This Module for Interactive Teaching (MINT) may be found online at
https://ivv.rit.edu/sm-mint.php

Data as Evidence

- Scientific conclusions are made based on available evidence, but new evidence can shift our understanding of a problem, and lead to new hypotheses.

Contents:

MINT Learning Objectives

- Demonstrate an understanding of the cumulative nature of scientific understanding, but citing examples in which understandings changed due to new discoveries.
- Elaborate on the relationship between hypothesis building and evidence based conclusions
- Compare and contrast species richness, species evenness, and species diversity

National Standards Alignments:

- Vision and Change Core Concepts and Competencies (http://visionandchange.org)
  - Core Concept:
    - Systems: Living systems are interconnected and interacting.
  - Core Competencies:
    - Ability to apply process of science: Biology is evidence based and grounded in the formal practices of observation, experimentation, and hypothesis testing.
    - Ability to use quantitative reasoning: Biology relies on applications of quantitative analysis and mathematical reasoning.
    - Ability to use modeling and simulation: Biology focuses on the study of complex systems
- Biocore Guide (Brownell et al., https://doi.org/10.1187/cbe.13-12-0233)
  - Systems: The size and structure of populations are dynamic. A species' abundance and distribution is limited by available resources and by interactions between biotic and abiotic factors.
  - Systems: Biodiversity impacts many aspects of ecosystems.

- Process of Science Skills, Pelaez, N, *et al*. "The Basic Competencies of Biological Experimentation: Concept-Skill Statements" (2017). PIBERG Instructional Innovation Materials. Paper 4. http://docs.lib.purdue.edu/pibergiim/4
    - Hypothesis
        - Use a model (i.e. an abstraction or simplification: an equation, computer simulation, conceptual drawing, or other explanatory representation that shows key elements and their relationships) to generate new hypotheses
    - Representations
        - Construct a visual representation (e.g. a graph or diagram) of predicted results
    - Data summary
        - Display findings with a representation that is effective in summarizing trends or major findings, including illustrating contrasts among categorical groups where relevant
    - Patterns and Relationships
        - Describe trends in numeric and visual representations of data
        - Interpret whether the results suggest a causal mechanism beyond simple correlation
    - Inferences and Conclusions
        - Generalize results to an appropriate level (more than single experiment, less than universal)
        - Connect analysis of results with valid claims or conclusion in a logical way
        - Compare results to other previously reported results and reconcile differences
        - Align conclusion with analyses, hypotheses, research question(s), and existing knowledge
        - Determine and articulate whether data support or refute hypotheses and predictions
        - Understand that scientific knowledge is tentative

Interactive Video Vignette Information

IVV Title: *Show Me the Data!*

IVV URL for students: https://ivv.rit.edu/SM/2/
Copy the URL to the Clipboard. Either paste it into an email to your students, or use it to create a link in your course management system.

IVV Description:
Two students talk about science related course work, including examples of how new information allowed has the scientific community to adjust and advance understandings, and a specific lab assignment based on species richness and biomass measurements. Viewers are asked to make conclusions based on provided evidence, and then based on new evidence that alters the original conclusion. In the end, the cumulative effects of data collection are considered in the context of refining scientific knowledge.

Novice Ideas and IVV Learning Goals
Novice ideas

- Students make conclusions using only portions of their data, or make conclusions that are too broad for the scope of data collected.
- Students have incorrect ideas about the nature of hypotheses
- Students view disproven hypotheses as a failure of the experiment
- Students conflate diversity with species evenness or richness

IVV learning goals

- Students will develop an understanding that scientific knowledge changes over time as theories evolve to accommodate new observations and data
- Students will make conclusions based on plant biomass as a function of plot species richness, and then reevaluate those conclusions upon the presentation of new data.

Recommended In-class Curricular Material

Please see the MINT FAQ (https://ivv.rit.edu/FAQ.php) for general information on the use of MINTs and IVVs with your class. The following curricular materials are provided as examples of resources that may be used in class to further student learning towards IVV and MINT learning objectives.

- Allen ME, Gyure RA. 2009. Using Microbial Ecology to Teach Experimental Design and Sampling Methods. MicrobeLibrary Curriculum Archive, http://www.asmscience.org/content/education/curriculum/curriculum.6
- Wessner D. 2007. Improving your graphs: an exercise in data presentation. MicrobeLibrary Curriculum Archive. http://www.asmscience.org/content/education/curriculum/curriculum.13

Assessment Question Information:

The research team has developed multiple select questions for assessing IVV effectiveness. Please contact the research team (https://ivv.rit.edu/about.php) if you are interested in assessing IVV use in your course.

Acknowledgement

This material is based in part upon work supported by National Science Foundation (NSF) grants 1432286 and 1432303. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.