

The Scientific Method For Experimental Design

Research Question: The research question is the single most important part of the scientific method. Every part of your project is done to answer this question. The research question is sometimes formed as a statement and is called the "Problem" or "Problem Statement."

Simple Example: Would vinegar, added to the water of a Sunflower plant, slow the plants' rate of growth?

Hypothesis: The hypothesis is an educated guess, formed as a statement; you propose to be the answer to the research question. An educated guess means that it is based on some prior knowledge.

Simple Example: Vinegar, added to the water of a Sunflower plant, would slow the plant's rate of growth.

Experimental Design: An experimental design is a planned experiment set up to test your hypothesis and to find out if your hypothesis is incorrect. If you cannot discover the hypothesis is incorrect, then it is more likely to be correct.

Variables: The experiment will contain an element or elements that do not change (called controlled variables or dependent variables) and elements that will change (called manipulated variables or independent variables).

Dependent variables: amount of soil, size of pot, type of plant, amount of water, frequency of watering, composition of water

Independent variables: number of times 10 ml. of vinegar is added to plant watering

Control: The control sample is treated the same as all other samples except it is not exposed to the manipulated variables.

Control: One of the Sunflower plants was treated exactly like all the other Sunflower plants, but did not receive any vinegar.

Observation: When you interact with your experiment, you are using your senses to observe. Does it smell, make a noise, become larger or smaller, change color, change shape or consistency? Can the change be measured?

Journal: All scientists keep a written record of their observations in some form of a journal. The journal entry will begin with the date and time the experimenter collected the data. If important to the experiment, data will include environmental values such as humidity, temperature, etc. Entries must be written clearly and with detail of description so another scientist could read the journal, simulate the conditions of the experiment, and recreate the experiment exactly.

Repetition: In any experiment, the investigator must repeat the test process no fewer than 3 times to be assured that results are consistent. In professional laboratories, tests may be repeated as many as 10 or 15 times. If any part of the experiment proves inconsistent, the experimenter must analyze the procedures to determine the problem, then start over.

Collect Data: As you observe your experiment, you will need to record its progress. Data can be whatever you observe about your experiment that may or may not change during the time of the experimentation. Examples of data are values in pH, temperature, growth measurement, color, smell, etc.

Data: The data are the values written down as the experiment progresses. Examples given are of data entries on measuring growth of plants:

	1/2/07-4 PM	1/16/07-4 PM	1/30/07-4 PM
Control Plant	7.4 cm.	7.9 cm.	8.9 cm.
Test Plant A-1	6.2 cm.	6.4 cm.	7.6 cm.
Test Plant A-2	4.9 cm.	5.1 cm.	6.5 cm.
Test Plant A-3	7.2 cm.	7.4 cm.	7.7 cm.
Test Plant B-1	6.3 cm.	6.4 cm.	6.7 cm.
Test Plant B-2	4.6 cm.	4.7 cm.	5.1 cm.
Test Plant B-3	7.2 cm.	7.2 cm.	7.5 cm.

Charts & Graphs: When at all possible, illustrations of data are advisable. They create a professional appearance and convey a great deal of information. Examples include: Bar Graph, Pie Chart, X & Y axis Graph, Histogram, etc.

Materials: List all supplies and equipment.

7 Sunflower plants	7 Flower Pots	10 ml. graduated cylinder
250 ml. beaker	Potting Soil	Distilled Water
Vinegar	Measuring tape	

Procedure: The procedure is a somewhat detailed, step - by - step written description of how you conducted your experiment. This can be written as a story

Every two days for two months, all plants were watered with 100 ml. of distilled water. The first three times test plants A were watered, 1 ml. of vinegar was added to the water. The first six times test plants B were watered, 1 ml. of vinegar was added to the water.

or as a numbered outline.

17. 10/12/06 @4pm: All plants were watered with 100 ml distilled water. Test plants A and B received 1 ml of Vinegar.

Results: The results are usually written in the form of a statement that explains or interprets the data. You do not go into any detail or explanations here. You simply write in words what your data is telling you.

Test plants in each group were consistent in rate of growth. Plants that were watered 6 times with vinegar grew more slowly than plants watered 3 times with vinegar. All plants watered with vinegar grew more slowly than the Control Plant.

Conclusion: The conclusion is a summary of the research and the results of the experiment. This is where you answer your research question. You make a statement of whether your data supported your hypothesis or not. You may have data that supported part of your hypothesis and not another part. You may also have data that did not support your hypothesis at all. In this case, you may explain why the results were different.

Vinegar made the soil more acidic and caused the sunflower plants to have a slower rate of growth. The more times they were watered with vinegar, the slower the rate of growth. The hypothesis was correct.

Application: The application is how the information or knowledge gained in the experiment can be used. It is not often included in science fair projects.

Resources: One of the most important things for a student to do is recognize the people and resources used in developing and conducting the project. List the people who offered knowledge or helped, and list web sites, retail stores, magazines, books, computer programs, etc. that were used as sources of information or supplies.

