Promoting Analytical Thinking by Adding Data Collection to Observationally-Based Labs

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Introduction

One semester of our Introductory Biology Lab for Biology majors is entitled "Biodiversity Lab" in which students examine many different organisms, focusing on anatomical and morphological differences among members of the animal, plant, and fungi kingdoms. We noticed that our students rushed through these labs without paying careful attention and often commented that they felt it was a waste of time to "just look at something". We thought that students would feel more engaged when they were collecting data to test a hypothesis. Therefore, we asked our students to collect data while they were dissecting organisms, and then perform data analysis using that data set. Students responded positively to these new exercises and appeared more engaged in their dissections. Additionally, students are now learning both anatomical features of organisms as well as basic principles of hypothesis testing and data analysis.

The goal of this workshop was to describe some of the new modifications we implemented to convert primarily observationally-based labs into vehicles for hypothesis testing and data analysis, with the hope that participants could use these ideas as a starting point to modify their own laboratory curricula. To aid in this process, participants in this workshop were asked to brainstorm ideas about how to modify a simple observational lab to include hypothesis testing, data collection, and analysis. Three lab exercises and the results of the brainstorming session are described below.

Example Lab 1: Crayfish Dissections

The original lab exercise asked students to perform a crayfish dissection to learn the basic anatomical features of this animal. In the new lab exercise, students learned about natural variation in the sizes of organisms of the same species by measuring the body length of their crayfish. Students then created histograms and calculated mean and standard deviations for their crayfish body length data sets. Next, we had students determine if their crayfish were male or female, and asked students to test the hypothesis that male and female crayfish were different sizes using a t-test.

Example Lab 2: Plant Leaf Anatomy

The original lab exercise asked students to examine *Spathiphyllum* (peace lily) leaves and observe their stomata, openings in leaves that allow for gas exchange. To observe stomata, students performed a leaf peel by clipping one leaf off the plant, coating the blade with clear nail polish and letting the nail polish dry. Students then peeled off the dry nail polish and mounted this on a glass slide. The impression from the leaf blade is transferred to the nail polish and students used basic light microscopy to view their nail polish slides and observe stomata and their surrounding guard cells. In the new lab exercise, we asked students to hypothesize whether the top or the bottom of the leaf would have more stomata. They then performed a nail polish peel from both the top and bottom surfaces of the leaf, and counted the number of stomata on each surface. They analyzed the class data using a t-test. This exercise could be expanded to show the difference between plants with horizontally-oriented leaves (such as peace lily) in which the bottom surface contains many more stomata to conserve water loss during hot days, and plants with vertically-oriented leaves (such as corn) in which the top and bottom surface of the leaf contain a similar number of stomata.

Example Lab 3: Angiosperm Reproduction

The original lab exercise asked students to dissect typical angiosperm flowers and compare their reproductive anatomy. In the new version of the lab, we modified an investigative plant reproductive lab exercise (Thompson, 2000) and asked students to compare flowers from wind-pollinated plants (such as corn) and insect-pollinated plants (such as snapdragons). In addition to performing dissections, students removed the stamens from the flowers, and used a sharp-pointed dissecting tool to crush the stamens onto a drop of water on glass slide, releasing the pollen grains from the stamens. Students used basic light microscopy to examine freshly-made pollen grains, and used an ocular micrometer to measure the average diameter of the pollen from each plant species. Students then compared the average diameters of insect pollinated plants versus wind-pollinated plants using a t-test. Students discovered that wind-pollinated plants tend to have smaller pollen grains (to help with dispersal) than insect-pollinated plants.

Workshop Brainstorming Session

Participants were asked for their ideas about how to modify a lab in which students examined cellular diversity by examining animal cells (human epithelial cheek cells), protozoan cells (*Tetrahymena*), and plant cells (*Elodea*). Participants devised many suggestions including measuring the average size of student's epithelial cells, determining if each *Elodea* cell had the same number of chloroplasts, measuring the rate of water flow in or out of *Elodea* cells after placing in different concentrations of salt solutions, and measuring the rate of *Tetrahymena* uptake of an insoluble visible particle (India ink or Carmine red).

Literature Cited

Thompson, L. K. 2000. Plant reproductive systems: An investigative approach. p198-217, *in* Tested studies for laboratory teaching, Vol 22 (S. J. Karcher, Editor). Proceedings of the 22nd Workshop/Conference of the Association for Biology Laboratory Education

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