

The Scientific Method

Exploring Experimental Design

Scientific Method Practice 2

DIRECTIONS: Answer these questions on a separate sheet of paper using complete sentences to answer all questions. Be sure to restate the question in your answer!

Stephanie and Amy were vacationing in Canada. Bundled up in warm clothing, they walked along the beach. Glistening strips of ice hung from the roofs of the beach houses. Only yesterday, Stephanie commented, these beautiful icicles had been a mass of melting snow. Throughout the night, the melted snow had continued to drip, freezing into lovely shapes. Near the ocean's edge, Amy spied a small pool of sea water. Surprisingly, she observed the sea water was not frozen like the icicles on the roofs. What could be the reason, they wondered?

A scientist might begin to solve the problem by gathering information. The scientist would first find out how the sea water in the pool differs from the fresh water on the roof. This information might include the following facts: The pool of sea water rests on sand, while the fresh water drips along a tar roof. The sea water is exposed to the cold air for less time than the fresh water. The sea water is saltier than the fresh water.

Using all of the information that has been gathered, the scientist might be prepared to suggest a possible solution to the problem. A proposed explanation or solution to a scientific problem is called a hypothesis. A hypothesis almost always follows the gathering of information about a problem. Sometimes, however, a hypothesis is a sudden idea that springs from a new and original way of looking at a problem.

A scientist (or a science student) does not stop once a hypothesis has been suggested. In science, evidence that either supports a hypothesis or does not support it must be found. This means that a hypothesis must be tested to show whether it is supported. Such testing is usually done by performing experiments.

Experiments are performed according to specific rules. By following these rules, scientists can be confident that the evidence they uncover will clearly support or not support their hypothesis. For the problem of the sea water and freshwater, a scientist would have to design an experiment that ruled out every factor but salt as the cause of the different freezing temperatures. Stephanie and Amy, being excellent science students, set up their experiment in the following manner.

First, they put equal amounts of fresh water into two identical containers. Then Stephanie added salt to only one of the containers. [The salt is the independent variable. In any experiment, only one independent variable should be tested at a time. In this way, scientists can be fairly certain that the results of the experiment are caused by one and only one factor — in this case the variable of salt.] To eliminate the possibility of hidden or unknown variables, Stephanie and Amy conducted a controlled experiment. A control group is set up exactly like the one that contains the variable. The only difference is that the control setup does not contain the independent variable. Scientists compare the results of the experimental setup to the control setup.

In the experiment, Stephanie and Amy used two containers of the same size with equal amounts of water. The water in both containers was at the same starting temperature. The containers were placed side by side in the freezing compartment of a refrigerator and checked every five minutes. But only one container had salt in it. In this way, they could be fairly sure that any differences that occurred in the two containers were due to the single variable of salt. In such experiments, the part of the experiment with the salt is called the experimental setup. The part of the experiment without salt is called the control setup.

Stephanie and Amy collected the following data: the time intervals at which the containers were observed, the temperature of the water at each interval, and whether the water in either container was frozen or not. They recorded the data in the tables below and then graphed their results.

Water (Control Setup)							
Time (min)	0	5	10	15	20	25	30
Temperature (°C)	25	20	15	10	5	0*	-10

*Asterisk means liquid has frozen

Water with Salt (Experimental Setup)							
Time (min)	0	5	10	15	20	25	30
Temperature (°C)	25	20	15	10	5	0	-10*

*Asterisk means liquid has frozen

Stephanie and Amy might be satisfied with their conclusion after just one trial. For a scientist, however, the results from a single trial are not enough to reach a conclusion. A scientist would want to repeat the experiment many times to be sure the data was reproducible. In other words, a scientific experiment must be able to be repeated. Also, before the conclusion of a scientist can be accepted by the scientific community, other scientists must repeat the experiment and check the results. Consequently, when a scientist writes a report on his or her experiment, that report must be detailed enough so that scientists throughout the world can repeat the experiment for themselves. In most cases, it is only when an experiment has been repeated by scientists worldwide that it is considered to be accurate and worthy of being accepted.

By now it might seem as if science is a fairly predictable way of studying the world. After all, you state a problem, gather information, form a hypothesis, run an experiment, and determine a conclusion. However, sometimes it is not so neat and tidy.

In practice, scientists do not always follow all the steps in the scientific method. For example, while doing an experiment a scientist might observe something unusual or unexpected. That unexpected event might cause the scientist to discard the original hypothesis and suggest a new one. The scientist may never do the analysis and conclusion steps, but use the revised hypothesis to design and complete a new experiment. The scientific method is more like a cycle, as results are often the basis of writing a new, revised hypothesis.

As you already learned, a good rule to follow is that all experiments should have only one variable. Sometimes, however, scientists conduct experiments with several variables. Naturally, the data in such experiments are much more difficult to analyze. For example, suppose scientists want to study lions in their natural environment in Africa. It is not likely they will be able to eliminate all

the variables in the environment and concentrate on just a single lion. So, although a single variable is a good rule and you will follow this rule in almost all of the experiments you design or perform, it is not always practical in the real world.

CONCLUSION QUESTIONS

1. State Stephanie and Amy's problem in the form of a question.
2. Form a hypothesis to answer the problem question above based on the fact that fresh water does not contain salt.
3. According to the data table from Stephanie and Amy's experiment, at what temperature did the experiment begin?
4. At what time intervals were the temperature measurements taken?
5. What conclusions can you draw from these data tables about the effect of salt on the freezing point of water?
6. What can you say about the rate at which the temperature in the fresh water container dropped compared to the rate at which the temperature in the salt water container dropped?

7. What was the independent variable in Stephanie and Amy's experiment?

8. What was the dependent variable?

9. Explain why detailed, step-by-step written procedures are an essential part of any scientific experiment.

10. The following hypothesis is suggested to you: Water will heat up faster when placed under the direct rays of the sun than when placed under indirect, or angled, rays of the sun. Design an experiment to test this hypothesis. Be sure to number each step of your procedure. Identify your independent variable, dependent variable and control. Identify those things which will remain constant during your experiment.