College Students’ Misconceptions About Evolutionary Trees

Evolution is at the center of the biological sciences and is therefore a required topic for virtually every college biology student. Yet several core aspects of evolution are non-intuitive. Evolutionary biology is broadly divided into two sub-disciplines: microevolution, which looks at how the distribution of traits in a population changes over relatively short time periods, and macroevolution, which looks at how new taxa arise over long time periods. Many studies have shown that students harbor misconceptions about key ideas in microevolution such as natural selection (e.g., Greene, 1990; Ferrari & Chi, 1998; Lawson & Thompson, 1998; Anderson, Fisher & Norman, 2002), and have outlined the classes of misconceptions that are most common. Yet macroevolution has received little attention (see Baum et al, 2005), despite being the area of evolution that receives the most media attention through newsworthy topics such as fossil discoveries, speciation, and the relationships among species.

Over the past year we have been building a new simulation software package called EvoBeaker (Meir et al., 2005) to teach college-level evolutionary biology through simulated experiments. We have built both micro and macroevolutionary laboratories into the program. For labs dealing with microevolution, we were able to examine the literature to identify the misconceptions that were most prevalent among college students, and therefore most important for us to address. We could find no similar literature on misconceptions about macroevolution. We thus began our software design phase by seeking to identify misconceptions among college students about the subject of evolutionary trees, the diagrams used to display branching evolutionary relationships between populations or species (which include cladograms and other diagrams showing reconstructions of evolutionary history), and the ideas embedded in these diagrams. Here we report the most common misconceptions among college students in their understanding of evolutionary trees, and their demonstrated ability to perform typical “tree-thinking” skills.

Methods

Instrument Development

We used a seven-step process to gauge students’ tree-thinking misconceptions.

1. Two authors of this study (Herron & Kingsolver) reflected on their experiences teaching evolutionary trees and created an initial list of misconceptions they anticipated would be common among college students.

2. Using this list, we developed written questions we thought would elicit those misconceptions. To fully elicit students’ thought processes and provide as little prompting as possible, all questions were open-ended, free response questions. Each required students to draw diagrams, write short essays, or provide written explanations of their answers.

3. We submitted a version of the written test to a group of subject matter experts—evolutionary biologists at the University of North Carolina, Chapel Hill—for feedback.

4. To refine and expand the list of student misconceptions, we pilot-tested the initial open-ended questions with 34 Seattle-area college students enrolled in an evolutionary biology course.

5. The initial student responses were used to modify the pilot questions and list of misconceptions.

6. An additional 10 Boston-area college students were given varying versions of the pilot instrument. Immediately after taking the written test, these students were each interviewed and asked to rephrase the questions in their own words. After each student, we refined our list of misconceptions and modified, added or deleted questions from our written test as new, unanticipated ideas came from the students and as we observed which questions worked to elicit misconceptions.

7. Finally, based on students’ written answers and verbal explanations, we selected common misconceptions and commonly-used rationales and wording to construct multiple choice answers reflecting the variety of different misconceptions students expressed in answering each question. The primary aim of constructing these multiple choice responses was to be able to correlate specific answers with specific misconceptions. However, some open-ended questions (e.g., asking students to draw diagrams) were kept to provide students with the chance to give more open-ended responses. Rubrics detailing how these open-ended questions were coded are available on request. The complete 21 question instrument is available by request from the lead author.

Instrument Validation & Data Collection Procedures

Once we felt that the instrument elicited misconceptions effectively, we recruited 124 students from Boston area colleges (herein referred to as “local” students) to take the revised sur-