Two-Way ANOVA

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Focus: In this lesson, students will learn the necessary statistical terms to understand two-way ANOVA, how to visualize their data, how to perform two-way ANOVA and interpret their results, and how to check for the ANOVA assumptions.

Overview: Students design, conduct and analyze a plant experiment to investigate (1) if competitive interactions are present (either interspecific or intraspecific competition), and (2) which, if any, limiting factors (i.e. nutrient, space, light, etc.) affect this population. This semester-long experiment is part of the lab for an upper level General Ecology course. The swirl lesson focuses on how to perform two-way ANOVA using R and RStudio with the help of a mock data set resembling the results of students' plant experiments. Lesson implementation begins with the swirl lesson (1 hour class period), after which students analyze their own plant data sets and write their lab reports.

Learning Objectives: In this lesson, students will:

- 1. Learn the necessary statistical terms to understand two-way ANOVA (factor, factor level, replicate, experimental unit and response variable).
- 2. Visualize a two-factor data set.
- 3. Perform two-way ANOVA.
- 4. Interpret the results of two-way ANOVA.
- 5. Check for the ANOVA assumptions.

Computational thinking practices: Computational thinking practices from the Weintrop et al. (2016) taxonomy that are addressed with this lesson:

Data Practices	Modeling & Simulation Practices	Computational Problem Solving Practices	Systems Thinking Practices
Manipulating Data		Programming	Understanding the Relationships within a System
Analyzing Data		Troubleshooting and Debugging	
Visualizing Data			

Lesson Sequence:

- 1. Mini-lecture to introduce/discuss the concept of two-way ANOVA (Half an hour class period): Students discuss how they design their experiments, and why two-way ANOVA is appropriate to analyze their data sets.
- 2. The swirl lesson on two-way ANOVA (1 hour class period)
- 3. Post-Class Assignment: Students apply what they learn in the swirl lesson to their own data sets and prepare their lab reports.

Pre-lesson Activities: Students learn about ANOVA, and how to use R and RStudio before this lesson.

Post-lesson Activities: Students analyze the results of their plant experiments and write a lab report applying what they learn in the swirl lesson.

Implementation Notes: This swirl lesson was designed for the General Ecology course which is an upper level course. As stated in the 'Pre-lesson Activities', students learn about ANOVA, and also practice R and RStudio prior to this lesson. This lesson should not be used to introduce students to R and RStudio. After the implementation of this lesson, the instructor provided help sessions while students were preparing their lab reports. Students received the swirl lesson (.swc) and to-do list file (.pdf) via the Blackboard course management software.

References:

Beckerman, A. P., Childs, D. Z., Petchey, O. L. (2017) Getting Started with R: An Introduction for Biologists. New York, NY: Oxford University Press.

Kutner, M. H., Nachtsheim, C. J., Neter, J., Li, W. (2005) Applied Linear Statistical Models. New York, NY: McGraw-Hill/Irwin.

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