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THINKING LIKE A SCIENTIST

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During studying at the University, we are doing many science activities. To work like scientists, we have to think like them. In this article we will describe what the scientific method is.

For example, our group is going to do an activity on the chemistry of food. The objective of the activity is to study bread mold. The latter grows best in a warm, moist environment. It is easy to moisten bread and place it in a covered dish. The problem is keeping the dish warm over the weekend, when there is no heat. The solar heating walls may give us an idea about how to solve this problem. Maybe the dish with moistened bread can be kept warm with solar heat. But what substance is best for storing this heat after the sun goes down? We might decide to do an experiment to answer this question. An experiment is a scientific test designed to give information under carefully controlled conditions [1].

The success of an experiment often depends on how the question it tests is stated. The more limited the question, the easier it is to set up an experiment to answer it. “What substances store heat best?” is too broad a question. Many substances can be solutions and we couldn't test them all. Some students might think that water is a good substance for storing heat. Others might guess that gravel is better. Now we can ask a more limited question. “If heat can be stored, which is better for the purpose: water or gravel?”

Once the question is stated, we can form a hypothesis. It is an educated guess about the answer to a problem or question. A hypothesis for this question might be: “Gravel stores heat better than water.” Now that we have a hypothesis, we can test it. Before testing our hypothesis, we should find out what is already known about the question. We might go to the library and read articles or books on materials that store heat. The information might even suggest ways to set up our experiment.

Suppose we and our groupmates are ready to test the hypothesis. To do the experiment, the students could be divided into groups. All of them are measuring out the same mass of each of the materials to be tested. One group puts water in a beaker. A second group puts an equal mass of gravel in its beaker. A third group puts nothing in its beaker. Each group places a thermometer in its beaker and then places its beaker in an oven set at low heat. When the temperature reaches 70°C, the students remove the beakers.

As the beakers are removed from the oven, each group reads the temperature in its beaker. Each group records this observation in a table. They put this first reading in the space marked Time = 0 minutes. They continue to record temperatures every 20 minutes. When the beakers cool to room temperature, they stop recording.

The temperatures written in the table are the data of the experiment. Data are the measurements and information that a scientist gets from an experiment. Careful observation is needed to get the best data possible from an experiment.

Why did the groups use the same mass of each substance? Using different masses might have changed the data. The data from an experiment done in this way might lead us to a false result. The data could differ, too, if the groups had used different kinds of containers. Starting the tests at different temperatures could also have given misleading results.

Mass, starting temperature, or any condition that can be changed is a variable. In a well-planned experiment, a variable is changed only to test the hypothesis. In this experiment, we are interested in only one variable: the materials used. The experiment can be a fair test of this variable only if we keep all the other conditions the same for each beaker.

The empty beaker is a control setup. A control is an extra setup in which all the conditions are the same except for the variable being tested. The control does not contain the variable being tested. Using a control makes sure that any changes seen in the other setups are due only to the variable being tested.

After taking our data, we compare it with that from the other groups to see which material stayed warm the longest. These results may support the group hypothesis or disprove it. Whatever the result, the group may be able to draw a conclusion from the experiment. A conclusion is a judgment based on the data gathered in an experiment. Our conclusion should be an answer to the question asked by the group.

Many times, the data taken in an experiment are numbers. It is often hard to draw a conclusion from a table of numbers. For this reason, scientists often graph their data. A graph is like a picture of the numbers. Such a picture often shows a pattern that we cannot see in the numbers themselves [1].

After graphing their data, the groups compare their results. The patterns in the graphs show that the beaker with the water stayed warm longer. These results show that the original hypothesis was incorrect. The groups conclude that water seems to be a better heat-storing material than gravel.

Our group can now use its conclusion to try to find a way to keep the bread mold warm. Perhaps the group might float the dishes in a tub of hot water. Or they might want to try another method. To find the best design for a water heater, the group will have to do more tests. These tests will use the results of the first experiment.

Scientists usually repeat experiments many times to make sure the data are accurate. If the results are the same over and over again, the conclusion may be stated as a law.

A scientific law is a statement that describes how something behaves. A law does not explain why something happens. It only describes what happens. For example, after repeating our experiment several times we might be able to state a law. "Water stores heat better than gravel."

We may want to know why our experiment turned out the way it did. We may form a hypothesis to explain the results. Our hypothesis might be “The air spaces in gravel make gravel lose heat faster than water.” We may want to experiment to test this hypothesis.

If our explanation passes many such tests, we might state a theory. A theory is an explanation for the way something behaves. Our theory might be “materials lose heat in air spaces.” Most scientific theories are changed or replaced many times.

These changes result from new data that do not agree with the established theory.

References

1. Hypothesis & Experiment (Part 1): Where to Begin? [Electronic resource] – Mode of access: https://misaelneto.medium.com/hypothesis-experiment-part-1-where-to-begin-476c148caa96. – Date of access: 13.03.2024.