**Overview & Guiding Questions**

Students continue to take measurements and maintain plants and make preliminary comparisons across treatments. They discuss use of comparisons in science experiments to test hypotheses, and carry out comparisons of plants among student teams in class.

* How are comparisons used in ecological research?
* Why might comparisons among teams be useful in our class experiment?

**Objectives**

***Ecological Understanding***

* Students will observe how soil type affects plant growth across multiple experimental units by comparing with another team.

***Scientific Process***

* Students will observe variation across the samples by comparing and contrasting with other teams.
* Students will be able to describe variation within the class data and why it is necessary to look at more than two pots.
* Students will continue to practice careful measurement and recording of data.

***Sense of Place***

* Students will continue to take measurements on an experiment based on local ecology.

**Time Required**

55 minutes

**Supplies**

* Rulers
* Stakes
* Twist ties
* Scissors
* Colored toothpicks
* SmartBoard documents

**Preparatory Activities**

None

**Classroom Activities**

Students continue to work in teams in where they make direct measurements of their growing plants, and carry out comparisons using their own plants and another team's plants. Students describe and assess plant height as a measurement for success. They describe how plants are continuing to grow, and place their personal data in the context of class data.



**Lesson 5: Evaluating Success**

**LESSON PLAN OUTLINE**

1. INTRODUCTION (10 MIN)
2. MEASURE PLANT HEIGHT (15 MIN)
   1. Thin plants as necessary

**Adapt This!**

This is a short lesson, mostly intended to provide additional time for experiment maintenance and additional data collection before moving on to more formal data assessment lessons (graphs and averages). It can be skipped if needed, or extra time can be used to discuss volunteer interests and pathways or the upcoming field trip.

1. PROVIDE SUPPORT FOR TALL PLANTS (10 MIN) as necessary
2. COMPARING MEASUREMENTS WITHOUT GRAPHS (20 MIN)

**LESSON PLAN**

1. **INTRODUCTION (10 MIN)**

Review progress of experiment: we asked a question (what question?), made a hypothesis (what hypothesis?), set up the experiment, took emergence data, and started taking height data. We will continue taking height data for a few more weeks—then we will learn to use this data to answer our research question.

1. Remind the students of the comparisons they made between different soils and habitats in Lesson 1.
2. Emphasize the importance of making comparisons for science research (whatever comparisons of treatments you may do in your own research).
3. Tell the students that in today's lesson, they will have the chance to make comparisons with their own plants/soil treatments! (But first, we need to keep taking some data).
4. Emphasize that height is not the only thing we can compare—we can compare anything we can observe (color? mold?).
5. **MEASURE PLANT HEIGHT (and thin as necessary) (15 MIN)**
   1. Measure height on each plant as you learned last week. (Review use of the datasheet). Note the “day” of the experiment. Record the data. *What does this entail?*
   2. Volunteers: walk around as students are measuring and help them to thin plants as necessary (i.e. use scissors to cut all but the 3 focal plants that are marked with toothpicks)
   3. **Experimental log:** the experimental log for Lesson 5 has questions for each pair (describing measurement methods, looking back at hypotheses). Discuss each question as a class.
6. **PROVIDE SUPPORT FOR TALL PLANTS (10 MIN)**
   1. Briefly discuss why we might want to support the plants somehow. (Possible questions for students: *Has anyone noticed plants that seem unstable? What can we do about that? Beans often grow as vines – how do vines grow in nature? Has anyone ever seen plants crawling up a fence or a wall, or seen a gardener build a trellis?*)
   2. To stake plants gently:
      1. Carefully place stakes in the soil about 1-2 cm from the base of the plant to avoid damaging plant roots.
      2. Tie a twist tie to the stake about 7-8 inches above the soil.
      3. Make a loop around the plant that is at least the size of your thumb. This will give the plant a little bit of room and will support it without damaging the stem. What would happen if ties were too tight on the stem (plants would wilt or break)? Why is that? (Stems transport water, nutrients and air throughout the plant).
      4. Students whose pots have no plants can practice staking on pots of nearby groups that do have tall plants.
7. **COMPARING MEASUREMENTS (20 minutes)**
   1. *Scientists learn by making comparisons. We make comparisons between treatments (what are your treatments? What comparisons have you already made?), but we can also compare one team’s results with another. Scientists who study similar questions are constantly discussing and comparing their results—these kinds of comparisons let us gather lots of information to answer our question!*
   2. Each team will fill out the first column in **Part I** of the **Plant Growth Comparison Datasheet,** making comparisons between their own plants/soil types.
   3. Teams should exchange pots with another team sitting nearby, and fill out the rest of Part I in the datasheet. If teams need guidance, the class can do one step at a time together. *Remind the students: Remember that these new pots have been carefully tended, observed and measured by the other team. Treat the other team's plants very, very gently!*
   4. **Class discussion***: Did you find it easy or difficult to decide on answers when you were asked to compare the heights of plants between groups and between soil types (questions 3a and 3b)?* Groups can volunteer to answer each question. Students should discuss why it was sometimes difficult to compare groups of numbers to each other. (**Important point:** It is especially hard to compare groups of numbers when there is a lot of variation within each group. In this case, variation in plant height within a pot may mean that there is overlap in the height range between groups you are trying to compare. It can also be hard to compare more than two groups at a time, or to compare groups in which the measurements are very similar to each other.)
   5. **Optional discussion points**: *Could some of the variation we observe be due to measurement error? It is hard to measure plants gently and accurately because of their irregular shapes. Is there some way we could figure out how consistently we can measure plants?* (One approach: use the last column of the height data table on the Plant growth comparison datasheet to compare measurements made on the SAME plants by two different groups.)
   6. Carefully return all pots to their “home” teams.
   7. **Make sure that datasheets are filled out!** If students have only written data for one plant from their team on the chart, they should get the data for the other plant from their partner(s).

**Adapt This!**

The second part of the lesson focuses on comparison. The main idea is to get students thinking about comparison between different treatments at different sample sizes--between their own plants, between their plants and another pair, and at the whole class level. This idea can be explored in a variety of ways and for different experiments. If you have time, have students move around the room to see all of the variation in the pots.