# Controlled Science Investigation

***NCATE Competency Assessment for SCE 4350***

Indicator 8.1 and 8.2

The following guide provides steps for helping students learn how to 1) plan and conduct a simple investigation that can be used in a science fair, and 2) communicate their research design and findings with others. The project is also the NCATE Competency Assessment for SCE 4350 for indicators 8.1 and 8.2.

**STEP 1. Selecting an Investigable Question**

Selecting an investigable question is one of the most difficult tasks as you begin scientific research. The following 7-Question Strategy can be used to help students develop brainstorm experiment or project ideas. This strategy may also be used to adapt a laboratory activity.

**Practice Example**

Use the 7-Question Strategy and Experimental Design Diagram described below to design an experiment related to fishing. Use the following newspaper article on ***fishing*** for ideas.

> Everglades City: Fishing guide, Captain Suzi Sinker, reported that fishing season is in full swing. When asked the best way to catch the most fish, she replied, “Time is important; the hour just after sunrise and just before sunset are best.” She also said use blue colored bait or six inch blue plastic worms. Captain Suzi Sinker also thinks weather patterns may affect fishing.

1. Make a list of materials or variables can you use to conduct experiments on _____?

2. Choose one of these materials or variables that you can change? This will be your independent variable (manipulated variable).

3. How will you change the independent variable? This will be known as the levels.

4. How can the _____ respond to the independent variable? These will be possible dependent variables.

5. Choose a dependent variable (responding variable).

6. Write a title that includes both the independent and dependent variable.

7. Make a hypothesis based on your title.

## STEP 2. DESIGNING AN EXPERIMENT

### Experimental Design Diagram

The Experimental Design Diagram is used to plan an experiment or to analyze and improve an experiment. (Do not confuse this diagram with a results table.)

You may use your question on fishing or the example investigation, Brand and Absorption, to complete the Experimental Design Diagram.

| **Experimental Design Diagram** | | | | |
|---|---|---|---|---|
| **Title:** | | | | |
| **Hypothesis:** | | | | |
| **Independent Variable (IV):** | | | | |
| **Levels of IV** | | | | |
| **Number of trials for each IV** | | | | |
| **Dependant Variable:** | | | | |
| **Constants (Controlled Variables):** | | | | |

## Example Investigation - Brand and Absorption

**Materials**
Various brands of paper towels
Plastic container or beaker
Water
Graduate cylinder (ml)
Watch with second hand

**Procedure**

1. Obtain one square of each paper towel brand.
2. Measure 100 ml of water with the graduated cylinder. Add the water to the container (plastic container or beaker).
3. Push the square of paper towel into the water for 30 second. Use a pencil to push the towel under the surface.
4. Remove the paper towel. Hold the paper towel over the container until it stops dripping.
5. Use the graduated cylinder to measure to amount of water (ml) absorbed by the towel.
6. Repeat Steps 2 to 5 with each of the brands of paper towels.
7. Record your results in the table and calculate the average of each team's results.
8. Construct an appropriate graph.

**STEP 3: CONDUCTING THE SCIENTIFIC RESEARCH**

**Once you have an experimental design you are ready to begin collecting data.**

**Types of Data**
**Measurement data is quantitative data collected.**
**Categorical data**

1. **Nominal data** is data that can be assigned a code in the form of a number, where the numbers are just labels or codes (such as males coded as 0 and females coded at 1).
2. **Ordinal data** is data that can be ranked (put in order), such as activity level of an animal or a person's opinion on a Likert-type survey (1= strongly disagree, 2= disagree, 3= neutral, 4= agree, or 5 strongly agree)

**Results**

Results are described in a paragraph format. Data collected from an experiment are usually displayed in simple data tables and appropriate graphs within the paragraphs.

***1) Tables***

A data table is a chart to organize and display the data collected in an experiment. This table provides an example for the Brand and Absorption Investigation from *Students and Research.*

| *Independent Variable* | *Dependent Variable* | | | | | | | *Average* |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | Trials | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

***2) Graphs***

A graph communicates in pictorial form the data collected in an experiment.

**Graph the average of your trials, not data for each trial.**
The independent variable is placed on the horizontal (X axis), and the dependent variable on the vertical (Y axis). The unit of measurement is placed in parentheses next to or beneath the variable.

**Line versus Bar Graphs**

A **line graph** is used when both variables are continuous data. Continuous data are measurements made using standard measurement scales with equal intervals (Time and volume are examples.) The line graph shows the relationship between the independent variable and the dependent variable.

A **bar graph** is a pictorial display of a set of data using bars to indicate the value, amount, or size of the dependent variable for each level of the independent variable tested. A bar graph is used for discrete data, which are categorical. Examples include

gender, brand, or color. If the intervals between the data do not have meaning, a bar graph should be used to display the data.

Quantitative Data that is discrete is graphed using a bar graph; for example, the number of wolves born in a given year. Discrete quantitative data are collected using standard scales in which only whole numbers are used.

**ANALYZING THE DATA**

Measurement data is typically summarized using averages or means and ranges. Categorical data is typically summarized using medians (the middle value) or modes (the value that occurs the most) and frequency distributions (a representation of the number of counts of values or responses).

## STEP 4: WRITING THE REPORT and PRESENTING YOUR RESEARCH

### Written Report Guidelines:

**Title Page –**

Include the name of your project, your name first followed by your team members, Instructor name, class, and date.

**Introduction –**

In a paragraph form, describe the rationale, purpose, and hypothesis for the experiment. Use these questions to guide you:

- Why did you conduct the experiment? (Rationale)
- What did you hope to learn? (Purpose)
- What science concepts are involved in this experiment?
  - You may discuss the independent and dependant variables.
  - For example, if you wrote up the previous "Brand and Absorption" Investigation, you would discuss adhesion and capillary action.
- What did you think would happen? (Hypothesis)

**Methods**

In a paragraph form, describe the materials and procedures used to conduct the research project. Step listings are not acceptable. Provide sufficient detail to allow a reader to repeat the study. Include precise descriptions of the sample, any apparatus that was constructed or modified for the study, and the methods of data collection.

**Results**

Include a sentence directing the reader to see the table with your data and figure (graph) that shows the relationship between the independent and dependant variable. Each table and graph should have a title.

Summarize the data in narrative form. Include any statistical analysis, such as the average. Describe the relationship between the variables on the graph.

**Conclusion**

Describe the purpose, major findings, an explanation for the findings, and recommendations for improving the experiment or conducting future research.

- What was the purpose of the experiment?
- What were the major findings?
- Was the hypothesis supported by the data?
- How did your findings compare with other researchers or with information in the textbook?
- What possible explanation can you offer for the findings?
- What recommendations do you have for improving the experiment and for further study?

## Written Scientific Research Report Scoring Rubric

| | Points | Self | Peer | Teacher |
|---|---|---|---|---|
| **Title** | | | | |
| Correct title including both independent (IV) and dependent variable (DV)<br>Authors (Team Members) | 2 | | | |
| **Introduction (Paragraph Format)** | | | | |
| Rationale | 4 | | | |
| Purpose | 2 | | | |
| Connection to science concept | 7 | | | |
| Hypothesis | 3 | | | |
| **Methods (Paragraph Format)** | | | | |
| All steps, equipment, and materials included | 4 | | | |
| Written for one level of independent variable | 4 | | | |
| Repeated trials for each level of independent variable | 4 | | | |
| **Results** | | | | |
| **Data table** | | | | |
| Labeled vertical column for independent variable | 2 | | | |
| Labeled vertical column for dependent variable | 2 | | | |
| Correct values of independent and dependent variables | 2 | | | |
| **Graph** | | | | |
| Correct label/Units/Scale for X-axis | 2 | | | |
| Correct label/Units/Scale for Y axis | 2 | | | |
| Data pairs correctly plotted | 2 | | | |
| **Summary of Results (Paragraph format)** | | | | |
| Data trends summarized in a paragraph | 4 | | | |
| **Conclusion (Paragraph format)** | | | | |
| Purpose of experiment | 3 | | | |
| Major findings | 3 | | | |
| Support of hypothesis by data | 3 | | | |
| Comparison to other research or possible explanation related to science concept | 5 | | | |
| Recommendations for further study/improvement of experiment | 2 | | | |
| **Form** | | | | |
| Paragraph format throughout | 2 | | | |
| Past tense in single or third person voice | 2 | | | |
| Overall spelling/grammar | 2 | | | |
| **Presentation of Research Report** | 10 | | | |
| **Total Points** | 75 | | | |

### Scoring

Exceeds Expectations: Scores ≥ 70

Meets Expectations: Scores 65 - 69

Does not Meet Expectations: Scores ≤ 64

## Science Research Presentation Guidelines

| Outline Form for PowerPoint Slides |
|---|
| **Introduction**<br><br>• Introduce yourself.<br>• Explain why you were interested in the topic.<br>• State the problem.<br>• Explain the science concept that your experiment relates to.<br>Give background information on the variables and prior research (if appropriate).<br>• State the research hypothesis. |
| **Methods and Materials**<br><br>Describe the design of the experiment. (You may show the experimental design diagram.)<br>Describe the methods and materials. (You may list the materials, procedure, or show photos of the experiment.)<br>Explain how the data were analyzed. |
| **Results**<br>Display the results in a table and graph format.<br>Describe the results. |
| **Discussion/Conclusion**<br><br>Summary the findings, including support of research hypothesis.<br>Compare findings with prior research.<br>Suggest improvements, related topics for future study, and potential applications.<br>Explain or further elaborate on the connection to the science concept.<br>(You may show a diagram to illustrate the science concept. Use google images.) |

**Poster Layout for Science Fair – Not for this Class**

| | | |
|---|---|---|
| **Introduction**<br>Purpose<br>Rationale<br><br>Hypothesis<br>Including IV and DV<br><br>**Methods**<br>Materials | **Title of Project:**<br>**Including IV and DV**<br><br>**Procedure**<br><br>**Results**<br>Data Table<br>Including all trials and average | Graph<br>Average of trials<br>IV: Horizontal Axis<br>DV: Vertical Axis<br><br>**Conclusion** |

## References

Cothron, J. Giese, R., & Rezba, R. (2000). Students and Research. Dubuque, Iowa: Kendall Hunt Publishing Company.

Cothron, J. Giese, R. & Rezba, R. (1996). *Science Experiments by the Hundreds.* Kendall Hunt. (Teacher Edition)

Rezba, R., Sprague, C., & Fiel, R. (2003). *Learning and Assessing Science Process Skills.* Kendall Hunt.

## Getting Ideas from Science Textbooks or Science Fair Trade Books

When choosing a science activity to convert into a controlled experiment, you should choose an activity that has one variable, which can be manipulated or changed (independent variable), and a second variable, which can be measured (dependent variable).

## Possible Topics Related to Climate Science

Choose one of the following and design a controlled investigation. Have your group's experimental design diagram checked before beginning the investigation. You will present your investigation in a PowerPoint format and turn in a written report using the guidelines in this guide.

- The Effect of Salinity on the Density of Water
- Does Land or Water Absorb Heat Faster? Or Does Land or Water Lose Heat Faster?
- Does the Color on an Object Affect the Amount of Light (Heat) Absorbed?
- Does the Area of Earth's Surface Receiving Sunlight Vary at Different Latitudes?
- The Effect of Water Temperature on Dissolving Rates
- The Effect of Type of Ice Melt (Glaciers versus Floating Ice) on Sea Level Rise
- Does an Enhanced Greenhouse Effect Cause Temperature to Rise?