

Feature Current Insights

Recent Research in Science Teaching and Learning

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This feature is designed to point *CBE—Life Sciences Education* readers to current articles of interest in life sciences education, as well as more general and noteworthy publications in education research. URLs are provided for the abstracts or full text of articles. For articles listed as “Abstract available,” full text may be accessible at the indicated URL for readers whose institutions subscribe to the corresponding journal. This themed issue focuses on recent studies of concepts and conceptualization—from how textbook images and students’ attitudes and levels of acceptance can influence their understandings to design of tools that educators can use to understand what their students know.

1. Novick LR, Stull AT, Catley KM (2012). Reading phylogenetic trees: the effects of tree orientation and text processing on comprehension. *BioScience* 62, 757–764.

[Abstract available: www.jstor.org/stable/10.1525/bio.2012.62.8.8]

Cladograms—branching, nested hierarchical diagrams drawn in a variety of formats—are commonly used to depict how organisms might be related. Although differently formatted cladograms can convey the same information, informationally equivalent cladograms are not necessarily equivalent “computationally,” that is, with respect to the ease with which observers interpret and use them. Because diagonal cladograms with a slanting up-to-the-right (UR) orientation are most commonly used in college-level textbooks, the authors explored whether a diagonal cladogram drawn with a UR backbone line is computationally equivalent to its informationally equivalent mirror-image, drawn in a slanting down-to-the-right (DR) orientation. Drawing from existing studies on the influence of processing biases and prior

experience on directional scanning of visual materials, the authors hypothesized that the direction of the slant influences students’ processing of the cladogram and that the more commonly used UR format is harder for students to understand.

They tested this hypothesis with a study population of 19 upper-division students majoring in biology or biology-related subjects. The subjects processed a series of 24 diagonal cladograms, each paired with a rectangular-format cladogram. The diagonal cladograms varied in one of three ways: 1) UR or DR orientation, 2) forward or reverse alphabetical order of taxa labeling, and 3) the taxon topology (branching pattern). The subjects initially viewed a diagonal cladogram presented on the center of a computer screen, and their eye movements were tracked electronically. When they indicated that they understood the diagonal cladogram, they were presented with a rectangular cladogram, and then were asked whether the evolutionary relationships depicted in the two cladograms were the same. The authors used rectangular cladograms for comparison, because information about how students interpret them was available from a previous study (Novick and Catley, 2007). Incorrect rectangular cladograms could therefore be modeled after common types of interpretation and translation errors observed in this earlier study.

Analysis of the results indicated that, for both the UR and DR orientations, the subjects tended to scan the cladograms from left to right (upward for the UR cladograms and downward for the DRs); that is, most used the processing direction that they use to read text. There was a significant effect of cladogram orientation on the accuracy of translation to the rectangular format. As predicted, the subjects were more successful at translating the diagonal cladogram to the rectangular format when the DR orientation was used. As a possible explanation for this finding, the authors suggest that people generally encounter the branching points in an order that reflects the nesting pattern when reading from left to right in the DR orientation. Thus, in this study, informationally equivalent UR and DR cladogram formats were not computationally equivalent for students.

The authors conclude by discussing the implications for instruction. They suggest that if textbook diagrams do not change, students could benefit from instruction and practice

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in how to change their processing strategies to successfully interpret the computationally more difficult UR-oriented cladograms.

2. Liben LS, Kastens K, Christensen AE (2011). Spatial foundations of science education: the illustrative case of instruction on introductory geological concepts. *Cogn Instr* 29, 45–87.

[Abstract available: www.tandfonline.com/doi/abs/10.1080/07370008.2010.533596]

The concepts of strike and dip, used to describe planar features such as the orientation of layers of rock, are notoriously difficult aspects of spatial thinking for novice learners of geology to grasp. The “strike” of a planar surface (such as a fault, bed, or other type of geologic formation) refers to the compass direction of a line of intersection of the planar surface with a horizontal plane; the latter is often referenced to the surface of a still body of water. The “dip” is the angle of tilt of the surface from the horizontal. Textbook illustrations of the strike and dip of geologic features often attempt to make the concepts more accessible by using water level and falling water to help students understand these concepts. However, educators are becoming increasingly aware that, for some students, these illustrations may convey insufficient information about three-dimensional spatial relationships. In this study, the authors used various tasks related to strike and dip to explore the nature of students’ underlying difficulties. In doing so, they anticipated that performance on strike and dip tasks would shed light on broader issues related to spatial perception and how it influences science learning.

The study population consisted of 125 college students (roughly equal numbers of males and females) who had completed a pencil-and-paper water-level test in which they drew lines of predicted water levels on diagrams of straight-sided empty bottles tilted at different angles. Participants were assigned to high-, medium-, and low-scoring water-level groups (WLG) based on their test scores. Each WLG was then assigned a series of additional field and laboratory tasks. Field tasks included estimating and recording (on a campus map) the strike and dip of an artificial rock outcrop, indicating the location of a wooden rod placed on the ground on a campus map, and additional tasks that assessed sense of direction. Laboratory tasks consisted of a series of three-dimensional horizontality (shoreline) and verticality (drop) tasks. Both sets of tasks used plastic models with paper-covered planar surfaces of different shapes attached to clear Plexiglas pillars; the dip of the surfaces varied, but the strike was held constant. In the shoreline task, subjects were asked to imagine that the whole model was covered in water up to the midpoint of the paper-covered surface and to then draw on the paper how the water would look. In verticality tasks, the subjects were asked to imagine that a drop of water had fallen on the paper surface, were then asked to draw the path of the drop along the paper after it fell. Participants were asked to supply information about their level of confidence in their performance on all tasks, and observations were made of their behaviors and the strategies they used.

The authors determined the variance of the absolute values by which scores on the directional responses to field and laboratory tasks deviated from the correct scores, with WLG and participant gender as between-subject factors. Although they found that students in the low WLG generally had the

lowest task scores, the entire study population appeared to be challenged by the tasks. The authors used multiple regression analysis, in which confidence served as the criterion variable to determine whether the water-level “pretest,” actual performance on the field and laboratory tasks, and being female were predictive of participants’ confidence level. They found that low water-level scores and being female were predictive of low confidence scores, and performance on tasks was generally predictive of participants’ confidence ratings. In groups of students with similar scores on the water-level test, females scored lower than males on a number of the tasks. The authors speculate that the water-level test may not have identified all key components of spatial skill needed to complete the tasks, because the gender differences were most pronounced when participants had to orient in relation to a larger, more distal environment and were absent when more local frames of reference for orientation could be used. Finally, observations of the participants’ task performance indicated that they often did not use strategies that educators might assume are too basic to warrant mentioning in the course of instruction.

The authors conclude that, in fact, strike and dip are difficult geological concepts to teach, and the difficulty may lie in part with underdevelopment of students’ “Euclidean conceptual system” (p. 81). They suggest the need for more research to inform the design of instructional programs that would foster development of specific foundational spatial concepts and skills.

3. Fulop RM, Tanner KD (2012). Investigating high school students’ conceptualizations of the biological basis of learning. *Adv Physiol Educ* 36, 131–142.

[Full text available: <http://advan.physiology.org/content/36/2/131.long>]

This study sets the stage for increasing the amount and relevance of high school neuroscience education by exploring what students already know about the biological basis of learning. Recent studies (e.g., Blackwell *et al.*, 2007) suggest that the nature of students’ understandings about this area of cognitive neuroscience—the biological basis of learning—has implications for their academic success.

High school juniors ($n = 339$) enrolled in chemistry classes in a large urban high school participated in the study, which used a mixed-methods design consisting of written assessments (both multiple-choice and open-ended assessment prompts) and interviews. Although all participants were invited to participate in the interviews, only a few ($n = 15$) actually did so. Most of the 19 “yes/no/I don’t know” multiple-choice assessment prompts were taken from the literature, and all were demonstrated to elicit agreement from neuroscientists (>90%) on the answer. The first of the two open-ended prompts was designed to determine whether students would place the process of learning within a biological or some other framework; the second was designed to explicitly elicit responses of a biological nature. Two independent observers analyzed the interview responses by: 1) sorting them into one of three categories (nonbiological, minimally biological, or primarily biological) using a rubric; 2) scoring for the level of understanding they revealed about neural structures, mechanisms of learning, and plasticity of the nervous system using a second rubric; and then 3) coding them for emergent conceptual themes.

The findings indicated a low level of knowledge about the biological basis for learning in this set of high school juniors: <70% of the students agreed with the neuroscientists' responses to the majority of the multiple-choice prompts; 75% of the responses to the first open-ended assessment exhibited a nonbiological framework; and 67% of the interviewed subjects revealed misconceptions during the interview. The authors provide numerous quotes from students to illustrate these conclusions. Fewer than half of the interview subjects reported having had prior (albeit minimal) instruction about neuroscience, a topic that is included in the National Science Education Standards. However, the majority thought that understanding how people learn was of value to their own learning.

The authors conclude by underscoring the importance to the general public of teaching about the biology of the brain, particularly since high school biology represents the last opportunity for formal education to reshape preconceptions of the >70% of the U.S. population that will not go on to college. Although the teaching of neuroscience in high school is not yet prevalent, in the words of the authors, the good news is that "students appear to be ready, willing and able to learn about their own brains" (p. 139).

4. Nadelson LS, Southerland S (2012). A more fine-grained measure of students' acceptance of evolution: development of the inventory of student evolution acceptance: I-SEA. *Int J Sci Educ* 34, 1637–1666.

[Abstract available: www.tandfonline.com/doi/abs/10.1080/09500693.2012.702235]

Science, technology, engineering, and mathematics educators and education researchers are becoming increasingly aware of the potential role that affective constructs, such as learning dispositions, self-efficacy, beliefs, and motivation, can play in shaping the learning process. This study is based on a premise that, for emotionally charged topics such as evolution, the affective perceptions of belief and acceptance can interfere with conceptual understanding. The authors have developed an instrument for measuring students' acceptance of biological evolution in a way that avoids blending acceptance with belief or understanding of specific content. They

report having taken particular care in designing the instrument to distinguish acceptance of evolution—based on the validity of the evidence supporting it and its plausibility and utility as an explanatory paradigm—from beliefs about evolution based on feelings, personal convictions, or faith.

The article guides the reader through the processes of instrument design, item and scale development, and field-testing (with groups of high school and college students) of an initial 49-item Likert-scale instrument: the Inventory of Student Evolution Acceptance (I-SEA). The instrument has three subscales designed to differentiate between areas of evolution that are perceived differently by the general public: microevolution (the results of evolution in the short term), macroevolution (long term), and human evolution. After field-testing, the authors performed statistical analyses to determine instrument and subscale reliability, as well as an exploratory factor analysis to guide instrument refinement. They conducted a refined analysis of the resulting 24-item instrument as a whole and for each of the three subscales. Ten postsecondary biology faculty contributed to the process of expert validation and final refinement of the items. The authors point out the potential usefulness of the instrument, as well as its possible limitations, in making curricular decisions and assessing their subsequent impact on student perceptions. Appendices include the items from both the field-tested and final versions of the I-SEA.

I invite readers to suggest current themes or articles of interest in life science education, as well as influential papers published in the more distant past or in the broader field of education research, to be featured in *Current Insights*. Please send any suggestions to Deborah Allen (deallen@udel.edu).

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