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EVIDENCE-BASED TEACHING GUIDES

Peer Instruction

Jennifer K. Knight and Cynthia J. Brame

This essay introduces an evidence-based teaching guide presenting research and resources related to peer instruction. The guide provides links to key articles accompanied by summaries organized by teaching challenge and an instructor checklist. In addition to describing the guide, the article identifies areas for further research.

ESSAYS

Contemporary Issues in Group Learning in Undergraduate Science Classrooms: A Perspective from Student Engagement

Linda C. Hodges

This essay provides an analysis of current research on how group work during class time in undergraduate biology and other science, technology, engineering, and mathematics courses affects student learning based on the ICAP (interactive, constructive, active, passive) model of student engagement.

How to Identify the Research Abilities That Instructors Anticipate Students Will Develop in a Biochemistry Course-Based Undergraduate Research Experience (CURE)

Stefan Mark Irby, Nancy J. Pelaez, and Trevor R. Anderson

A novel Process to Identify Course-Based Undergraduate Research Abilities (PICURA) is described. PICURA was developed within the context of a biochemistry course-based undergraduate research experience (CURE). The stepwise application of PICURA is demonstrated, and its utility in evaluating CURE learning formats is discussed.

A Faculty Professional Development Model That Improves Student Learning, Encourages Active-Learning Instructional Practices, and Works for Faculty at Multiple Institutions

Karen N. Pelletreau, Jennifer K. Knight, Paula P. Lemons, Jill S. McCourt, John E. Merrill, Ross H. Nehm, Luanna B. Prevost, Mark Urban-Lurain, and Michelle K. Smith

A group of 16 faculty from five institutions collaboratively designed, taught, iteratively revised, and published an instructional unit. Information is presented on how the group was organized and facilitated to use student data to affect learning and increase faculty use of active-learning practices.

A Community-Building Framework for Collaborative Research Coordination across the Education and Biology Research Disciplines

Nancy Pelaez, Trevor R. Anderson, Stephanie M. Gardner, Yue Yin, Joel K. Abraham, Edward L. Bartlett, Cara Gormally, Carol A. Hurney, Tammy M. Long, Dina L. Newman, Karen Sirum, and Michael T. Stevens

This framework for collaboration among educators and research scientists is based on personal experience of the Advancing Competencies in Experimentation–Biology Network and relevant literature. The “Five ‘C’s’ of Collaboration: Commitment, Collegiality, Communication, Consensus, and Continuity” are proposed as guiding principles for promoting knowledge integration across disciplines.

ARTICLES

Connecting Structure–Property and Structure–Function Relationships across the Disciplines of Chemistry and Biology: Exploring Student Perceptions

Kathryn P. Kohn, Sonia M. Underwood, and Melanie M. Cooper

To inform future interdisciplinary course reform that may bridge student understanding of structure–property and structure–function relationships across chemistry and biology, undergraduate students coenrolled in relevant introductory chemistry and cell and molecular biology courses were interviewed.

Challenging Cognitive Construals: A Dynamic Alternative to Stable Misconceptions

Julia S. Gouvea and Matt R. Simon

Results presented here challenge the idea that teleological, anthropocentric, and essentialist statements are evidence of deeply held intuitive cognitive frameworks. An alternative perspective of cognition as dynamic and context dependent is proposed.

Promoting Collaborative Classrooms: The Impacts of Interdependent Cooperative Learning on Undergraduate Interactions and Achievement

Joshua Premo, Andy Cavagnetto, and William B. Davis

Interdependent cooperative learning was integrated into 11 undergraduate science classrooms to promote collaborative engagement and achievement (10 additional classrooms constituted a control). Cooperative-learning students demonstrated increased collaborative engagement at both whole-class and individual levels but did not differ in achievement.

Identifying and Remediating Student Misconceptions in Introductory Biology via Writing-to-Learn Assignments and Peer Review

Audrey S. Halim, Solaire A. Finkenstaedt-Quinn, Laura J. Olsen, Anne Ruggles Gere, and Ginger V. Shultz

Writing-to-learn is known to promote conceptual learning. A series of introductory biology writing assignments and associated peer-review comments were analyzed to identify misconceptions. Profiles were generated that describe the pathways through which misconceptions were addressed during peer review and revision.

A Course-Embedded Comparison of Instructor-Generated Videos of Either an Instructor Alone or an Instructor and a Student

Katelyn M. Cooper, Lu Ding, Michelle D. Stephens, Michelene T. H. Chi, and Sara E. Brownell

This study used a randomized crossover design in the context of a college physiology course to compare videos of an instructor alone to videos of an instructor tutoring a student. Students preferred instructor-only videos. Lower-achieving students performed better after watching instructor-only videos.

Reading Quizzes Improve Exam Scores for Community College Students

Pamela Pape-Lindstrom, Sarah Eddy, and Scott Freeman

A 6-year study shows that implementing reading quizzes in an introductory biology course can boost exam performance for community college students.

Exploring Biology: A Vision and Change Disciplinary First-Year Seminar Improves Academic Performance in Introductory Biology

Caroline J. Wienhold and Janet Branchaw

Results from a study investigating Exploring Biology, a disciplinary first-year seminar, are presented. The *Vision and Change* core concepts are used to support first-year biology students' transition to a large research university. Participants achieve higher levels of academic performance in introductory biology relative to a matched comparison group.

Learning Gains from a Recurring “Teach and Question” Homework Assignment in a General Biology Course: Using Reciprocal Peer Tutoring Outside Class

E. G. Bailey, D. Baek, J. Meiling, C. Morris, N. Nelson, N. S. Rice, S. Rose, and P. Stockdale

Inclusion of a reciprocal peer-tutoring homework assignment in a general biology course resulted in increased exam scores (~6%) compared with a section of the same course that merely required students to study on their own. The number of questions students asked during their tutoring sessions was predictive of final exam performance.

A Mixed-Methods Investigation of Clicker Implementation Styles in STEM

Erin D. Solomon, Michelle D. Repice, Jacinta M. Mutambuki, Denise A. Leonard, Cheryl A. Cohen, Jia Luo, and Regina F. Frey

Faculty members at one institution were observed and interviewed to determine how they implemented clicker-based active learning in their classrooms, with attention given to the procedures they used and how they situated the activities into the rest of their class sessions. A mixed-methods approach was used to categorize faculty based on quantitative observation data and qualitative interviews.

Design and Assessment of Online, Interactive Tutorials That Teach Science Process Skills

Maxwell Kramer, Dalay Olson, and J. D. Walker

The design, implementation, and assessment of interactive online tutorials that specifically teach science process skills are described. Completion of the tutorials significantly contributed to higher scores on a science process skills assessment given to undergraduate students.

Effects of Discovery, Iteration, and Collaboration in Laboratory Courses on Undergraduates’ Research Career Intentions Fully Mediated by Student Ownership

Lisa A. Corwin, Christopher R. Runyon, Eman Ghanem, Moriah Sandy, Greg Clark, Gregory C. Palmer, Stuart Reichler, Stacia E. Rodenbusch, and Erin L. Dolan

Opportunities for discovery, iteration, and collaboration in undergraduate lab courses have small but significant effects on students’ research career intentions, with iteration having the largest effect. These effects were fully mediated by students’ ownership of their course work.

Working and Learning in a Field Excursion

Torstein Nielsen Hole

This paper proposes a novel approach to learning in a field excursion by employing sociocultural theories of knowing and short-term ethnographic techniques. Students were found to make advances in their understandings and dispositions toward epistemology and the enactment of biology knowing as they participated through work and enacted biology in the high Arctic.

Validating Common Measures of Self-Efficacy and Career Attitudes within Informal Health Education for Middle and High School Students

Karen Peterman, Kelley Withy, and Rachel Boulay

This study explored whether two existing instruments could be used as valid tools within the context of health science programs. The results provide an example of how practitioners can explore the use of common measures in new contexts and provide some evidence to support the use of the subscales tested in health science education projects.

EcoEvo-MAPS: An Ecology and Evolution Assessment for Introductory through Advanced Undergraduates

Mindi M. Summers, Brian A. Couch, Jennifer K. Knight, Sara E. Brownell, Alison J. Crowe, Katharine Semsar, Christian D. Wright, and Michelle K. Smith

EcoEvo-MAPS (Ecology and Evolution–Measuring Achievement and Progression in Science) is designed to measure student thinking in foundational ecology and evolution concepts at multiple time points during an undergraduate degree. Evidence of validity and reliability was collected through an iterative process of faculty review, student interviews, and analyses of assessment data from more than 3000 students at 34 institutions.

Further Effects of Phylogenetic Tree Style on Student Comprehension in an Introductory Biology Course

Jonathan Dees, Caitlin Bussard, and Jennifer L. Momsen

This study investigated how style impacted student interpretations of phylogenetic trees. Before instruction, students were significantly more accurate interpreting and constructing bracket-style phylogenetic trees. Instruction mitigated some, but not all, style effects.

Teaching Assistant Attention and Responsiveness to Student Reasoning in Written Work

Cynthia F. C. Hill, Julia S. Gouvea, and David Hammer

This study investigates graduate TAs' written feedback on student lab reports for an introductory biology lab course. It was found that TAs focused on matters of scientific writing, student thinking, and correctness. Practices of instruction to encourage instructor engagement with students' biological reasoning are proposed and discussed.

Institutional Interventions That Remove Barriers to Recruit and Retain Diverse Biomedical PhD Students

Marenda A. Wilson, Anthony L. DePass, and Andrew J. Bean

This article outlines efforts of the MD Anderson UTHealth Graduate School to increase the diversity of the student body independent of student metrics. It also provides recommendations based on the data presented to identify and remove barriers that prevent participation of the underrepresented and underserved in the STEM pipeline.

Competing Discourses of Scientific Identity among Postdoctoral Scholars in the Biomedical Sciences

Rebecca M. Price, Ira Kantrowitz-Gordon, and Sharona E. Gordon

In interviews, postdocs from biomedical fields used two primary discourses to describe their scientific identities: bench scientist and principal investigator. These discourses support generating publications and an idealized view of the academy. Understanding them can improve professional development programs for postdocs.

Factors Contributing to the Success of NIH-Designated Underrepresented Minorities in Academic and Nonacademic Research Positions

Luis R. Martinez, Dwayne W. Boucaud, Arturo Casadevall, and Avery August

Undergraduate research experiences, individual laboratory mentorship, and mentor accessibility are important factors for the *success* of underrepresented minority (URM) scientists. A record of publications in high-profile journals is not considered important for URMs' *success*. Significant differences in the interests of URMs in academic and nonacademic careers are reported.

On the Cover

This image of the rat hippocampus was taken with an ultra-wide-field high-speed multiphoton laser microscope. Tissue was stained to reveal the organization of glial cells (cyan), neurofilaments (green), and DNA (yellow). The microscope used was developed in conjunction with Roger Tsien (2008 Nobel laureate in Chemistry) and remains a powerful and unique tool today. Credit: Tom Deerinck, National Center for Microscopy and Imaging Research; NIH funding from the National Institute of General Medical Sciences (NIGMS). License: Attribution 2.0 Generic (CC BY 2.0).