Using Word Associations as a Formative Assessment for Understanding Phylogenetics

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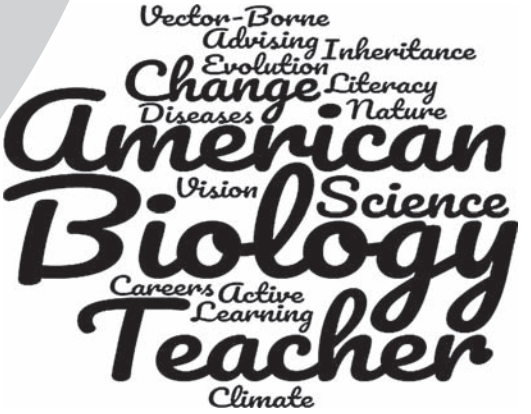

Abstract

It is commonly said that perception is everything. Political candidates are judged by how the public understands their platforms; consumers make purchases based on how they view the products; and business executives make corporate decisions based on potential outcomes of business deals. Likewise, a person's preconception of a topic can change how they learn about and associate that knowledge. Topics with a shared vocabulary between science and common language, such as the terms used when teaching evolution and phylogenetic trees, are especially subject to misconceptions stemming from a lack of understanding how the terminology is used in science. One way to assess the preconceptions students have about specific topics is through using free association techniques. Free association word recall (word association) activities ask students to recall words and phrases associated with stimulus term. Educators can use student responses to learn how students understand and organize prior knowledge, and thus structure subsequent instruction activities to target the revealed preconceptions of the topic.

Key Words: *summative assessment; phylogenetic tree assessment; word association.*

Finding quick and effective ways to engage students and uncover preconceptions of complex topics, like phylogenetics, can be challenging. To understand phylogenies, students are simultaneously learning how to mentally rotate phylogenetic trees and new extensions of common words. In everyday language, "root" can mean the object attached to plants or the base of a word. In phylogenetic language, "root" can mean the base of the diagram or a specific diagram style (i.e., rooted vs unrooted trees). Learning the skills and language needed to understand phylogenies can add to the difficult task of learning to read them. How an individual makes sense of a subject (Rutledge & Warden, 2000) and their lack of knowledge about it (Jakobi, 2010) can influence learning.

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Everyday experiences can influence how a person's understanding of scientific concepts is developed, especially when using specific language (Cremer et al., 2010). When people look at a particular word or phrase, they have a tendency to think of another specific word or phrase (Lyle, 2003), an association. As individuals take in new information and combine that with what they already know, a new mental organizational system is created. How people recall information changes based on how the information is cognitively organized.

Word association exercises provide insight into this cognitive organization (Cremer et al., 2010; Lyle, 2003; Nelson et al., 2004; Ma, 2013). These exercises prompt individuals to think of a single word or phrase in response to a prompt word; the choice of response word or phrase depends on two things: the organizational system of an individual's knowledge (Nelson et al., 2004; Ma, 2013), and the prompt term causing the response (Lyle, 2003; Ma, 2013). Using a word association activity as a formative assessment serves two purposes: it introduces students to scientific terminology, and provides teachers with the opportunity to see how students initially link vocabulary. Word association assessments grant teachers access to how students organize and draw upon knowledge about the concept being explored. For example, if scientific words are often used together with other everyday terms, people may relate scientific and nonscientific terms more closely together than other words. By investigating how students associate topic-specific terms, it is possible to see how they link the vocabulary associated with that topic.

To administer a word association activity, it is critical to select terms that are commonly used in conjunction with the topic being assessed. In this case, we assessed students' associations with terms specific to phylogenetic trees using the prompts: ancestry, branch, character, clade, classification, node, phylogenetics, relationship, root, species,

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taxon, and tree. Each of our chosen prompt words represents a different aspect of the nature of phylogenetic trees: conceptual, organizational, and structural. The chosen prompt terms should represent all aspects of the concept in question, as different learners may understand different aspects of the topic in different ways. A person may understand phylogeny structures (branch, node, tree) but not the underlying concepts (species, ancestry, relationships). Additionally, the prompt terms included should not be redundant to reduce confusion for the student; this also provides a better understanding of the learner's association of terms. Both taxa and species are included in our list and are not redundant as "taxa" describes one or more groups of populations or organisms, and "species" describes groups of organisms in the context of species concepts.

There are two approaches that can be used to administer a word association assessment: (1) you can present each term to the class as a whole, by speaking and/or showing the term on a slide presentation, or (2) you can provide students with notecards presenting each term. Using either technique, the objective is to have each student record the first word or phrase that comes to mind when presented with the stimulus term. It is important that students are aware that you are not seeking a "correct" answer, but rather are trying to understand connections they draw among terms.

We created a 13-slide Microsoft PowerPoint presentation composed of an initial instruction slide followed by 12 slides showcasing a single prompt term centered on the slide in large font. We showed each slide to the students for 30 seconds until all 12 prompt terms had been presented; total time 6 minutes. We used this assessment with 128 undergraduate students and sorted their responses into groups of Phylogenetic and Non-Phylogenetic related terms (Boyce, 2015). Student responses were considered non-phylogenetic if the response term provided was not directly related to phylogenetic trees or systematics, such as "clade" eliciting "spade," "ancestry" eliciting "pedigree," and "tree" eliciting "oak" (Figure 1).

The majority (85%) of our students associated the prompt terms with non-phylogenetic words. This is not surprising, as past research has found that a person's understanding of evolution is greatly influenced by everyday interactions, including news outlets (Horenstein, 2010) and popular media (Jakobi, 2010). Thus having non-phylogenetic-specific associations with the prompt terms is to be expected from students who do not know about or encounter phylogenetic trees. After reviewing student responses, we were able to sort the response terms into different piles, allowing us to see how students associated phylogenetic-specific terminology. If students said "husband/wife/mother/father" in response to "relationship," we knew they are thinking of "relationship" in terms of interpersonal contexts rather than how different species are related. Additionally, if students said "Mickey Mouse/SpongeBob/cartoon" in response to "character," we knew they were thinking of animations rather than character states.

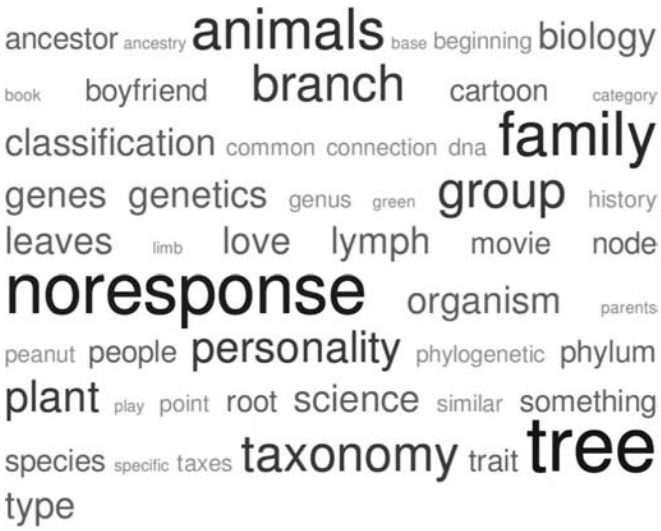

Figure 1. Word cloud of phylogenetic term word association.

For students to assimilate new information they first need to engage with their prior knowledge and recall what they know. This activity served as a quick engagement tool, allowing students to trigger their prior knowledge, and providing a snap-shot of student understanding when presented with the prompt terms. If, however, instructors are interested in understanding in greater detail the misconceptions students have about a given topic, then an alternative technique like concept mapping should be used. Concept maps can provide a detailed road map of relationships between the various terminology and concepts found within a given topic (Novak, 1990), whereas word association assessments allow students to engage their prior knowledge quickly in a low-risk setting. After students engaged in our activity, they were eager to see why they were shown these terms. This eagerness primed them to assemble the information they were learning and incorporate it into their existing knowledge framework.

The results allowed us to tailor our subsequent instruction to directly address the knowledge gaps, inaccuracies, and misconceptions that students brought with them to class. After reviewing student responses, the instructions they received in how to read phylogenetic trees included the terms related to the phylogeny structure (i.e., branch, node, tip) on the images rather than separate from the images, so students could directly associate those terms with specific phylogenetic tree structures. We also defined all terms in context of phylogenies, explaining, for example that a "node" in botany indicates where the stem divides, and a "node" in a phylogeny is where a branch divides.

Word association activities can be used with any topic, and can be especially useful in topics where there is a shared vocabulary between the concepts being taught and common vernacular. When teaching an introductory biology course, this engagement tactic would be useful to see how students think about the terms "theory," "law," and "hypothesis," which are commonly used in pop culture and everyday conversations yet mean different things to scientists. The essential aspect to control for when utilizing word association techniques as either an engagement or formative assessment tool, is the terminology. This tool only allows you to see how students organize information related to the stimulus words, therefore the terminology must be specific to the content being assessed.

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