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# K-12 Partnership Lesson Plan

## Experimental Design and Communicating Scientific Findings

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## Overview

Students will learn essential part of the experimental design (replication, randomization, and control). This will be especially useful for students conducting independent projects. Students will also learn how to present their scientific findings and practice by critiquing scientific posters.

**Objectives**

At the end of the lesson, students will be able to:

* Design experiment (randomization, replication and control)
* Communicate scientific findings (general structure)
* Make a poster and evaluate constructively

**Length of lesson**

Total length of the lesson is about 50 minutes

Experimental design lecture : 15 min

Poster judging activity: 20 min

Discussion:10 min

How to make scientific poster presentation: 10 min

**Grade Levels**

Middle school and high school

**Standards covered**

B1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.

B1.1EDescribe a reason for a given conclusion using evidence from an investigation.

B1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.

B1.2D Evaluate scientific explanations in a peer review process or discussion format.

**Materials**

* Poster Evaluation Checklist
* Posters to evaluate
* PowerPoint presentation on experimental design (Experimental Design.ppt)
* PowerPoint presentation on poster design (Designing Poster.ppt)

**Background**

Students in K-12 schools are often asked or encouraged to conduct independent (yet guided) experiments or studies on a question of interest to them. This may come in the form of a regular science course, a science fair project, or an independent project. While actually conducting the study is challenging and can require significant guidance, the specific nature of the study requires one-on-one advice from a teacher. Two elements of the project, however, can be taught to a broader audience (i.e., the entire class): the experimental design process (the beginning), and communicating scientific findings (the end).

Before an experiment or study can be carried out, it must be planned. Once a question of interest is identified (hypothesis), the variables of interest must be identified. What variables will provide the answer to your question (dependent variables)? What variables will produce a meaningful response (independent variables)? Once variables are identified, the experiment must be designed properly, accounting for *controls*, *replication*, and *randomization* properly. These elements of experimental design are more nuanced than they appear at first glance, and it is often difficult for students to understand their purpose and application. For example, idea of a “control” as the *unmanipulated* treatment in an experiment is very confusing for students because the multiple meanings of the word. To *control* something usually means to *manipulate*.

Communication of scientific findings requires students (as with professional researchers) to condense the results of a study into the important elements. Most scientific communication (journal articles, conference presentations, posters) follows a conventional pattern: introduction, methods, results, and discussion. Integrating these elements into a cohesive, engaging, and informative presentation is extremely challenging and requires thought and practice.

### Activities of the session

### This session is intended to be split between two sessions: a) before the project planning; and b) after the project is completed.

### a) Part I: Before choosing an experiment (or at the same time).

1. Lead a discussion on the necessary elements of designing a scientific experiment, or experimental design (with PowerPoint). These elements are:
   1. Independent vs. Dependent Variables
   2. Control
   3. Randomization
   4. Replication
2. Once the presentation/general discussion is complete, you can talk about ideas for an experiment/study. Students can suggest research questions, and you can guide them through thinking about how the four elements of experimental design will be implemented on some theoretical or real experimental studies.

b) Part II: After completion of the experiment, with results in hand.

1. Lead a brief discussion about what students might expect to see in a poster.

2. Show posters to students. Either lead a group discussion or assign individual posters to students or groups of students. Ask them to critically assess the posters, using the “Poster Evaluation Checklist.”

3. Get initial feedback from students. Which posters were good? Why?

4. Present elements of communicating scientific findings (with PowerPoint).

5. Discuss with students what works and why.

**Resources**

* A “Google images” search for the keywords “scientific poster” will yield several examples for comparison, good and bad. Additionally, “science fair poster” will yield some examples that may be more similar to what the students will create.
* Scientific Poster Evaluation (MS Word Document)
* Grading Rubric created by Science Buddies (http://www.sciencebuddies.org)

**Assessment**

It will be clear from the student’s work how well they understand. Rank students posters based on criteria outlined in PowerPoint.