Designing Experimental Investigations

An experimental investigation is an organized series of steps used to test a theory or an idea. Experimental design is a specific set of steps that are organized such that the results are as valid as possible. The purpose of experimental design is to eliminate experimental error and to ensure that the results are due to the factor or factors being tested. The experiment, based on a testable hypothesis that was inferred from research, must be repeatable.

Step 1: Stating the Purpose

What do you want to find out? Write a statement that describes what you want to do. It should be as specific as possible. Often, scientists read relevant information pertaining to their experiment beforehand.

The purpose will most likely be stated as a question such as:

"What are the effects of _____ on _____?"

Step 2: Defining Variables

- **INDEPENDENT VARIABLE** (IV) – The variable that is changed on purpose for the experiment; you may have several levels of your independent variable.
- **DEPENDENT VARIABLE** (DV) – The variable that acts in response to the manipulation of the independent variable.
- **CONSTANTS** (C) – All factors in the experiment that are not allowed to change throughout the entire experiment. Controlling constants is very important to assure that the results are due only to the changes in the independent variable; everything (except the independent variable) must be constant in order to provide accurate results.
- **CONTROL GROUP** - For some experiments, a control (standard of comparison for checking or verifying the results of an experiment) is necessary. All variables must be held constant in the control group.
- **EXPERIMENTAL GROUP** - The group(s) being tested with the independent variable; each experimental group has only <u>one</u> factor different from each other, everything else must remain constant.
- **REPEATED TRIALS** – The number of times that the experiment is repeated. The more times you repeat the experiment, the more valid your results will be.

Step 3: Forming a Hypothesis

- A hypothesis is an inference statement that can be tested.
- The hypothesis describes how you think the independent variable will respond to the dependent variable. (See "Forming a Hypothesis" for additional help in writing a hypothesis.)
- It is based on research and is written prior to the experiment . . . never change your hypothesis.
- For example: The rate of the reaction will increase when the temperature increases.
- Never use "I" in your hypothesis (i.e. I believe that . . .)
- It is OK if the hypothesis is not proven by the experiment as long as an explanation is given in the conclusion.

Step 4: Materials

- List all materials needed to conduct the experiment
- Include exact quantity needed
- If you are using data collection tools such a beakers, be sure to include specific size needed.

Step 5: Designing an Experimental Procedure

- Select only one thing to change in each experimental group (independent variable).
- Change a variable that will help test the hypothesis.
- The procedure must tell how the variable will be changed.
- The procedure must explain how the change in the variable will be measured.
- The procedure should indicate how many trials would be performed (usually a minimum of 3-4).
- It must be written in a way that someone can replicate your experiment.

Step 6: Results (Data Table and Graph)

- Qualitative Data is comprised of a description of the experimental results (i.e. larger, faster).
- Quantitative Data is comprised of numerical experimental results (i.e. 5 cm, 10.4 grams)
- The results of the experiment will usually be compiled into a table for easy interpretation.
- A graph of the data (results) may be made to more easily observe trends.
- Refer to "Making a Data Table" and "Making a Graph" skill sheets.

Step 7: Conclusion

The conclusion should be written in paragraph form and must follow the proper rules of grammar. This is a summary of the experiment not a step-by-step description. The following must be included in each conclusion:

Paragraph 1 – Review the Problem and Hypothesis.

- Restate the problem.
- Explain the reasoning behind the hypothesis.
- Restate the hypothesis.

Paragraph 2 - Review and Relate the Data to the Hypothesis.

- Describe what happened in the experiment and support the description with data.
- Use both quantitative and qualitative data when available.
- Validate the data with multiple trials. (This may be a comparison with classmates' data results.)
- Does the data support the hypothesis?

Paragraph 3 - Analysis.

- Indicate flaws discovered and changes made during the experimentation phase.
- Recognize and cite sources of error or assumptions.
- Simple statements such as "human error" or "equipment problem" cannot be used. Explain the exact cause of the error.

Title:		Date
Essential Question		
Student Developed Questions	**Part 1** Define Variable-	
	Six Components of an experiment	
	Component / **Definition/ Description** / **Example**	
	The variable that is changed on purpose by the experimenter	
	The variable that changes in response to the independent variable	
	All the factors that are not allowed to change during the experiment	
	The group (standard) to which everything is compared	
	The group(s) being testing using the independent variable	
	An experiment should be carried out many times to produce valid and accurate/repeatable results	
	Forming a hypothesis A good hypothesis: • Is a statement (NOT a question) • Is written in clear and simple language • Relates the independent and dependent variables • Is testable • Can be written several ways (including an if, then statement)	
	Example Hypothesis-write a hypothesis for the plant experiment in the space below:	

	Part 2 - Results (data)
	1. Where should results from your experiment be recorded?
	2. In a data table the independent variable (IV) is always a. b.
	3. In a data table the dependent variable (DV) is always a. b.
	4. What must you be sure to include once you have competed your data table?
	5. Other than a data table, what is another way to display your data?
	6. Describe where each type of variable is plotted on your graph.
Summary	