ELEMENTARY SCIENCE INQUIRY GUIDE

Pinellas County Schools

Science Project Inquiry Guide

Science, as defined by the National Academy of Sciences, is “the use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process."

So what does that definition mean? If you look up the definition in an online dictionary, you will see something similar to the following:

> **sci·ence** *(noun)* systematic knowledge of the physical or material world gained through observation and experimentation

Notice that the definition has two parts. The first part, “systematic knowledge of the physical or material world,” is a noun. These are the facts that you learn in science class such as the formula for speed or the different types of chemical changes.

However, science is more than facts. The second part of the definition, “gained through observation and experimentation,” indicates that science is also a verb. Science is a process. It is a way of observing, a way of thinking, and a way of knowing about the world. The goal of science is to provide explanations for events that happen in nature. Scientists use those explanations to understand patterns in nature and make predictions about future events.

Types of Scientific Investigations

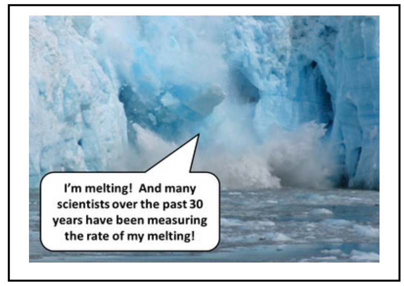
A **Controlled Investigation** involves changing one thing to observe and measure the effects of that one change. In a controlled experiment, the scientist has total control over the environmental conditions. Such things like the temperature, humidity, amount of light, amount of noise, and materials, can all be controlled and monitored by the scientist throughout the investigation. For this reason, controlled investigations are usually done indoors, such as in a classroom or kitchen.

Example Controlled Investigation Question:

- *How does the pH of water affect the growth (height) of a fig plant?*
- *How does the number of coils of an electromagnet affect its strength?*

A **Design Investigation** is very similar to a Controlled Investigation. A Design Investigation involves changing the design of something (Independent Variable) in order to ***create*** the effect desired by the scientist. For example, the scientist may wish to design a paper rocket that will travel the furthest distance. Therefore, the scientist might test his/her rocket with three different lengths. Once he/she has the results of the experiment, the scientist can then create the final product and test it via a controlled experiment to see if it has met the goal.

Example Design Investigation Questions:



- *How does the length of the wings on a paper rocket affect the distance the rocket travels?*
- *What is the effect of the circumference of the wheel on the speed of the wooden car?*

A **Field Investigation (Field Study)** involves observing and measuring plants and animals (including people) in their natural habitat or environment without changing, harming, or altering the setting or any part of the test subjects. Like a controlled experiment, the scientist <u>may</u> choose to observe and measure how ***one*** change (Independent Variable) has a measurable effect (Dependent Variable) on something else. The key different is that the scientist ***does not*** change anything in the environment, but rather, gathers data on the conditions or situations that already exist. There may be times when there are **not variables**. In this case, information is collected to answer wonderings that do not compare groups. This type of Field Investigation is more appropriate for younger students.

Example Field Investigation Questions <u>with</u> variables:

- *How does the time of day affect the number of fish a penguin eats?*
- *What is the effect of the temperature in Prospect Park on the number of ducks in Prospect Park Lake?*

Example Field Investigation Questions <u>without</u> variables:

- *What types of birds are in my backyard?*
- *How many squirrels will I find in my backyard?*

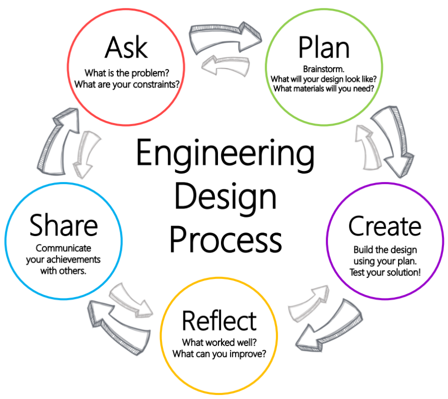
A **Secondary Research Investigation** involves using data (evidence) that has already been gathered by other scientist to answer a question. Therefore, there is no direct "experimenting" done by the scientist in a secondary research investigation. The data that is used can come from the internet, in print, or other sources. The major advantage of secondary research investigations is that the scientist can take advantage of data sets that have been gathered over many years or over very large areas. Questions that involve studying long term cause-and-effect relationships (ecosystems, climate, water quality, etc.) may be best suited for research.

Example Secondary Research Investigation Question:

- *What is the effect of the increase in carbon dioxide in the Earth's atmosphere on the rate of glaciers melting in the Artic?*

An **Engineer Design Project**

The engineering design process is a series of steps that engineers follow to find a solution to a problem. The steps include problem solving processes such as, for example, determining your objectives and constraints, prototyping, testing and evaluation.



While the design process follows a predetermined set of steps, some of these may need to be repeated before moving to the next one. This will vary depending on the project itself but allows lessons to be learned from failures and improvements to be made.

The process allows for applied science, mathematics, and engineering sciences to be used to achieve a high level of success to meet the requirements of an objective. The steps include problem solving processes such as, for example, determining your objectives and constraints, prototyping, testing and evaluation.

The steps of the engineering process are not always followed in sequence, but it is common for engineers to define the problem and brainstorm ideas before creating a prototype test that is then modified and improved until the solution meets the needs of the engineers' project. This is called iteration and is a common method of working.

<table>
<tr><th colspan="3">TYPES OF INVESTIONS SUGGESTED FOR DISTRICT SCIENCE SHOWCASE</th></tr>
<tr><td>EXPERIMENT</td><td>Recommended for K-5</td><td rowspan="5">More information can be found on Grade Level Canvas pages.

</td></tr>
<tr><td>FIELD STUDY</td><td>Recommended for K-5</td></tr>
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ELEMENTS OF SCIENTIFIC INVESTIGATIONS

Depending on the type of investigation, you choose, you will include some or all of these elements during the process.

Science Research Question:

The Science Research Question is made up of two components – the Manipulated or **Independent** Variable (the one thing that will be changed) and the Responding or **Dependent** Variable (the one thing you are measuring based on the change). The Science Research Question needs to be measurable. A suggested format for the Science Research Question is:

When I change________________, what happens to_____________?

If you are studying plants, an example of a Science Research Question could be:

- *When I change <u>the amount of fertilizer</u>, what happens to the <u>height of the plant</u>?*
- *How does the <u>amount of fertilizer</u> affect the <u>height of the plant</u>?*
- *What is the effect of <u>different amounts of fertilizer</u> on the <u>height of the plant</u>?*

Independent Variable:

The Independent Variable is the **<u>one</u>** thing that will be changed in the experiment. When graphing the data from the experiment, it is recorded on the X-axis. If you are studying plants, examples of Independent Variables could be the following:

- *Amount of water used*
- *Type of water used (e.g. salt vs. fresh)*
- *Amount of fertilizer used*

A sample Independent Variable could be: *The Independent Variable in the experiment is the amount of water that will be used to water the plants. The **experimental groups** will receive 10mL of water in one cup, and 20mL of water in another cup, and the **control** group will receive no water.* Ten trials of each group should be conducted for reliability and validity (10 cups with 10mL of water, 10 cups with 20mL of water and 10 cups with no water).

Control Group:

The Control Group is defined as the group in an experiment or study that **does not** receive treatment by the researchers and is then used as a benchmark to measure how the other tested subjects do. Consider what might be considered to be in “normal” conditions. If studying the amount of friction of a concrete sidewalk, the control group might be a dry, clean sidewalk. The experimental groups could be wet with water and covered in ice or leaves. In many cases, the Control Group set of trials is defined by the scientist conducting the experiment. For example, not watering the plant each day would be the Control Group in our plant experiment. The results of the two experimental groups (10mL and 20mL)

Dependent Variable:

The Dependent Variable is what will be **measured** based on the one change in the experiment. When graphing the data from the experiment, it is recorded on the Y-axis. If you are studying plants, examples of Dependent Variables could be the following:

- Height of flowers
- Number of leaves
- Size of flowers

A sample Dependent Variable could be: *The Dependent Variable in the experiment is the height of the plants. The height of the plants will be measured and recorded in # centimeters (always use **metric units**) and will be influenced by the amount of water (Independent Variable).*

Prediction:

A Prediction is a guess as to what might happen based on an observation. When making a prediction, it is important to look at possible patterns and current observations. To make a dependable prediction:

- Collect data using your senses. Remember you use your senses to make observations.
- Search for patterns or behavior and/or characteristics.
- Develop statements about what you think future observations will be.

When formulating a prediction, include the reasoning that led you to your prediction. This information may come from your own background knowledge or from information you gathered during background research.

Examples of predictions:

- *I predict the plants will grow more when more water is added because it is very hot in Florida and water evaporates quickly.*
- *I predict my plants that are given 10mL water will grow the most because they will not be too dry or too wet.*

A *hypothesis* is similar to a prediction. A hypothesis is a possible explanation for an observation or problem that can further be tested by experimentation. This term is not used during the inquiry process at the elementary level as it is not part of the tested standards on the State Science Assessment (SSA).

Materials List:

The Materials List is a specific list of items that are necessary to conduct the experiment. The Materials List can be thought of as a "grocery" list and needs to include the **<u>size</u>**, **<u>quantity</u>**, and **<u>unit of measure</u>** of each item and should include any additional details that are specific to the materials that a scientist should be mindful of. Unit of measure should be recorded in metric measurements. One might equate a materials list to the ingredients list of a recipe.

An example and non-example of a material list could be the following:

Materials List	
Non-Example	***Example***
Water	**Water**: 10mL in one cup, 20mL in one cup (amount used in daily watering)
Seeds	**Seeds**: 25 radish seeds in each cup
Cup	**Cup**: 3-500mL, clear plastic cups

NOTE: This is not an exclusive list but is provided as a guide the amount of required detail.

Set-Up Conditions:

The Set-Up Conditions are all of the things that will be kept constant that might affect the outcome of the experiment. The Set-Up Conditions can also be referred to as the **<u>constants</u>** because they are all the things that you will keep the **<u>same</u>** in order to conduct a **<u>fair trial</u>** in both the control and experimental groups. The Set-Up Conditions should be in list form.

If you decide to change **only** the amount of water given to the radish plant (Independent Variable), then you must keep everything else constant. These would include:

- *Same temperature (How will temperature be the same?)*
- *Same soil type (specify soil type)*
- *Same soil amount (specify how much soil per cup or plant)*
- *Same amount of sunlight (How will sunlight be the same?)*
- *Same growing location (describe the location)*

This is not an exclusive list but is provided as a guide the amount of required detail. Remember to consider both what needs to remain the same when setting up the experiment as well as when conducting trials.

Procedures (Directions):

The Directions are a step-by-step list of what you did with each item in the materials list, in the exact order in which they were done. Just like in a recipe, the key to the Directions is that someone should be able to read your directions and replicate **exactly** what you did throughout the experiment. The directions should include steps in setting up the experiment, conducting trials and collecting data for the experimental groups and control group. The experiment should be conducted with a minimum of 10 trials. (Increasing the number of trials will provide more valid data.) Ask yourself, "Could I give someone my set of directions and they be able to replicate this experiment, arriving at the same conclusion?"

Directions	
Non-Example	***Example***
1. Water plants	1. Gather materials necessary to conduct the experiment
2. Measure plants	2. Measure and add 250mL of soil to each of the three sets of cups
3. Repeat steps 1 and 2	3. Spread 25 radish seeds on top of the soil in each of the three sets of cups

NOTE: This is not an exclusive list but is provided as a guide the amount of required detail.

Data Collection:

Data Collection is where the results from the experiment are recorded using metric measurements. The Data Collection chart is used to organize the results from the experiment and will be referenced when creating a graph. Data needs to be collected from the ***control group*** (the group in which there is no change of the independent variable/item tested under normal conditions applied) and from the two **experimental groups** (groups in which the independent variable is applied). When the results of the experiment are all recorded, find the average of the results. The average of the results will be used when creating the graph. **The experiment should be conducted a minimum of 10 times (trials) for each tested group.**

Example of a data collection chart:

ITEMS TESTED	**TRIALS (Increasing the number of trials increase the validity of the investigation.)**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Control Group											
Experimental Group #1											
Experimental Group #2											

NOTE: Chart format will differ depending on type of investigation and data gathered.

Graph:

When setting up the graph, decide which type of graph would be appropriate to display the data from the experiment. **Most** experimental data can be displayed using a **bar graph.** Bar graphs are used to compare things between different groups. **Line graphs** are used to track changes over periods of time (continuous data). Line graphs can also be used to compare changes over the same period of time for more than one group.

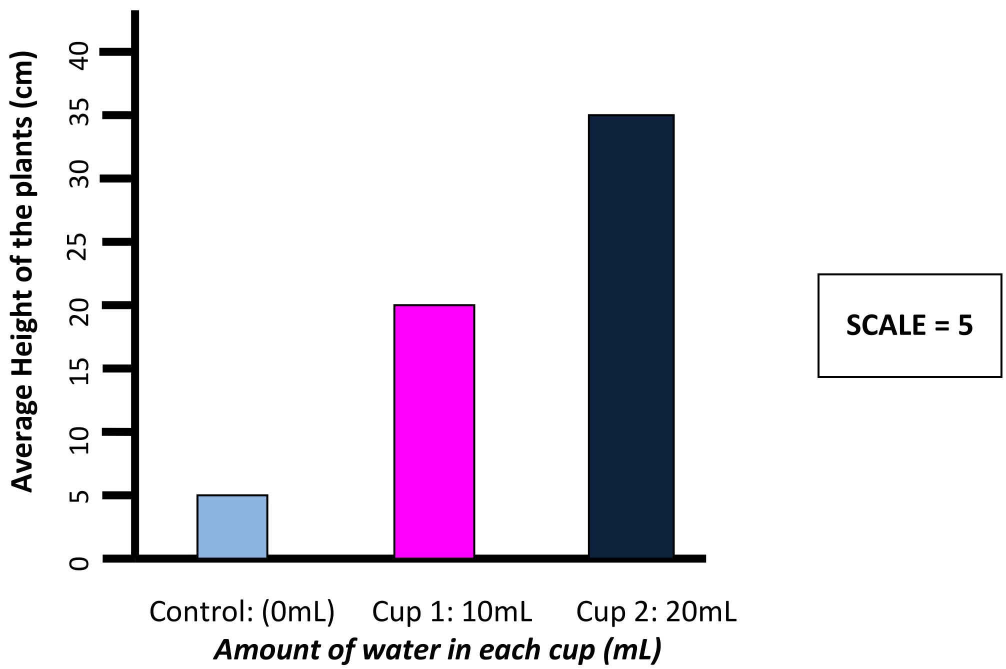
If using a **bar graph**, the graph should reflect the **averages** of each data set (2 experimental groups and the control group). Line graphs display the data points across time. For example, you would use a line graph if you were investigating the change of speed of an object or the dissolving rate over time.

The Independent (Manipulated) Variable is recorded on the X-axis, along the bottom of the graph and the Dependent (Responding) Variable is recorded on the Y-axis, vertically on the left-hand side of the graph.

Acceptable graphs **must** include (1) a **descriptive title**, (2) **labels on both the X-axis and Y-axis**, (3) **appropriate units provided on each axis**, and (4) the **scale needs to be appropriate for the data being displayed**. When determining the scale, refer to the data point with the greatest value of the three data sets. From there, decide if you will number by 1s, 5, 10s, 100s, etc.

Example of Bar Graph:

Measuring Up: The Height of Plants (cm)



NOTE: Information recorded on this graph is not actual data. It is an example of what elements are required in creating a graph that accurately displays the data from the experiment.

Results:

The Results statement describes what happened in the experiment. Focus the Results statement on factual information from the graph. *What does the graph show?* When writing the Results Statement, integrate mathematical terms such as *twice as much*, *one-third as much*, *less than*, or *no significant difference*. **Avoid words that cannot be measured** such as *healthier, better,* or *greener.* **Avoid saying "I proved."** No single experiment ever proves anything.

Explanation (Conclusion):

This is a summary of findings that evaluate the experimental procedures for their effectiveness and determine possibilities for further study. The explanation should further delve into the science that was driving the project. This is when you state whether your prediction was correct or incorrect, backing it up with evidence you gathered during your investigation. Furthermore, the explanation should explain why certain phenomenon occurred as a result of data collected.

Real World Uses Relating to Research:

Based on research (Internet, books, reference materials, newspapers, etc.), identify who in the "real world' might find the results from the experiment useful. Ask yourself, "Who cares?" Identify when, where, why or how they may use the information from the experiment. Link the Real World Uses to current events that are happening during the time of the experiment. This information should be written in paragraph form. Provide three examples of who or what might benefit from knowing the results/explanation (conclusion) of the investigation. Think back to our plant experiment. Some examples of Real World Uses might include, a home gardener living in a rainy climate vs. one living in a dry, arid climate, a zookeeper who is maintaining a natural habitat for an herbivore animal, or a landscaper at Disney World.

Science Journal:

The science journal is an ongoing record from Day 1 that contains each phase of the scientific process along with anecdotal records of observations and further wonderings. It should contain the date and specific details of record keeping either in the form of summary statements, numbers, or diagrams. The science journal can be in the form of a spiral bound notebook, composition book or folder with notebook paper.

Components that should be found within the science journal are the same as the requirements on the Science Showcase Rubric such as research question, prediction, independent variable, dependent variable, control group, set-up conditions, materials list, directions, data collection, graph, results, explanation, and real world uses. (These required elements will vary depending on the type of investigation.) The layout of a science journal may be formatted differently depending on the type of investigation. A Field Study journal may have more sketches and anecdotal notes whereas an Experiment Journal may have more diagrams, reflections on what worked/did not work, and changes made during the experimental process.

Available Support:
If you have any questions or need additional support while working through this process, please do not hesitate to reach out the Elementary Science Department.

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