. Let the water come to a boil.
4. Record the temperature of the boiling water with the thermometer. Record the data.
5. Repeat the experiment, using the salt water solution instead of plain water.

Data: Boiling point of water:_____˚C Boiling point of salt water solution:_____˚C

Data Analysis:

Which boiled at a higher temperature, water or salt water? _____

Conclusion: Was your hypothesis proven or disproved? Use a complete sentence.

_____

_____

_____

Further Questions:

1. Why was it important to determine the temperature at which water (without salt) boiled?
   a) Non-salted water acted as the control in this experiment.
   b) Non-salted water was the hypothesis in this experiment.

2. Do you think a 30% salt water solution will boil at a higher temperature than a 20% solution?
   a) yes
   b) no

