Fostering Academic Success in STEM: Speakers' Presentation Abstracts

Diane Ebert-May

Professor of Plant Biology, Michigan State University

Presentation Title: *Evidence-based Teaching: Just the Facts or Thinking Like Scientists?*

Our research on large introductory biology courses at Michigan State University is uses two national frameworks that are guiding transformation in courses and curricula across institutions, Vision and Change in Undergraduate Biology Education (2009) and the Next Generation Science Standards (NGSS, 2012). Our transformed courses focus on core concepts rather than long lists of topics and emphasize scientific practices in which all students should become proficient. In our introductory courses, we integrate research models into teaching approaches by bringing into our classrooms the core scientific practices desired for all students, such as working with data, building, testing, and refining models, developing arguments, and communicating and collaborating across disciplines. Our findings show that novice students who engage in sustained scientific practices grounded in core concepts show significant advancement toward more expert ways of thinking about biology compared to students in traditional classrooms focused on knowledge transfer. Among the sections of transformed courses, there is minimal instructor effect and the majority of students performed at higher cognitive levels. We will examine questions and approaches for curriculum assessment and critique our students' learning data.

Shana Carpenter

Associate Professor of Psychology, Iowa State University

Presentation Title: *Using Prequestions to Enhance the Effects of Retrieval Practice in STEM Courses*

Using Prequestions to Enhance the Effects of Retrieval Practice in STEM Courses

Much research has shown that practicing to retrieve information enhances learning. In nearly all of the studies on

retrieval practice, students retrieve information after they have been introduced to it via a lecture or reading assignment. Very little is known about the effects of asking students questions before they learn something. In a series of laboratory- and classroom-based studies, students were given "prequestions" over information that they were about to learn. Students who received prequestions, relative to a control group who did not receive prequestions, remembered material better at the end of the lesson, and sometimes prequestions boosted memory even for material in the lesson that was not included in the prequestions. In Biology and Engineering courses, follow-up performance on later quizzes showed that students retained material best when it was prequestioned at the beginning of class and then asked again at the end of class, relative to when the material was questioned only at the beginning or only at the end of class. Overall, these studies show that retrieval practice—asking students questions over what they have learned—has positive effects on long-term learning in STEM courses, and these benefits can be significantly enhanced by having students preview the questions at the beginning of class.

John Dunlosky

Professor of Psychological sciences and Director of Science of Learning and Education (STEM), Kent State University

Presentation Title: *Helping Students Achieve: Promising Strategies from Cognitive and Education Sciences*

Students are expected to learn a great deal of information, and as they progress from grade school to college, they are increasingly responsible for guiding their learning outside of class. Thus, students could benefit from easy-to-use strategies that support durable and efficient learning. I'll discuss which strategies students believe are the best and which ones they use the most, and I'll describe a variety of promising strategies that they should use. Although these strategies are not a panacea for every learning challenge, they provide robust tools that will improve student success across many domains.

Samuel Pazicni

Associate Professor, Chemistry, University of New Hampshire

Presentation Title: *Investigating and Mitigating Students' Illusions of Competence*

We have demonstrated that low performing general chemistry students suffer from illusory competence—they are substantially miscalibrated from their actual standing on

course assessments. This miscalibration phenomenon also appears to persist across a semester, despite repeated course feedback. However, meaningfully engaging in exam task and process feedback appears to abate students' illusions of competence. Briefly, students completed a reflection addressing why a specific exam response did not receive full credit, provided responses that would have received full credit, and discussed learning/studying issues that resulted in receiving less than full credit. Using a combination of graphical analyses and hierarchical linear modeling, we confirm that self-assessments help students to become more calibrated to their performance, as well as improve performance, on subsequent exams.

Carrie L. Hall

Assistant Professor, Biology, zoology, University of New Hampshire

Presentation Title: *Does Method Matter?: A Study of Teaching Methodology and Content Learning in Introductory Biology*

National initiatives to bring innovative teaching into introductory undergraduate biology courses are grounded in well-established empirical studies of methodology. The goals of innovative teaching are to increase retention in courses, increase persistence in the biology major, increase student engagement with and learning of content material, and decrease student dissatisfaction and "boredom" in foundational courses. Innovative empirically validated teaching practices can include cooperative group learning, classroom flipping, using primary literature during lecture sessions, and hybrid models of combinations of lecture and these other methods. Despite the overwhelming breadth of literature supporting hypotheses that these methods increase student engagement, studies of student learning increases as a result of these approaches show unconvincing results. In this longitudinal three-year study of a first-semester introductory biology course, we corrected for aptitude and learned from pre-and post-instruction exams that increases in learning correlated with ACT score in most content areas, and that teaching method did not result in significant increases in content knowledge compared to traditional lecture courses. Surprisingly, we also found that flipped classroom approaches in ecology and evolution content areas resulted in less learning gain than in lecture sections. In these content areas, use of primary literature resulted in the highest increases in learning, but this result fell short of significance.

Melissa Aikens

Assistant Professor, Biology, University of New Hampshire

Presentation Title: *Incorporating Quantitative Skills into the Undergraduate Biology Classroom*

National reports such as Bio2010 and Vision and Change have advocated for the inclusion of more quantitative skill training in the undergraduate biology curriculum. However, instructors cite a number of unique challenges to incorporating quantitative skills into biology courses, including the decision of which quantitative skills to include, how to fit quantitative skills into an already packed curriculum, and concerns that their biology students are math averse. In this discussion-based session, I will use a backward design approach to guide participants into thinking about how they can incorporate quantitative skills into their own courses. We will begin by discussing quantitative learning goals appropriate for the courses that participants teach and ways to assess whether our students are achieving these goals. I will then spend the remainder of the session discussing teaching strategies and evidence-based learning activities that align with a variety of quantitative learning goals. Participants will leave this session with resources and ideas to implement that will enable their students to learn the quantitative skills they need as a 21st century biologist.

Joe Kim

Associate Professor in the Department of Psychology, Neuroscience and Behavior, and director of the Applied Cognition in Education Lab, McMaster University

Presentation Title: *Applying the Interleaving Effect to Promote Student Learning*

Students typically practice concepts through blocking—learn Concept A and complete practice questions on Concept A; learn Concept B and complete practice questions on Concept B, and so on until all concepts are practiced in discrete blocks. Although intuitive, this approach is counter to findings from cognitive science which show that practice schedules with learning concepts that are interleaved (A1B1C1B2C2A2C3B3A3…) produce better skill retention than learning tasks that are blocked (A1A2A3B1B2B3C1C2C3…). In a series of experiments, we gave students example problems of different statistical concepts to learn and later tested them on their ability to correctly classify new problems on a final test. Interleaving example problems of different to-be-learned concepts, rather than blocking by concept, enhanced classification performance, demonstrating the interleaving effect. Interestingly, students

with lower working memory capacity (WMC) – a measure of ability to process incoming information and integrate it with long-term memory – benefited more from interleaved schedules than those with higher WMC. These finding supports the discriminative-contrast hypothesis – juxtaposing problems of different concepts through interleaving highlights critical features that differ. Interestingly, disruptions to this discriminative process eliminates the interleaving benefit. It follows that introducing temporal spacing between successive problems decreased classification performance in the interleaved schedule. These studies and many others suggest that interleaving should be a feature of STEM instructional practice.

Michael Melville

Teaching and Learning Research Coordinator, CEITL, University of New Hampshire

Presentation Title: *How Can We "Activate" Student Engagement?*

An important lesson from the science of learning is that instructional media itself does not cause learning. Rather, it is the details of the teacher-student interaction and the strategic presentation of such media that has been shown to affect learning outcomes. Indeed, research has shown that students are not passive learners, and, moreover, that their levels of motivation and engagement can vary based on their experience with the instructor and presentation of information. Consequently, there are several evidence-based strategies for instructors to consider when designing their courses to optimize learning outcomes for their students. In this session we will review and discuss different ways for instructors to optimize student engagement and facilitate learning across all disciplines.

Joint Presentation Title: *Designing Instruction and Practice to Benefit Students'*
Performance in STEM courses

Victor Benassi
Director, Center for Excellence and Innovation in Teaching and
Learning, and Professor of Psychology, University of New
Hampshire

Catherine Overson

Director of Teaching, Learning, and Research Services, and
Affiliate Associate Professor of College Teaching, University of
New Hampshire

Presenters will provide examples of three classes of knowledge acquisition: memory &
fluency; induction & refinement; and understanding & making sense. Based on
Koedinger, Corbett, and Perfetti's (2012) Knowledge-Learning Instruction (KLI)
framework, presenters will describe, for each of the three classes of knowledge,
corresponding cognitively supported course-situated (*in vivo*) experiments that they
conducted with resulting observed learning benefits. Practice strategies explored
through their experimentation include: for knowledge components requiring memory &
fluency acquisition – flashcards that promote retrieval practice, for induction and
refinement – guiding questions, and for understanding and making sense – prompted
self-explanation.