A student-centered approach to teaching phylogenetic analysis improves student comprehension

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Background

- SoTL research in the sciences has resulted in a call to incorporate the following teaching philosophies and techniques in the classroom:
  - Student-centered
  - Process & concept based learning
  - Active learning
  - Collaborative, inquiry-based work
- In 2010, with support from the IU Teagle Collegium, we initiated a SoTL project to examine the effectiveness of these techniques to address a specific topic in an undergraduate Biology course.

The Subject

Phylogenetic analysis, or cladistics, is the technique of inferring patterns of evolutionary history:

1. Student-centered
2. Process & concept based learning
3. Active learning
4. Collaborative, inquiry-based work

The process of constructing evolutionary trees requires both simple (knowledge of terminology) and complex (application of methods and evaluating potential outcomes) levels of cognition. As such, this subject is perennially difficult for undergraduates to master and is often avoided in the classroom.

The Problem

Previously, our course only briefly addressed phylogenetic analysis through:

- 3 required textbook readings covering basic terminology
- A single “canned lab” in which students were to learn the process of conducting phylogenetic analysis
- Assessments totaling less than 5% of students’ lab grades

Students (and GTAs!) consistently viewed the phylogenetic analysis lab as “the worst lab of the semester.”

GTAs testified that students “went through the motions” of constructing evolutionary trees, but did not understand the process. Our failure to convey necessary conceptual skills was exemplified by consistently low scores on student assessments of the subject.

Our Intervention

In 2009 and 2010 we implemented newly designed materials in the course:

1. New exercises:
   - A set of five exercises that were designed to introduce the concepts and processes of phylogenetic analysis in a step-by-step fashion.

2. Pre-post knowledge survey:
   - Designed to address several common misconceptions including:
     - Direction of time on a evolutionary tree
     - Relationship between common traits and common ancestry
     - Relatedness and position on a tree
     - Interpreting character maps on a tree
   - Students (and GTAs!) consistently viewed the phylogenetic analysis lab as “the worst lab of the semester.”

3. Other student assessments:
   - New questions in the mid-term exam
   - Student feedback on 4×6” card surveys
   - Final exam questions

Phylogenetic analysis comprised a larger component of students’ grades (10%). Eight questions in the final exam were left unchanged to allow direct comparisons to past student performance.

References & suggested readings: