

Module 1: Everyday Toxicology

Lesson 3: How Can We Refine Our Experimental Designs?

Lesson Overview

Summary:

At the conclusion of this lesson, students will have refined their experimental designs based on peer feedback and set up their experiments. (They will conclude their experiments, collecting and interpreting data, in Lesson 6, three to five days from today.)

The homework assignment draws the distinction between acute and chronic doses, and then directs students to play the role of a senior executive at a pharmaceutical company and consider the quantitative criteria for determining the safety and effectiveness of a new drug.

Objectives:

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

1. refine experimental designs to address peer review concerns to instructor satisfaction.
2. explain the importance of deliberate and creative planning prior to conducting an experiment to instructor satisfaction.
3. differentiate between acute and chronic doses (and responses) with 100% accuracy.
4. assess the criteria of safety and effectiveness for the approval of a new drug to instructor satisfaction.

Grades:

9th through 12th

Prepping the Lesson

Instructions:

Materials/Technical Resources:

It is our recommendation that you walk through the teacher and student materials for this lesson to ensure that students will be able to receive the information through the modes of delivery that we intended prior to using the material in the classroom. If you or your school does not have the resources needed, you may need to make some modifications depending on the resources you have available.

The following materials/technical resources will be needed to complete the lesson. We recommend using Option #1 to provide the materials to your students in the manner in which they were intended to be delivered.

Option #1 (Preferred Requirement)

You will need to have access to a computer, the Internet, and a projection device during the entire lesson. Your students will need to have access to computers and the Internet. You and your students will simultaneously step through the module while using their given computers. You may have to make special arrangements for all of your students to have a computer. Be sure you and your students will not be blocked from Google Documents, YouTube, and your selected online collaborative tool. You may be currently using an online collaborative tool but if not, we recommend Facebook groups, Edmodo, or eChalk.

Option #2 (Minimum Technology Requirement)

If you do not have a way for your students to access the Internet individually, then you will need to facilitate their access to the information. You will need access to a computer, the Internet, and a projection device during the entire lesson. You will step through the module as your students watch and complete the presented activities. There may be modifications to the delivery of the materials that you will need to make, depending upon the resources you have available. Be sure you have access to Google Documents, You Tube, and your selected online collaborative tool. You may be currently using an online collaborative tool but if not, we recommend Facebook groups, Edmodo, or eChalk.

Lesson Time and Supply List:

This document will provide you with information on prep time needed, a list of supplies, and total lesson time for this particular lesson. See appendix for the Lesson Time and Supply List document.

Student Homework:

Prior to starting this module, it is important to determine which online collaborative tool you and your students will be using. Once you have had an opportunity to review all of the lessons, decide how you will facilitate the homework discussions and submissions using your selected online collaborative tool. Be sure to give your students clear directions and objectives on your expectations of the use of this tool and their participation in their homework activities. We highly encourage you to participate with your students in their homework discussions to enhance the quality of the experience.

Essential Vocabulary:

acute effects, calcium crystals, cardiovascular, cholesterol, chronic effects, continuous exposure, coronary disease, environmental

concentration, experimental systems, germinate, long-term responses, median germination failure concentration or GFC_{50} , neurological disorders, pharmaceutical, plasma membrane, regulator, short-term responses, tubules, vitamin D (See Lesson 1 and 2 for additional vocabulary words.)

Student Notebook:

Laboratory notebooks are arguably the most useful tool at an experimenter's bench. Remind students of the critical importance of recording all experimental observations, and especially recording all experimental conditions (e.g., the type of chemical treatment, the range of concentrations, number and species of seeds, etc.) when starting an experiment so that they can maintain comprehensive, unambiguous control over those variables when they follow up with subsequent experiments.

Implementing the Lesson

Instructions:

**1. Guided Discussion
(5 Minutes)**

Comparing Experimental Designs

Identify one or two students' experimental designs to review with the entire class. Be sure to provide guidance to designs that are not still sufficiently complete to be carried out. Students should also be given the opportunity to revise their experimental designs based on feedback from their peers in the homework assignment, appropriately updating their observation tables and otherwise documenting the changes in their notebooks.

**2. Group Activity
(5 Minutes)**

Setting Up the Experiment

Starting with a comprehensive and clear experimental design, and an observation table to collect their data, students should proceed to set up the experiment: mixing dilutions, preparing and labeling petri dishes, planting seeds, and the like. Students can review the “**Serial Dilution**” video if needed.

When students are done setting up the experiment, collect the petri dishes and incubate them in the dark (an easy way to do so is to put the stacked petri dishes back in the box they were shipped in).

**3. Guided Discussion
(1 Minute)**

Conclusion

As students are finishing their experimental setup, address any student questions or concerns, and introduce the homework assignment.

Homework

9. Video (5 Minutes)

Acute Versus Chronic Toxicity

The homework assignment includes two parts:

1. The “**Acute Versus Chronic Toxicity**” video explains concepts students will apply in the activity;
2. In the “**Pharmaceutical Company Scenario**,” students will consolidate their understanding of the dose/response relationship and extend it to cover chronic as well as acute effects.

Please post both the video and the activity to your class’s online collaborative tool for your students to review and complete.

10. Activity (30 Minutes)

Pharmaceutical Company Scenario

Imagine that you are a senior executive for a large pharmaceutical company. You are responsible for the safety and effectiveness of the new drugs that your company introduces to the market.

The company is preparing to launch a new pain reliever. What sorts of effects would you examine in order to convince yourself (and regulators) that the drug is safe and effective? **Remember to consider both acute and chronic effects!**

1. **Select at least three biological responses** that you would evaluate for your new drug. Choose any biological responses, harmful and beneficial, acute and chronic, that you think would be relevant to evaluating a pain reliever. **Sketch your best guess** of the dose/response curves for each response. The precise values of the median doses are not so important as your **educated guesses about which will be lower and which will be higher.**
2. Which responses are acute? Which are chronic?
3. What criteria would you use in order to call a new drug “safe”? (You might recall the concept of Therapeutic Index.) What criteria would you use in order to call a new drug “effective”? (Are these criteria different for chronic, as opposed to acute, effects?) On the basis of your results, would you call your new drug “safe”? Would you call it “effective”?
4. Using your online collaborative tool, share your answers (including the dose/response curves) with your classmates. You might find these “**sharing suggestions**” helpful examples which are located in your appendix.

5. Using your online collaborative tool, comment on at least one other student's response to these questions.
 - Are they measuring appropriate responses?
 - Are they drawing the correct conclusions about safety and effectiveness?
 - What did they think of that you did not?
6. During your next class you will review some of your answers and discuss them together.

Answers: *Students might suggest both acute and chronic therapeutic uses, and may suggest any number of possible side effects—death, coma, stomachache, insomnia, diarrhea, ringing in the ears, dizziness, stroke, stomach ulcer, allergic reaction, etc.*

This video (<http://blah.org>) is an example of a good response to this activity. It may help to frame the discussion of the activity at the beginning of the next meeting, but don't share it with the students before they try thinking it through themselves.

Two main ideas to review during the next class meeting: (1) There is more to toxicity than lethality—dose/response curves depend on measured response. (2) There is more to toxic effects—and beneficial effects—than those that can be measured immediately (acutely); many effects can only be measured over the long term (chronically).

Appendix

Prep Time, Supply List, and Total Lesson Time

Prep Time:

We recommend 30-45 minutes depending on your expertise level with the content. Each module will vary depending on your previous experience with the content and technology.

Materials:

Each student will need

- their comprehensive and clear experimental design.
- their observation table to collect their data.
- their “Mixing Dilution” handout from the lesson prior.
- access to a computer to view the “Serial Dilution” video (unless you decide to show the video through the class projector unit).
- their homework added to the online collaborative tool.

You will need

- to identify one or two of your students’ experimental designs to review with the entire class.
- to post your students’ homework to your class’s online collaborative tool.

Items Needed to Complete the Experiment

Each student will need:

- a laboratory notebook, preferably separate from their other notebooks
- some method to draw a semilog graph (paper, Microsoft Excel, Google Spreadsheet, etc.)

Each group will need

- 40 ml of stock 3.50% NaCl
- a 50 ml graduated cylinder
- a 10 ml graduated cylinder
- 8 beakers (disposable clear plastic cups will work)
- 8 100 mm petri dishes
- 100 radish seeds (or other garden seeds)
- paper towels
- distilled water
- indelible markers to label the petri dishes
- a ruler
- a pair of scissors

It will be helpful for each group to have

- a calculator
- forceps (to handle seeds and sprouts)
- magnifying glass

Recipe for stock solution: 3.50% (w/v) NaCl solution

- 35.0 g NaCl
- (optional: 20-30 drops of red food coloring per liter)
- 1.00 L H₂O total volume

Teacher Tip: Do not discard the box that the petri dishes are packed in. After the seeds have been placed into the petri dishes, carefully stack the dishes back into the box so the seeds can incubate in the dark.

Total Lesson Time:

Lesson Activity	Amount of Time in Class
Guided Discussion: Comparing Experimental Designs	10 Minutes
Group Activity: Setting Up the Experiment	35 Minutes
Guided Discussion: Conclusion	1 Minute
Total Time	46 Minutes
Lesson Activity	Amount of Time out of Class
Video: Acute Versus Chronic Toxicity	5 Minutes
Activity: Pharmaceutical Company Scenario	30 Minutes
Total Time	35 Minutes

Sharing Suggestions for Dose/Response Curves

Sharing your dose/response curves is intended to be fun and provide you with an opportunity to use your own creativity with the resources you have available. We want you to be able to make your dose/response curve and provide comments or answers to guiding questions. Listed below are suggestions, but you are not limited to these and in fact, your teacher may have specific guidelines for you.

1. Use software you have access to that will provide you with the capability to publish your work to a file that can be uploaded to your online collaborative tool.
2. The Scatter Plot feature in Google Spreadsheets provides you with the ability to create your dose/response curve, save the image, and share it through your online collaborative tool.
3. Draw your dose/response curve on a piece of paper then take a picture of it or scan it, and post it with your written comments within your online collaborative tool.
4. If you like using video, record yourself and your dose/response curve as you provide explanation and comments. Keep in mind many phones and computers have video cameras that make it easy to record. Don't forget to upload your file for your classmates to view.