9th Annual SABER National Meeting Conference Materials

July 26-28, 2019
University of Minnesota
Twin Cities, MN

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SABER National Meeting Schedule

Friday July 26, 2019

11:00-12:45 Registration outside Bruininks 220

	Opening Session- Smith 100
1:00-1:20	**Welcome**
1:20-2:20	**The Need for Unpacking** Vincente Talanquer, Department of Chemistry, University of Arizona
2:20-2:40	Walk briskly across street to Bruininks

	Bruininks 220	**Bruininks 230**	**Bruininks 312**
	Graduate Student Professional Development	**Student Thinking, Reasoning, & Metacognition**	**Student Learning, Perceptions, & Identity Related to Research/ers**
2:40-3:00	202* **Responsive Teaching Training for Teaching Assistants: Examining Shifts in Noticing and Attention** Matthew Simon*; Julia Gouvea (Tufts University)	199 **Unwrapping Exam Wrappers in Introductory Biology** Joel Ledford *, Geoffrey Benn; Susan Keen; Katherine Ransom (UC Davis)	192 **Making LEAPS in Intro Biology Lab: Development & Course Outcomes of Laboratories Engaging Students in the Application & Process of Science** S.E. DeChenne-Peters*; et al
3:00-3:20	227 **Program SAGES: Promoting collaborative teaching development through graduate student/faculty partnerships** Isabelle Barrette-Ng*; E. Khoury (Calgary)	150* **Student Thinking About Metabolic Pathway Dynamics and Regulation** Kush Bhatia*; Austin Stack; Cheryl Sensibaugh; Paula P. Lemons (Univ of Georgia)	256 **How do students learn complex experimental design skills in rich instructional environments?** Susan Hester*; Shane Thomas; Molly S. Bolger (Univ of Arizona)
3:20-3:40	50 **Testing the "cherry-on-top" hypothesis: How important is evidence in convincing TAs to use evidence-based teaching practices**? Lorelei E Patrick; Hillary Barron Sehoya Cotner (Univ of Minnesota)	226 **What did they learn? Investigating student understandings after clicker discussions** Brian Couch *; Kati Brazeal; Emily Bremers; Cal Koch; Anya Morozov (Univ. of Nebraska-Lincoln)	116* **Examining the variations in undergraduates' conceptions of researchers: A phenomenographic study** Austin Zuckerman*, Stanley M Lo (Univ of California, San Diego)
3:40-4:00	139 **Graduate student instructors (GSIs) with more teaching experience positively impact student confidence**Lisa L Walsh (Michigan)*	25 **Targeting mis-strategies in scientific reasoning leads to increased ability and performance in STEM** Jamie L Jensen *; J.Woolley S. Kurtz (BYU)	224* **Do self-selected student roles impact group dynamics and affect learning?** Alex R Paine*, J. Knight (UC-Boulder)
4:00-4:20	209 Ex**ploring Graduate Student Instructors' Attention to Pedagogy and Student Thinking in Non-Majors Lecture Course**	42 **Development of metacognition and biological understanding from introductory students to seniors: A longitudinal study.** Jaime L Sabel (Univ of Memphis)*	10 **Augmented Reality as an Effective and Accessible Tool for Teaching Macromolecular Structure and Function** Rou-Jia Sung *; Andrew Wilson (Carleton College); Stanley Lo

	Ryan C Coker*; M. Tekkumru-Kisa; B. Kraft; K. Hill; E. Humphrey (FSU) A. Grinath (Middle Tennessee State)		(UCSD); Jane Liu (Pomona College)
4:20-4:40	53 **To cope or not to cope? How Biology graduate teaching assistants cope with teaching & research anxieties** Miranda Chen, B. Schussler (UTKnoxville)	112 **How do instructors support students' engagement in authentic scientific practices? A study of real-time dialog in a model-based inquiry laboratory course** Lexi Cooper*; Molly S. Bolger (Univ. Arizona)	97 **Scrub Envy: Investigating Sources of Self-efficacy and Identity in Anatomy and Physiology Students** Emily Royse*; Jessie Sutton; Emily Holt; M Peffer (U Northern Colorado)
4:45-5:45	**Special Interest Groups - Please note new room assignments** ● Graduate students and Post docs- **Room 220** ● Community College faculty **-Room 230** ● Motivation- **Room 312** ● Experimental Design Concepts in Course-based undergraduate research experiences CUREs (EDCCUREs) **Room 123** ● Physiology**- Room 131A** ● Undergraduates – R**oom 131B**		
6:30-8:00	**Reception- The Graduate Hotel- Foyer near Ballroom on mezzanine (light appetizers and beverages)**		
	Dinner on your own		

Saturday July 27, 2019

6:20	**6:20 Yoga Stretch** **6:30 am SABER 5K run-** start line at Harvard and Beacon Street	
7:30 9:00	**Coffee and tea outside Buininks 220**	
	Bruininks 220	**Bruininks 230**
8:30-9:30	**Cultivating active learners: How instructors can change their teaching to help students engage with formative assessments** Kati Brazeal (UN-L)*; Tanya L Brown (Univ of Colorado); Chad Brassil; Brian Couch (UN-L)	**Classroom as genome: using genomics research methods to assess the student and instructor behaviors associated with clicker questions** Robert Erdmann (Univ of Minnesota, Rochester)*; Marilyne Stains (UN-L)
9:30-9:45	**Break**	

	220	230	312
	Mentoring & Career Development	**Equity & Inclusion in Biology Classes**	**Student Affect: Anxiety & Motivation**
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10:05-10:25	204* **"thank u, next": Characterizing negative mentoring in undergraduate life science research** Trevor T Tuma *; L.Limeri; M. Zaka Asif; B. Bridges; D. Sanders; A. Morrison; P. Rao (UGA); J.Harsh (James Madison); A. Maltese (IU); D. Esparza (UTEP); E. Dolan (UGA)	281 **First Year Near-Peer Learning Communities Promote Academic Success and Persistence within the Biology Major** Mike Wilton (UCSB)*	47 **The impact of student research anxiety on undergraduate biology students' intentions to pursue a scientific research career** Katelyn Cooper*; Logan Gin; Sara E Brownell (Arizona State Univ.)
10:25-10:45	121 **The Academic Career Readiness Assessment: Clarifying training expectations for future faculty** Laurence Clement; Jennie Dorman (UCSF); R. McGee (Northwestern)	23* **The self-advocacy experiences of students with learning disabilities and ADHD in undergraduate STEM courses** Mariel Pfeifer*; Julie Dangremond Stanton (UGA)	134 **For broadening participation in introductory biology, tackle test anxiety** Sehoya Cotner*; Ryan Laffin; Kendall Edstrom; Mark Jokinen (Univ Minn.)
10:45-11:05	24 **Dreams clarify, but strategies don't increase: Exploring the future work selves of lower division and upper division students** Julie F Charbonnier*; D.Hernandez (FIU); L. Corwin (UC); S. Eddy (FIU)	140* **From Belief to Reality: Characterization of Sex/Gender Beliefs in Undergraduates** Katherine E Ray King (Univ of Louisville)*	125 **A Critical Synthesis of the Literature on Motivation to Learn in Postsecondary Biology** Michael E Moore (Baylor)*; Amanda Sebesta (Saint Louis U.); Grant Gardner (Middle Tennessee State)
11:05-11:25	273 **Exploring barriers to graduate mentorship of community college students using the Social Cognitive Career Theory**	172 **Uncovering the Perspective of Underrepresented Students in an Active Learning Environment**	233* **Self-regulated learning strategy approaches and exam performance in undergraduate introductory biology** Amanda Sebesta*; Elena Bray-Speth (Saint Louis Univ)

	Ally Hunter (UC-SF)*; K. Leung (City College SF); J Lewis; N. Saul, L. Clement (UCSF)	Ashley Harlow*; Brian Sato (UC Irvine)	
11:25-11:45	**Break**		
11:45-12:45	**Posters 1-77 EVEN numbers 2nd floor white boards and rooms 312, 330, 412**		
12:45-2:00	**Lunch -- pick up box lunches outside 330**		
1:00-2:00	**Round tables 312, 330, 412, 512A, 512B see RT program for topics and rooms**		

Saturday	**220** **Course-Based Undergraduate Research Experiences**	**230** **Issues in Instructional Implementation**	**312** **Student Learning**
2:00-2:20	114* **It's Not a Red Herring! Exploring Student Beliefs About Research Authenticity in an Introductory Biology Killifish CURE** Emma C Goodwin *; Vladimir Anokhin; MacKenzie Gray ;Yelisey Gurzhuy; Erin Shortlidge (Portland State)	56 **Using a Fidelity of Implementation Framework to Understand the Impacts of Two Research-Based Instructional Strategies in High School Biology Classrooms** Grant E Gardner* (Middle Tennessee State);J. Parrish (U. of Northern Colorado)	229 **Comparison of Service learning and Research Projects in an Introductory Biology Class** Amy Kulesza (Center for Life Sciences Education)*; Kelsie M Bernot; Safa Imtiaz (North Caroline A&T State U.); Judith S. Ridgway (Ohio State Univ.)
2:20-2:40	43 **Two sequential research-based courses afford students opportunities to develop scientific coping skills** Lisa A Corwin (UC-Boulder)*; Joseph Harsh (James Madison); Michael Ramsey;Elizabeth Woolner Stevie Ellis; Nina Gustafson (UC, Boulder)	247* **Investigation of the role of lab instructors in mediating group conflicts in an undergraduate inquiry based intro biology lab.** Sukhada Samudra *; Peggy Brickman (UGA); Destiny Williams (Mount Holyoke College); Aarati Shah (UGA)	274 **Retrieval practice for jargon terms enhances definition responses but not conceptual questions** James Cooke *(UCSD)Steven Pan (UCLA); Mark McDaniel (Washington Univ, St. Louis); Timothy Rickard (UC SD)
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3:00-3:20	267 **The Effect of Project Ownership on Student Approaches to Writing in Laboratory Courses** Lisa M McDonnell, Anqi Yang (UC- San Diego)	136 **Classroom discourse patterns of biology faculty in undergraduate STEM courses** Petra Kranzfelder (U Minnesota)*; J. Bankers-Fulbright (Augsburg Univ); M. García-Ojeda (UC,	59 **Exploring Plant Blindness and Botanical Literacy in an Undergraduate Botany Course** Kathryn M Parsley *; Jaime L Sabel (Univ. Memphis); Laura Zangori (Univ. Missouri); Jason Koontz (Augustana)

		Merced); M. Melloy; S. Mohammed; Abdi Warfa (U MN)	
3:20-3:40	152 **Faculty Experiences during the Implementation of a Developed CURE Curriculum at Primarily Undergraduate Institutions and a Community College** Nicole Scheuermann; Sue Ellen DeChenne-Peters* (Georgia Southern)	82 **What do we mean when we say "random call"? Investigating why and how college biology instructors use random call** Alex Waugh*; Tessa C Andrews (University of Georgia)	214 **Which Components of Evidence-based Teaching Impact Student Learning?** Mary Pat Wenderoth *; Sungmin Moon; Mallory Jackson; Jennifer H Doherty (University of Washington)
3:40-4:00	**BREAK**		
4:00-5:00	**Posters 1-77 ODD numbers 2nd floor white boards and rooms 312, 330, 412**		
5:00-6:30	**Free time**		
6:30-9:30	**Reception and Banquet- Alumni Center**		
9:30----	**Game Night (lobby of The Graduate)**		

Sunday July 28, 2019

8:00-9:00	**Business Meeting – all welcome Rm 220**		
7:30-9:00	**Coffee and tea outside Buininks 220**		
	220	**230**	**312**
	Evolution & Science Acceptance	**Reading & Writing in Biology**	**Faculty Professional Development & Change**
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9:45-10:05	130 **Five years of evolution acceptance – Are general students different than biology students?** Ryan Dunk*, Jason Wiles (Syracuse University)	262 **Figure Facts leads novice students to engage in more expert-like practices and improved interpretation proficiency when reading primary scientific literature** Jaclyn Dee*; Warren J Code Bridgette Clarkston (UBC)	86 **The role of departmental climate and self-efficacy in shaping early-career faculty teaching practices** Nathan Emery *;Diane Ebert-May (MSU); Jessica Maher ("Delta Program in Research, Teaching, and Learning")
10:05-10:25	238 **Teaching Nature of Science in General Biology: Impacts on Students' Acceptance of Evolution** Jeremy D Sloane*,Lindsay Wheeler; Jessamyn Manson (UVA)	216 **Reframing the lab report: Epistemologically-oriented redesign of a laboratory course improves students' lab reports** Julia Gouvea (Tufts Univ.)*	142 **Teaching Professional Development: A Trajectory Toward Effectively Fostering a Focus on Student Thinking** Paula P. Lemons (UGA)*; J.McCourt (UPS); P.Zagallo (UGA); M. Smith (Cornell); J. Knight (UC, Boulder); T C Andrews (UGA); K Haudek (MSU); R Idsardi (Eastern Washington Univ); C Meaders (Cornell); J Merrill (MSU); R Nehm (Stony Brook); K Pelletreau (Univ.Maine); L.Prevost (USF); M. Urban-Lurain (MSU)
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10:45-11:05	174 **A comparison of the reconciliation model in a biology and theology classroom** Danny Ferguson*; Ethan Tolman (Brigham Young University)	279 **The hidden effects of writing in science classes: examining self-efficacy, science identity, and differential demographic effects** Benjamin E Carter (Duke)*	222 **A Close Look at Change: Understanding Factors that Shape Instructor Evolution during Instructional Reform Efforts** Katelyn Southard *; Jonathan Cox Young Ae Kim; Jazmin Jurkiewicz; Lisa Elfring Paul Blowers; Vicente Talanquer (Univ. Arizona)
11:05-11:20	**Break**		
11:20-12:20	**Posters 78-154 EVEN numbers 2nd floor white boards and rooms 312, 330, 412**		
12:20-1:30	**Lunch- outside Bruininks 330**		

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12:30-1:30	**Round tables- 312, 330, 412, 512A, 512B see RT program in your folder for topics and rooms**
1:30-2:30:	**Posters 78-154 ODD numbers 2nd floor white boards and rooms 312, 330, 412**

SUNDAY	**220**	**230**	**312**
	Biology & Quantitative Literacy	**Evolution Instruction**	**Instrument Design & Implementation**
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3:10-3:30	156 St**udents' perceptions of the purpose of commonly used mathematical expressions in biology** Linh Chau*;Anita Schuchardt (Univ. Minnesota)	228 **Testing the Effect of Human Examples When Teaching Evolution** Daniel Grunspan (ASU)*; Ryan Dunk ; Jason Wiles (Syracuse); Elizabeth Barnes; Sara Brownell (ASU)	66 **Development and National Validation of the BioSkills Guide: A Tool for Interpreting and Teaching Core Competencies** Alexa Clemmons (Univ. Washington)*; Jerry Timbrook (Univ. Nebraska-Lincoln); Jon Herron; Alison Crowe (Univ. Washington)
3:30-3:50	109 **Students' perceptions of the extent to which mathematical expressions contain meaning predicts problem solving accuracy** Anita Schuchardt *; Linh Chau; Fangfang Zhao (Univ. Minnesota)	61 **Implementing the Teaching for Transformative Experiences in Science Model in Introductory Biology for Non-Majors** Rachel A Sparks *; Rebekka Darner (Illinois State University)	93 **Exploring the role of learning assistants in the classroom: Development and use of a social supports survey** Dania Hernandez*, Gema Jacomin; Sarah L Eddy (FIU)
4:00	**Meeting adjourns**		

LONG TALK ABSTRACTS

Cultivating active learners: How instructors can change their teaching to help students engage with formative assessments

Kati Brazeal ("University of Nebraska, Lincoln")*; Tanya L Brown (University of Colorado); Chad Brassil (University of Nebraska-Lincoln); Brian Couch (University of Nebraska-Lincoln)

Paper ID: 263

Because formative assessments (FAs; e.g., clicker questions, in-class group activities, Just-in-Time-Teaching, homework assignments) are known to improve student learning and retention in STEM, national reports have called for instructors to adopt these techniques. While the use of FAs has increased in STEM courses, it has also been accompanied by challenges, including students who are resistant toward them or use them in ways that may undermine learning (e.g., not taking FAs seriously, searching the internet for answers). Student buy-in and utilization thus represent critical factors that potentially limit the adoption and efficacy of FAs. Furthermore, instructors often adapt these techniques, and these changes could lead to variation in learning gains. Thus, instructors need guidance about how to implement FAs to encourage student engagement and support learning. Moreover, while the FA literature provides many general insights, more work is needed to fully understand how to optimize student engagement with specific FAs that are commonly used in undergraduate biology. To address this gap and provide more specific guidance for instructors, we have investigated the overarching research questions of how students buy-in to and utilize specific FAs as well as how instructor implementation characteristics influence student FA buy-in and utilization. Our research is grounded in two theoretical frameworks. First, we applied Prosser and Trigwell's model of teaching and learning to establish an FA Engagement Model, in which implementation characteristics affect student perceptions about the FA (i.e., buy-in) and student behaviors during and after the activity (i.e., utilization). In turn, FA engagement (i.e., buy-in and utilization) influences subsequent learning gains. Second, we used Black and Wiliam's five objectives for how FAs improve learning to scaffold our investigations of each component of the FA Engagement Model (i.e., implementation, buy-in, and utilization). Our work has yielded multiple data streams. First, we collected mixed-methods survey data from over 1,000 students in 12 biology courses and 38 student interviews from 8 biology courses at a large midwestern university. We used factor analyses and mixed effects statistical models to analyze our quantitative data and thematic content analysis involving a combination of a priori and emergent processes to analyze qualitative data. We combined our insights from these quantitative and qualitative data to build and validate a diagnostic survey tool, the Formative Assessment Buy-in and Utilization Survey (FABUS), that instructors can use to monitor student buy-in and utilization. The development of FABUS involved an iterative process of piloting and revising based on student think-aloud interviews, feedback from instructors, and statistical analyses (i.e., exploratory and confirmatory factor analysis and reliability statistics). We administered the final version of FABUS to over 4,700 students in 55 biology courses at 9 institutions of varying types. This talk will synthesize the overarching findings from our 5 years of

research reported in several published manuscripts. Throughout this research, we have catalogued the range of variation for each of the three components of our FA engagement model for several FA types. We have catalogued 72 different characteristics across 8 categories of FA implementation, characterized how student buy-in aligns with the five FA objectives, and outlined the range of student FA utilization behaviors within categories of approach, discussion, resources, and later use. In addition, we have tested the relationships among the model components. In general, we have found that the majority of students buy-in to commonly used FAs, and our mixed effects models have identified factors that predict increased FA buy-in. Instructional implementation differences along with student beliefs about ownership of learning and behaviors have consistent significant influences on buy-in, while student demographics, previous experiences, and incoming GPA do not. In addition, our models have shown that higher buy-in toward FAs predicts deeper learning approaches and improved exam and course performance, even when controlling for student demographics and GPA. Taken together, these results suggest that instructors should care about student buy-in and that they have the power to improve it. Through in-depth analysis of student interviews, we have further fleshed out relationships between specific implementation characteristics and student buy-in and utilization, yielding a comprehensive resource that distills recommendations across each implementation category about how instructors can improve student FA engagement. These recommendations support those of previous research while also providing deeper insights from the student perspective and generating new recommendations for implementation characteristics that have received little attention in the literature. For example, we identified deliberate steps instructors should take to ensure student engagement with pre-class FAs. Other novel findings include insights about activity messaging, out-of-class peer learning, and grading policy. Additionally, we found that implementation characteristics have interacting effects on student engagement and that students will tolerate a degree of “acceptable discomfort.” This research refines the FA literature and provides important information for undergraduate biology instructors by systematically outlining implementation, buy-in, and utilization for several commonly-used FAs and demonstrating the connections among these variables and student performance. Moreover, FABUS represents a powerful tool that instructors can use to gain feedback about specific aspects of their FA implementation. Prior to FABUS, there have been no other instruments that directly assess student perceptions and behaviors regarding specific FAs within a course. In addition, we will share how we have used FABUS to scaffold a professional development workshop in which faculty reflected on their FABUS results and identified implementation changes they planned to make to improve student buy-in and utilization. These efforts provide a model for how faculty can use data from their own classes to improve FA implementation in ways that that are aligned with best practices.

Classroom as genome: using genomics research methods to assess the student and instructor behaviors associated with clicker questions

Robert Erdmann (University of Minnesota Rochester)*; Marilyne Stains (University of Nebraska-Lincoln)

Paper ID: 284

In this presentation, we address two problems in biology education. First, how do we achieve fine-grained analysis with classroom observation protocol data? Often, classroom observation data is compressed through summary statistics, meaning that only a coarse-grained perspective on the underlying instructional data is revealed. This results in the loss of potential insights on patterning within observed classrooms. Second, how can researchers measure the level of fidelity of implementation for an instructional technique within a broad source pool of observations, while minimizing the need for arduous manual analysis? It is difficult to target professional development efforts without a detailed accounting of current practices, and developing creative methods to extract such information from data collected for other purposes would be of great value to the research community. Here, we present the results of two projects that together address these problems. We have established a methodology for the analysis of observation data streams termed "classroom as genome" (CAG). Following that, we deployed CAG on a large population of classroom observations in order to analyze the implementation of Peer Instruction. Classroom observation data may provide a variety of insights to individual instructors looking to understand and improve their own classroom practices, while for education researchers, the analysis of classroom data at large scales can provide a big picture perspective on instructional practices. There are a growing number of published classroom observation protocols, each with its own focal points. These protocols have been broadly used in efforts to characterize the spectrum of instructional practices at individual colleges and universities, as well as to compare and contrast hundreds of class periods from sets of higher education STEM classrooms spanning multiple institutions. However, analyzing classroom observation data at large scales can be fraught with difficulty. Many of the above studies rely heavily on summary statistics to compress and restructure the underlying data prior to downstream analyses. These summary outputs can obscure meaningful patterns and differences within a pool of observations. A challenge for the field is to fully take advantage of the fine-grained data provided by many observation protocols. In order to address this challenge, we developed a new philosophy of classroom observation data structuring and analysis that leverages the many parallels between genomes and classrooms, including the layering of multiple forms of information, the meaningfulness of directionality, and underlying patterns within a larger superstructure. Taking this analogy to its logical end, we are enabled to draw upon the tools of a bioinformatics scientist, with the intent of repurposing genomics analysis approaches for education research. CAG approaches allow researchers to address a wide-ranging set of potential questions, from the dispersion and clustering of individual classroom behaviors to the sequencing of different classroom behaviors relative to one another. CAG methods have the potential to enable analyses that would otherwise be much more difficult, and should be of interest to biologists writ large who have an interest in seeing the tools of biology research being applied within the educational realm. Second, we apply CAG methods to the study of Peer Instruction (PI) within the STEM classroom. PI is a pedagogical technique characterized by individual student responses to an instructor's conceptual question using clickers or other personal response systems, followed by discussion of the question among peers and a second response to the question. Researchers have detailed a framework for the fidelity of implementation of PI, which highlights both the individual thinking/response step and the peer discussion step as critical for high fidelity usage of the technique. Research on PI and clicker usage has described implementation at small to medium scales, but large scale studies of the detailed implementation behaviors of PI have remained difficult to execute. To address this problem, we repurposed a data set of 412 classroom recordings (representing over 70 faculty members at over two dozen institutions) that had been coded using the Course Observation Protocol for Undergraduate STEM (COPUS). Using CAG, we were able to isolate and analyze 457 distinct occurrences of the "clicker question" code found across 177 of the classroom observations. We found that 382 of the clicker question episodes overlapped with the "group discussion of clicker questions" code, but that only 47 of these 382 episodes also incorporated the "independent thinking" code. Meanwhile, 64 of the clicker question episodes were found to overlap "independent thinking" without overlapping "group discussion of clicker questions." We found that there was a statistically significant different between the mean percentage of time spent lecturing between class periods containing a clicker question and those without (unpaired T-test, $p < 0.0001$), but that there was not a significant difference in class time spent lecturing or listening between class periods containing different forms of clicker question implementation. Our results suggest that, as a community of instructors, we are missing out on many opportunities to encourage better peer discussion episodes through the use of preceding individual thinking and responses. In addition, we describe the usage of ends analysis to describe patterns across clicker questions. In ends analysis, the starting end and the closing end of every instance of a code/feature of interest are lined up, while all other codes are plotted relative to those aligned ends, enabling the visualization of features that proceed, follow, or overlap other features of interest. Applying ends analysis to the 457 clicker question episodes, we uncovered distinctive patterns in the time leading up to, during, and after clicker questions, which shed additional light on the ways in which clicker question usage aligned (or didn't) with the high fidelity practices suggested by PI. Altogether, these results provide with a much broader, yet simultaneously more detailed, view of the PI "character" of instructor questioning in a broad range of classrooms, in a way that was not possible using traditional analysis techniques. This represents a streamlined approach to determining fidelity of implementation in a way that uses off the shelf data and can be a complement to specialized research instruments for the study of a given pedagogical technique. Citations: "Classroom as genome: Using the tools of genomics and bioinformatics to illuminate classroom observation data." CBE – Life Sciences Education, 18:es1, 1–12, Spring 2019. "Clicker usage in postsecondary STEM classrooms: a quantitative analysis of correlated student and instructor behaviors." In preparation.

SHORT TALK ABSTRACTS

Friday

Graduate Student Professional Development

Paper ID: 202

Responsive Teaching Training for Teaching Assistants: Examining Shifts in Noticing and Attention

Matthew Simon (Tufts University)*; Julia Gouvea (Tufts University)

The ability to notice and attend to student thinking is at the core of responsive teaching but can take practice for novice teachers to develop (e.g., Watkins, Coffey, Maskiewicz & Hammer, 2017). Instructors may be quick to dismiss a student's idea if it is difficult to interpret or shows superficial signs of being incorrect (Goertzen, Scherr & Elby, 2010). Practiced responsive teachers can draw out these beginning ideas and allow students to develop and refine their thinking. Graduate and undergraduate teaching assistants (TAs) are novice college STEM teachers who have disciplinary expertise but often lack formal training and experience with teaching (Schussler et al, 2015). Our goal in this study was to examine how a responsive teaching professional development (PD) for biology TAs impacted what they noticed and attended to in their students' thinking. We developed a video-based PD curriculum for biology TAs that encouraged responsive teaching practices. Nine TAs participated in the PD which ran concurrently with their teaching assignments as introductory biology lab instructors. TAs took turns sharing video clips from their lab sections for discussion in PD. TAs were also responsible for keeping a weekly teaching journal and were interviewed twice about their experience teaching lab. In this talk, we present a case study of one TA: Susan. In our analysis we triangulated interview and journal data with video from Susan's lab section to characterize what Susan noticed and attended to in her students' thinking. Initially, Susan tended to notice the potential flaws in ideas that students articulated. She routinely attended to ways in which her students were "wrong." For instance, in lab one, Susan wrote about a moment in which students were discussing mutation rates across species. Susan's account of the moment focused on a student, "misunderstand[ing] the definition" of mutation rate. Rather than try to understand the substance of the student's idea, Susan focused only on the flaw. Later in the semester, Susan began noticing the potential merit in student-produced ideas; she attended to the ways in which these ideas were "interesting." For instance, in her final lab, Susan attended to a moment in which a student proposed a novel (but convoluted) interpretation of a graph relating beetle oviposition patterns with resource quality. Rather than focus on the lack of clarity, Susan asked the student questions to, "build on my own understanding of her idea." We will present evidence that further characterizes what Susan noticed and attended to in her students' thinking. Our analysis shows that Susan began noticing (and perhaps even looking for) the potential value and merit in her students' thinking instead of focusing only on indicators of correctness. As the PD progressed, Susan put more effort into understanding the substance of student thinking rather than solely attending to potential flaws. These shifts are moves towards a more responsive pedagogical approach. The changes in Susan's approach to instruction provide a proof-of-concept that novice TAs are capable of engaging with responsive teaching. Our PD design gave TAs low-stakes practice at noticing and attending to the substance of student thinking – skills that Susan began to put into practice in her classroom. Training teachers to be more responsive has the potential to create classrooms in which students' nascent disciplinary ideas are noticed and developed.

Paper ID: 227

Program SAGES: Promoting collaborative teaching development through graduate student/faculty partnerships

Isabelle H Barrette-Ng (University of Calgary)*; Eliana El Khoury (University of Calgary)

Each year, graduate students shoulder many hours of instructional time with undergraduate students and some have more contact hours with students than academic staff in large introductory undergraduate courses (Sundberg et al., 2005). However, many graduate students are given minimal opportunities for teaching development, and there is a great need to help them develop a scholarly and reflective teaching practice (Kenny et al., 2014). Teaching development opportunities are becoming increasingly recognized as critical components of graduate education, as postsecondary institutions face the challenge of

preparing the next generation of faculty members (Chick & Brame, 2015; Kenny et al., 2014). Enhancing the teaching skills of graduate students is a critical investment that will also create a culture of educational leadership, and foster innovation and teaching development. To support STEM graduate students in the development of an evidence-based teaching practice, we designed and implemented the SAGES Program (SoTL Advancing Graduate Education in STEM) at a research-intensive university. This program was designed to provide graduate students with opportunities to learn about scholarly teaching and learning (SoTL) within the context of STEM through a semester-long course, followed by a semester-long practicum. The practicum gives graduate students an opportunity to apply their learning in an undergraduate class, in partnership with a faculty member acting as a mentor. Others have shown that pedagogical training programs for graduate students may increase teaching self-efficacy, knowledge and skills (DeChenne et al., 2012; Connolly et al., 2018). However, what is not known is whether establishing graduate student/faculty partnerships can lead to collaborative teaching development for both mentor and mentee. To assess the effectiveness of Program SAGES in promoting collaborative teaching development, we employed a mixed methods approach. Pretest and posttest surveys (DeChenne et al., 2012; Trigwell and Prosser, 2004) were administered to 57 graduate students across three cohorts of the program to measure changes in teaching self-efficacy and beliefs. Analyses of the data revealed statistically significant gains in teaching self-efficacy and a marked adoption of student-centered teaching approaches. These changes were further explored through semi-structured interviews. Thematic analyses of these interviews revealed: (1) how graduate students perceived changed in their teaching practice as a result of their experiences in the program, (2) the forms of support they felt were most useful, and (3) their experience working with both faculty mentors and undergraduate students. Semi-structured interviews were also conducted with 23 of the faculty mentors across three cohorts of the program. Thematic analyses of these interviews revealed that: (1) mentees became mentors by creating safe environments for faculty development; (2) mentors learned and adopted new teaching strategies; (3) mentors became more reflective teachers; and (4) mentors began to shift their teaching identities. The results of our study suggest that pedagogical programs like SAGES can serve to build broad, extensive networks of engagement between graduate students and faculty members where both mentees and mentors can collaboratively enhance their teaching practices. Establishing these partnerships provides opportunities for participants to develop new networks of practice that can foster future innovation and teaching development.

Paper ID: 50

Testing the “cherry-on-top” hypothesis: How important is evidence in convincing TAs to use evidence-based teaching practices?

Lorelei E Patrick (University of Minnesota)*; Hillary Barron (University of Minnesota); Sehoya Cotner (University of Minnesota)

Evidence-based teaching practices (EBTP) – such as inquiry-based learning, inclusive teaching, and active learning – have been shown to benefit all students, especially women, first-generation, and traditionally minoritized students in STEM fields. Thus, these teaching practices have been integrated into many courses, particularly lab classes, which are typically taught by teaching assistants (TAs). Until recently, little work has focused on how best to train TAs to use these teaching practices, much less identify the key components of such training sessions. Our previous work has shown that TAs who get to model active learning teaching practices in a workshop setting find the practices more valuable and useful than TAs who are exposed to the evidence for the practices’ effectiveness while facilitators do the modeling. This outcome indicated that one crucial training component was actively modeling teaching practices in a low-stakes environment. We suspected that exposure to evidence was the “cherry-on-top” in convincing TAs to adopt EBTP (i.e., a nice addition, but not critical for encouraging implementation); therefore we hypothesized that if we experimentally manipulated workshop groups such that all TAs actively modeled teaching practices, but only one group was exposed to evidence, there would be no differences between the experimental groups. To test this hypothesis, we offered a workshop on inclusive teaching (IT) and facilitating inquiry (FI) teaching practices. All TAs worked in teams to learn an IT and a FI technique in depth with a workshop facilitator, then the teams modeled the activity with their peers acting as students. In addition, participants in the Evidence (E) group were exposed to evidence showing the effectiveness and importance of IT and FI whereas Activity (A) group participants were not. Pre-workshop, post-workshop, and post-semester survey data were analyzed to assess TA self-reported knowledge of IT and FI; value and usefulness of the techniques demonstrated in the workshop; and how important exposure to the evidence for evidence-based teaching was to convince TAs to use them. TA knowledge of IT and FI increased after the workshop, indicating it was effective. However, there were no differences between the A and E groups at any time point. Our findings support the “cherry-on-top” hypothesis: modeling new teaching practices is the most important and effective means to train TAs, and, although exposure to evidence is helpful, it is not enough to convince TAs to use EBTP. This outcome has broad implications for how we provide professional development sessions to TAs and potentially to faculty: we should spend more time creating low-stakes environments in which to rehearse actually doing EBTP and less time on the evidence.

Paper ID: 139

Graduate student instructors (GSIs) with more teaching experience positively impact student confidence

Lisa L Walsh (University of Michigan)*

Across more than 100 American universities, graduate student instructors (GSIs) are most commonly the laboratory instructors at 91% of research institutions (Sundberg et al., 2005). Academic success in gateway courses and meaningful relationships with instructors positively influences an undergraduate student’s decision to pursue a STEM degree, situating GSIs in a potentially impactful role in STEM retention (PCAST, 2012). Despite this important role, few empirical studies have been conducted on how GSIs impact college-level student learning in the biological sciences. The objective of this study was to evaluate how a GSI’s previous teaching experience impacts undergraduate outcomes. This study was conducted across three semesters of Introduction to Biology Laboratory at a large, public R1 research university. Each week, students attend one hour of lecture by the professor and three hours of laboratory led by a GSI. 1474 undergraduates completed surveys at the beginning (pre) and at the end (post) of the semester. Student outcome data collected included confidence in succeeding in the course, interest in a STEM major, change in both (post-pre), and course grade. Thirty-six GSIs responded to a survey indicating their previous teaching experience. GSIs were broken into three categories: those who had never taught, those who had taught one semester, and those who had taught multiple times previously. Each student outcome was compared for students taught by the three tiers of GSI teaching experience using a one-way ANOVA with a post hoc Tukey test. Post-semester interest in a STEM major did not differ based on a GSI’s experience (all ANOVA $p > 0.379$, all $F < 1.377$; Supplemental Table 5s). First time GSIs gave significantly higher overall grades compared to GSIs with multiple previous semesters of experience (Tukey $p = 0.003$; Figure 1). Students taught by the most experienced GSIs had significantly less of a decrease in confidence that they would succeed in the course than those taught by first-time GSIs (Tukey $p = 0.018$, $F = 4.057$; Figure 2). This increase in course confidence was not tied to course grade, as students taught by first-time GSIs received higher overall grades (Supplemental Table 5s). Thus, a student can feel encouraged in a class by influences outside of their course grade. These results are consistent with a study that found GSIs required more than a year of teaching to develop inquiry-based teaching approaches known to positively impact undergraduate learning in STEM (Gormally et al., 2016). My data, along with Gormally et al. 2016, should encourage departments to require that graduate students teach at least three semesters for crucial professional development in academia. My data can also be used to encourage first-time GSIs that if they continue to teach for additional semesters, their positive impact on students is likely to increase.

Paper ID: 209

Exploring Graduate Student Instructors’ Attention to Pedagogy and Student Thinking in Non-Majors Lecture Course

Ryan C Coker (Florida State University)*; Miray Tekkumru-Kisa (Florida State University); Anna Grinath (Middle Tennessee State University); Brittany Kraft (Florida State University); Kate Hill (Florida State University); Eve Humphrey (Florida State University)

Recent reform efforts in postsecondary biology education call for the implementation of active learning strategies to transform post-secondary biology teaching into a student-centered endeavor (AAAS 2011). Even when these strategies are used, they are often implemented in ways that fail to elicit or advance students’ thinking and reasoning in science (Andrews et al., 2018). Investigating differences between expert and novice instructors, Auerbach et al. (2018) found that experts more deeply attended to and reasoned about the pedagogy employed to elicit, engage, respond to, and advance students' generative thinking. Informed by the literature on teacher noticing (e.g., van Es & Sherin, 2010, Levin & Richards, 2011), which focuses on what teachers attend to and how they make sense of what they see in a classroom episode, this study was guided by these research questions: What do graduate student instructors in a biology for non-majors course notice when reflecting on and analyzing instruction, and do patterns in their noticing correspond to differential opportunities for student learning provided in their instruction? We examined graduate student instructors' (GIs) teaching of discrete curricular units of the same general biology for non-majors lecture course. We focused on two cases selected through a maximal variation sampling scheme (Creswell, 2013), based on our observations of their instruction and the provision of either high (Pat) or low (Alex) levels of student-centered instruction (analysis of videoed instruction is planned). To understand whether these GIs noticed differently, each instructor participated in a noticing interview wherein they watched the same video of high-quality instruction and reasoned about what they attended to in the video. GIs also participated in 10-minute reflective interviews after teaching each lesson of a unit to reflect on important moments of instruction and student thinking that occurred during class each day—4 of these interviews were included in this study for each instructor. Interviews were "chunked" into idea units (Jacobs et al., 1997), which were then coded by using the analytical framework by Author (2018) based on the Learning to Notice framework by van Es & Sherin (2010). Analyses of the interviews revealed key differences in what each instructor attended to and how they made sense of what they saw. Alex attended to students' thinking less frequently than Pat, and most often attended to the biology content embedded in students' ideas. Alex often attended to student thinking in isolation of the pedagogical moves of the instructor, rarely noticing teaching as interactional between teacher moves and student thinking. In contrast to Alex, Pat often went beyond the content to reason about the meanings and understandings embedded in students' thinking, and connected this with reasoning about teacher pedagogical moves that surfaced and advanced student thinking. This study provides insights into the use of "noticing" as a lens to support GIs' pedagogical training. Improving attention and responsiveness to students' ideas while teaching is challenging, but can enable the instructor to more effectively enact student-centered instruction. Supporting GIs' learning to notice important features of classroom interactions may aid reform efforts to have instructors center their instruction around students, and in particular, their deep, authentic scientific thinking about content and practice.

Paper ID: 53

To cope or not to cope? How Biology graduate teaching assistants (GTAs) cope with teaching and research anxieties

Miranda Chen (University of Tennessee, Knoxville)*; Beth Schussler ("University of Tennessee, Knoxville")

Graduate students report increased levels of anxiety, affecting their overall mental health and attrition in graduate programs. In the United States, one in three graduate students report being depressed, a rate six times higher than the general public. Yet we are only beginning to understand what causes graduate student anxiety and potential coping strategies. Coping is defined as an individual's behavioral response(s) to external stressors, often with the objective to reduce or tolerate the stress. According to Skinner et al.'s (2003) coping framework, these strategies may be categorized as adaptive or maladaptive. Adaptive coping advances individuals through problems and supports their well-being (e.g. practicing for a presentation, seeking social support); maladaptive coping prevents stressors or problems from being resolved and can exacerbate threats to well-being (e.g. avoiding writing tasks, social withdrawal). Informed by previously identified themes related to Biology Graduate Teaching Assistant (GTA) teaching and research anxiety, we asked how these students cope with each type of anxiety. As the first qualitative study examining Biology GTA coping, identification of these coping strategies can inform how to better support the mental health of graduate students. For this qualitative study, we interviewed 23 Biology GTAs at a research-intensive southern university in Fall 2016 to probe coping strategies related to their teaching and research anxiety. GTAs explained things that made them anxious related to teaching and research, and for each, indicated how they coped with the anxiety. Each interview was ~60-90 minutes long and the participants were mostly experienced teachers, female, and Caucasian from across four Biology units. Our findings are framed by Skinner et al. (2003), who outlined 12 major families of coping. We used the 12 major families of coping as codes to guide the analysis of the interview transcripts, identifying and categorizing each coping strategy mentioned by the GTA for each anxiety. Of the 12 coping families, 9 families were identified for teaching anxiety, and 8 for research anxiety. Interviews revealed that the most prevalent teaching anxiety for Biology GTAs was related to the impact on others, e.g., how the GTA's actions or behaviors may impact students. To cope with teaching anxiety, GTAs often indicated coping through problem-solving (91% of participants) and information-seeking (83%). Problem-solving attempts to resolve the stressor, through planning and/or enacting a potential solution, while information-seeking attempts to learn more about the stressor. Research anxiety was most often related to lack of control or self-efficacy for specific research tasks. To cope with research anxiety, GTA interviews revealed support-seeking (96%) and information-seeking (87%) as the most prevalent coping strategies. Support-seeking relies on social resources such as colleagues or friends to help individuals find comfort despite the stressor. Interestingly, the top coping mechanisms identified in this study were considered adaptive, although maladaptive strategies were also present in the data set. In understanding how GTAs cope with teaching and research anxieties, this work can inform future professional development or intervention activities for Biology GTAs at our institution and encourage greater awareness and dialogue about the impacts of GTA mental health issues in academia.

Student Thinking, Reasoning, & Metacognition

Paper ID: 112

How do instructors support students' engagement in authentic scientific practices? A study of real-time dialog in a model-based inquiry laboratory course

Alexandra Cooper (University of Arizona)*; Molly S. Bolger (University of Arizona)

Inquiry-based classrooms give students a unique opportunity to practice ways of thinking that are often absent in laboratory courses. However, more research is needed to understand how instructors may best support students in inquiry classrooms. These environments include the need for students and instructors to navigate scientific uncertainty. Just as undergraduate students who join a research group require the guidance of a mentor, guidance is also necessary for students who conduct authentic investigations in a classroom setting. Existing literature provides insights into how instructors can support students in science classrooms, but these findings are often described in a domain-general way and with few examples in undergraduate classrooms. Given the current interest in rethinking undergraduate biology classrooms, we conducted a study to explore ways that instructors support students during these open-ended tasks. This study was conducted in the context of the development of AIM-Bio curriculum (Authentic Inquiry through Modeling in Biology), an introductory biology laboratory course in which students develop, test, and revise models to explain biological phenomena. This setting was chosen because a previous study demonstrated that students in the AIM-Bio curriculum benefited from conducting their own inquiries. Specifically, students gained a sense of project ownership, identity as a scientist, an understanding of the nature of science, and scientific skills. Our research focused on the instruction carried out by designers of AIM-Bio in the semesters during which they developed and tested this curriculum. Qualitative coding analysis was conducted on audio recordings of instructors supporting students at different points in the modeling cycle: creating models, experimental design, and revising models. Two researchers read and discussed transcripts of instructors in different AIM-Bio units. This process revealed that there were themes in how instructors supported students. These themes were used in an iterative process of coding scheme development, which included independent coding of episodes by two researchers and discussion until consensus was reached. Analysis revealed that instructors provided significant guidance in helping students use models to organize their ideas. They did this by pushing them to visualize their thinking, to use models to construct explanations, to connect evidence to their model, and to use models as thinking and communication tools. Additionally, instructors challenged students to further develop their own ideas by encouraging them to do the following: reason about alternatives, evaluate alignment between a proposed hypothesis and test, reason forward to expected results, and consider the implications of experimental results from peers. Results also pointed to the importance of instructors responding dynamically to the unique demands students face in each stage of the modeling cycle. In the future, our intention is to use these findings to help prepare novice instructors to teach this

course and to guide research on how novice instructors learn to support students in an inquiry setting. This work is supported by a grant from the National Science Foundation (DUE-1625015)

Paper ID: 150

Student Thinking About Metabolic Pathway Dynamics and Regulation

Kush Bhatia (University of Georgia)*; Austin Stack (University of Georgia); Cheryl Sensibaugh (University of Georgia); Paula P. Lemons (University of Georgia)

In an effort to improve the effectiveness of biochemistry instruction, we sought to identify undergraduate students' ideas about biochemical pathway dynamics and regulation, a key concept in biochemistry. Understanding student thinking about metabolic pathways will enable the design of instructional materials and refined pedagogies that build on students' prior knowledge and difficulties. This work is guided by the Knowledge-Learning-Instruction framework, which describes the importance of aligning assessment and instruction with knowledge students are to learn. Using this framework, we addressed the following research question: What knowledge do undergraduate students utilize while solving problems about metabolic pathways? We probed student thinking using well-defined problems about metabolic pathways that are unfamiliar to students. We conducted think-aloud interviews with 22 beginning biology and 22 intermediate biochemistry students. In these interviews, students solved several well-defined metabolic pathway problems and were prompted to describe the knowledge and strategies utilized during the solution process. We analyzed think-aloud interviews using qualitative content analysis and compared the prevalence of student interpretations, ideas, and strategies between introductory biology and biochemistry students. Prior research from another group identified metabolic pathway dynamics and regulation as one of five transformative concepts in biochemistry and further defined key pieces of knowledge that comprise the concept. Using this model, we categorized students' ideas into eight main topics: reversibility, free energy, reaction coupling, metabolic compound effects, understanding of branch points, discussion of flux, enzyme characteristics, and enzyme activity and regulation. We also found student visual literacy played a major factor in student concepts and processes used. We found that beginning and intermediate students frequently recognize reaction reversibility due to the use of arrows in the problems, but beginning students lack understanding about the reasons behind reversibility. Beginning and intermediate students accurately predicted the impact of changes in the pathways on the final products, even if they held naive ideas about intermediates in the pathway or what was occurring due to feedback inhibition. This included the inability to recognize images representative of negative feedback. Many beginning students held the naive idea that negative feedback arrows represents a compound being "recycled" or "reused." Some beginning students were able to recognize the key properties of enzymes. Yet many students at both levels could not describe causal details of the enzyme-facilitated processes. In summary, students may arrive at correct final answers, but their lack of mechanistic understanding limits their ability to make sophisticated predictions about pathway dynamics. This study adds to the literature base in biology education by identifying particular difficulties encountered by beginning biology and intermediate biochemistry students about metabolic pathway dynamics and regulation. These ideas will serve as targets for the development of instructional materials and pedagogies that will be empirically tested through further research.

Paper ID: 226

What did they learn? Investigating student understandings after clicker discussions

Brian Couch (University of Nebraska-Lincoln)*; Kati Brazeal ("University of Nebraska, Lincoln"); Emily Bremers (University of Nebraska-Lincoln); Cal Koch (University of Nebraska-Lincoln); Anya Morozov (University of Nebraska-Lincoln)

Clickers are handheld devices that enable instructors to pose questions and collect answers from students in real-time. Researchers suggest that clickers be incorporated as part of a series of steps that comprise the Peer Instruction pedagogy. In this sequence, students are first presented with a question and allowed to think and vote individually. For challenging questions, the instructor gives students an additional opportunity to discuss answers with their peers and re-vote. The instructor can then provide feedback by explaining the rationale behind the answers or asking students to share their reasoning with the broader class. Numerous studies have provided evidence supporting the idea that clickers with peer

discussion promotes learning, although further work is needed to understand how well this learning persists to later times. In the current study, we sought to investigate the extent to which students are able to explain correct reasoning after clicker discussions and whether improvements seen during in-class clicker polling are maintained on later exams. We conducted a study with students (n=347) in two large sections of introductory molecular biology at a large, public, research institution. After completing clicker questions in class, we asked students to complete an out-of-class homework assignment in which they were redisplayed the clicker question and answers and prompted to explain the rationale for each answer in writing. We also posed isomorphic questions on later exams related to each of these clicker questions. To analyze student explanations, we developed a coding rubric that captures the degree to which each response demonstrated understanding of the targeted concept. We refined this rubric, achieved high interrater reliability, and coded roughly 10,000 unique responses. We conducted logistic regression analyses to determine the extent to which student clicker vote patterns and subsequent reasoning can predict exam performance. Our findings suggest that higher performing students benefited more from clickers, maintaining their performance levels from in-class to the exam. Conversely, lower performing students benefit less, evidenced by a sharp drop from in-class performance levels to the exam. Furthermore, we found that the act of explaining their rationale for a clicker question in writing provides a modest boost in later exam performance. This work provides important insights into who clicker questions benefit in the longer term and why certain students do not benefit as much as others. It has particular relevance for instructors who utilize group work or struggle to engage the full range of students in learning activities. Discussion will focus more broadly on the need for additional research and instructional support to ensure that active learning benefits all students.

Paper ID: 25

Targeting mis-strategies in scientific reasoning leads to increased ability and performance in STEM

Jamie L Jensen (Brigham Young University)*; Jenica Woolley (Brigham Young University); Shelby Kurtz (Brigham Young University)

One of the main reasons for attrition from STEM majors is a lack of academic self-confidence resulting from poor performance in the introductory courses of the major. Scientific process and reasoning skills (SPARS) have been linked to success in STEM courses. However, how to teach SPARS, and whether implicit or explicit approaches are more effective has remained controversial in the literature. The purpose of our study was to test explicit teaching of SPARS as a way to increase acadmic performance. We have designed and tested an online training module, the Building Expertise in STem app (BEST App) that successfully and explicitly teaches these skills by focusing training materials on documented common mis-strategies in scientific reasoning. The first phase of the research was to identify the common mis-strategies. This was done through a series of testing, interviewing, and retesting of students. Results of this phase have already been published. Using these mis-strategies, we developed a question bank for each SPARS category that contained multiple choice questions with distractors patterned after the mis-strategies. We created video tutorials for each mis-strategy and embedded them into the ‘wrong-answer’ feedback in the modules. The program was placed into the Canvas online learning system such that students enter the course and must complete nine modules (one for each SPARS category) with a 90% or better. To complete each module, the student is presented with 10 questions from the question bank. Once they complete the quiz, they are given right/wrong feedback along with suggested tutorials. The student has unlimited attempts to pass the module by getting 9 of the 10 questions correct. The online module was administered to students in an introductory majors biology course. Students could choose to participate for extra credit. Scores were compared between participants and non-participants and between a control section of the course from a subsequent semester where the module was not offered. Students were given two weeks to complete the online modules. Results show that students who participated in the program gained an average of 5.29 points on Lawson’s Classroom Test of Scientific Reasoning (LCTSR), a 24-point reasoning scale. This is a statistically significant gain compared to students in the control section ($H(1) = 66.00$, $p < .001$). Importantly, this increase in scientific reasoning transferred to better performance in class. Controlling for prior reasoning ability and base performance in the course, a multiple linear regression showed a 4.2% increasing in average exam performance ($p<.001$) and a 5.4% (or half letter grade) increase in final grades ($p<.001$) in an introductory STEM course (Biology) for those who participated in the BEST App.

Implications of this research are that explicit teaching of scientific reasoning ability can increase ability as well as lead to higher achievement in the course. It is predicted that this higher achievement will lead to greater academic self-confidence and higher retention in STEM majors.

Paper ID: 42

Development of metacognition and biological understanding from introductory students to seniors: A longitudinal study.

Jaime L Sabel (University of Memphis)*

Students need feedback on their learning progress in order to integrate individual concepts into complex systems and reach robust understanding. However, it is difficult in large, undergraduate classes for instructors to provide feedback that is frequent and directed enough to help individual students in this process. Instructors can support students to generate their own feedback by providing them with scaffolds to support them in engaging in self-regulated learning by monitoring their own work, generating internal feedback, and using that feedback to adjust their learning strategies. Our previous work examined scaffolds for engaging undergraduate students in self-regulated learning and metacognition. We found that the scaffolds were useful to help students enhance their understanding and engage in metacognition, and that instruction on scaffold was an important part of maximizing their use and benefit for students. In the current study, we examined how these scaffolds support students as they progress through each of the five required core courses for the biology major: General Biology I, General Biology II, Cell Biology, Genetics, and Evolution. Each of the five courses is a prerequisite for the next, so students take them in order. Within this longitudinal study, we asked the following research questions: 1. How does students' engagement in metacognition change as they progress through a biology major? 2. What factors contribute to students' metacognition development? 3. To what extent can we influence earlier metacognition development using particular scaffolds? We recruited all students in each of these core courses over multiple semesters and asked them to complete two surveys: one at the beginning of the semester and one at the end. These surveys consisted of demographic questions, questions on how they study and how they know they have reached understanding, and the Metacognitive Awareness Inventory (MAI). We performed statistical analysis on the metacognitive score generated from each survey and grades collected at the end of each semester and qualitative trend analysis on the open-ended survey questions. We also randomly selected a subset of students from each class and invited them to interviews. The interviews allowed us to better understand how each student viewed studying and understanding, and how they used reflection questions that were provided as a scaffold for metacognition. Importantly, we were able to interview some students repeatedly through each of the five core courses. Qualitative analysis included an examination of how students are using scaffolds, how they are engaging in metacognition, how both may affect their performance in the individual course, how their metacognition develops as they progress through the major, and how early engagement with these scaffolds may support their development as biology majors. We also developed case studies for each of the students we were able to repeatedly interview over the course of the major. We found stark differences in metacognition engagement between introductory students and seniors. We also found interesting patterns of development among those students were following through multiple semesters. We will present both quantitative and qualitative results at the conference. Results from this study will help to structure how future scaffolds and instructional tools are created and utilized to best support students in learning and understanding biological concepts.

Paper ID: 199

Unwrapping Exam Wrappers in Introductory Biology

Joel Ledford (UC Davis)*; Geoffrey Benn (UC Davis); Susan Keen (UC Davis); Katherine Ransom (UC Davis)

Exam wrappers are a widely advocated strategy for promoting metacognition (Ambrose, 2010). They are easy to use and, in some studies, have been shown to improve performance (Achacoso, 2004) and metacognition (Lovett, 2013). However, recent work shows that performance benefits may be overestimated as no or minimal gains have been reported for some courses (Craig et al, 2016; Soicher and Gurung, 2017; Gezer-Templeton et. al, 2017). Review of published work indicates that most studies share limitations in experimental design (minimal controls), methods (non-random sampling), and low numbers (n<100) of participants. Although exam wrapper formats vary, most include a similar set of questions intended to guide students in evaluating where they performed best or worst, types of mistakes made, and possible adjustments for the next exam. Here we assess the effect of a deeper (more metacognitive) exam wrapper on student performance in a high-enrollment introductory biology course. Our exam wrapper incorporates the typical set of questions but is novel in that we increased the depth of questions related to study strategies and added questions on self-care. We hypothesize that completion of our exam wrapper will result in performance gains and positive trends in study strategies and self-care. Students (n=697) were randomly assigned to treatment and control groups. The treatment group received an exam wrapper focused on deeper analysis of performance, study strategies, and self-care. The control group received a minimalist exam wrapper limited to questions on raw performance. 88% of enrolled students consented to be part of the study (n=619) and Chi-square tests show that treatment and control groups were equally distributed across GPA and a standard set of demographic characteristics. Analysis of the data by ANOVA and linear regression show no significant difference in performance between the treatment and control groups when controlling for GPA and standard demographic characteristics. These results are consistent across multiple examinations and within GPA-delimited quartiles. Analysis of treatment group responses show no significant changes in study strategies or self-care activities, with the exception of a decline in rest and diet quality prior to the course final exam. We argue that our results, coupled with outcomes from recent studies, indicate that the overall effectiveness of exam wrappers needs to be more broadly examined.

Student Learning, Perceptions, & Identity Related to Research/ers

Paper ID: 192

Making LEAPS in Introductory Biology Lab: Development and Course Outcomes of Laboratories Engaging Students in the Application and Process of Science

Sue Ellen DeChenne-Peters (Georgia Southern University)*; Jennifer Broft Bailey (Georgia Southern University); Sherri Cannon (Georgia Southern University); Geneva DeMars (Georgia Southern University); Melanie Link-Perez (Oregon State University); Scott Mateer (Georgia Southern University); Traci Ness (Georgia Southern University); Sana Omar (Georgia Southern University)

The goals of laboratory instruction can be diverse including reinforcement of content in the lecture course, development of science process skills, and increased student science motivation. The objective of the Laboratories Engaging Students in the Application and Process of Science project (LEAPS) was to develop and implement a guided research experience in a multi-section, introductory biology course to engage students in scientific practices and prepare them for future programs of study. LEAPS was adapted from a high school curriculum “Discover the Microbes Within! The Wolbachia Project” for an undergraduate level. We measured LEAPS efficacy by analyzing student learning and motivation. In LEAPS, students contribute novel data about the prevalence of the endosymbionic bacterium Wolbachia in the local insect population. Students collect and identify an insect to taxonomic order, examine literature to determine Wolbachia prevalence within that order, and develop a prediction about Wolbachia within their specimen. Students isolate DNA, run PCR, and perform gel electrophoresis to determine if their specimen is infected with Wolbachia. Their PCR product is sequenced and the students use bioinformatics to determine the strain of Wolbachia in their insect. We used a data-driven process for six years to develop the present laboratory course. Student learning was measured using a survey developed by the authors and administered pre-post every semester. In addition, student assessments of learning gains and interest were also collected. Using this information and feedback from the community of instructors, the authors made iterative changes including a focus on scientific literacy in the context of LEAPS, development of a streamlined dichotomous key for insect identification, and expansion of skill development laboratory exercises. We compared the dimensions of LEAPS to course-based undergraduate experiences (CUREs). CURE characteristics include: use of scientific practices, discovery, broader relevance, collaboration, and iteration. CUREs increase student’s analytical skills, content knowledge, technical skills, communication, and collaboration skills. CURE students also show higher project ownership, self-efficacy, motivation in science, science identity, and persistence in science compared to traditional laboratories. LEAPS demonstrate CURE characteristics in their use of scientific

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practices, discovery, and broader relevance, while having some collaboration and no iteration. During the 2018-2019 school year, we collected pre-post survey data to measure student change in content knowledge, analytical skills, self-efficacy, science identity, and sense of scientific community. We also measured students' sense of project ownership at the end of the course. Preliminary paired t-test analyses of 254 student scores from Fall 2018 demonstrate a significant increase in knowledge of molecular biology and experimental techniques (pre=34%, post=64%, $p<0.001$), analytic skills (pre=51%, post=68%, $p<0.001$) and self-efficacy (pre=3.8, post=4.1 out of 5 on a scale of 1=strongly disagree to 5=strongly agree, $p<0.001$). There were no changes in science identity ($p=0.843$) or scientific community values ($p=0.956$). Students felt a sense of project ownership in content and emotion (3.6 each out of 5). These results indicate that LEAPS meet our learning and attitudinal goals. They also suggest that CURE outcomes may not depend on a full CURE model.

Paper ID: 256

How do students learn complex experimental design skills in rich instructional environments?

Susan Hester (University of Arizona)*; Shane Thomas (University of Arizona); Molly S. Bolger (University of Arizona)

Experimentation is at the very heart of biological science. Testing predictions of our explanatory models against reality allows us to move beyond speculation and build knowledge about how the living world works. Effective experimental design requires coordinating conceptual knowledge of a biological system, working knowledge of the available tools, and an understanding of the relationship between the data to be generated and the phenomenon being studied. Engaging in all stages of experimental design therefore provides students the opportunity to practice and develop the types of complex reasoning that are central to how scientific knowledge is built. A large and important body of work describes student struggles with and instructional interventions targeting aspects of experimental design such as control of variables, and accounting for natural variation and measurement error. Before samples are chosen and controls designed, however, one must grapple with the central challenge of how to align the experimental conditions and possible data collected to the hypothesis or model being tested. Recent reports suggest that students are likely to struggle with such alignment and that there is great potential for developing this capability in undergraduate courses. Up until now, however, there has been little focus on how undergraduates approach the task of designing an experiment that is well-aligned with a hypothesis or model, or what skills they draw on when doing so. This is likely because undergraduate courses that give students ownership of the initial stages of experimental design have only become widespread relatively recently. As biology educators continue to develop rich instructional environments that emphasize student-generated scientific explanations, an understanding of how students navigate this complex aspect of experimental design will be increasingly relevant. In light of this, we are investigating student learning about experimental design in the context of an Authentic Inquiry through Modeling in Biology (AIM-Bio) course, an introductory molecular and cellular biology laboratory course in which students iteratively propose, test and revise conceptual explanatory models for novel biological phenomena. We conducted pre-/post-course clinical interviews in which students proposed a model for a novel phenomenon and briefly described an experiment to test a component of their model. Two independent researchers coded student responses for experimental strategy, technical elements, and alignment with the model. Results of this analysis suggest a shift towards improved experimental designs with better alignment to the models. In a subsequent semester, we conducted post-course interviews in which students were asked to describe what was important and what was challenging when designing an experiment. A theme that emerged from students' responses was that they identified alignment to a hypothesis or model as both important and challenging. On the basis of interview responses and data availability, we identified student groups for qualitative case-study analysis of how students engaged in and learned about experimental design in the course using transcripts of classroom audio and student work. Among our initial findings is that the practice of explicitly reasoning forward to predict how results could be used to evaluate a hypothesis aided students' in designing well-aligned experiments. Studies such as this give us insight into how students engage in complex, scientifically authentic learning tasks and have implications for how we design rich instructional environments.

Paper ID: 116

Examining the variations in undergraduates' conceptions of researchers: A phenomenographic study

Austin Zuckerman (University of California, San Diego)*; Stanley M Lo (University of California San Diego)

Undergraduate research experiences play a critical role in training the next generation of scientists; these experiences also increase students' persistence in science and enhance their cognitive and personal development. However, participation in research requires awareness of existing opportunities and an understanding of the cultural norms within the research community. While some studies have identified the various ways in which researchers understand their profession, few studies have directly examined student conceptions of researchers, and even fewer focused on undergraduates. Given that the norms and values of the research community may be unfamiliar to students, especially for first-generation (FG) college students who lack access to the cultural knowledge of research communities, our study examined how undergraduates experience or conceptualize researchers as a profession, using phenomenography as the theoretical framework. Phenomenography describes the qualitatively different ways that individuals experience, understand, or think about the same phenomenon. Within phenomenography, variation theory formalizes the ways of experiencing a phenomenon into an outcome space with specific features (called "aspects") that describe the phenomenon, as well as the "variations" within these aspects that define the experiences. Data were collected from a summer-bridge program aimed at introducing incoming transfer students, who were disproportionately FG (75%), to biological research. To capture a wide range of research experiences, 29 participants were interviewed about two years after the program, near their target graduation date. Participants were asked to give their perception of what a successful researcher is and what a researcher specifically does to be successful. Participants were also prompted to indicate whether their conception of researchers had changed and what specific experiences (or "critical incidents") prompted these changes. Data were analyzed through iterative close reading of the interview transcripts using grounded theory, which is divided into three major phases of qualitative coding. In open coding, memos and in vivo codes were generated using participants' own phrases that capture critical meanings of a researcher. In axial coding, specific aspects and variations were identified and organized into an outcome space that describes different conceptions of researchers. In selective coding, data for each aspect and variation were revisited to further refine the definitions in the outcome space. Three conceptions of researchers (Type I, Type II, and Type III) were identified based on variations within the following aspects: research process, interactions with other researchers and broader communities, and scope of contribution. Most participants retrospectively described their initial conceptions of a researcher as simplistic, with little appreciation for the complex methodological processes and extensive collaboration needed to meaningfully contribute to the research community (Type I). However, extensive research experiences had shifted their conceptions. Participants who changed to the Type II conception recognize research as a defined process that requires extensive collaboration and contribution within the research community. The Type III conception includes and expands upon Type II by viewing research as not only a defined but also iterative process that is used to interact with and contribute to both the research community and a broader society. The disconnection between the initially simplistic conception of researchers (Type I) and the more mature conceptions (Types II and III) indicates the conflicting expectations that students with limited exposure to research may have prior to their own research experiences. Overall, our findings support the need for broad-scale institutional interventions that engage students in research and provide guidance for transition into research.

Paper ID: 224

Do self-selected student roles impact group dynamics and affect learning?

Alex R Paine (University of Colorado)*

Students find mastery of science process skills such as analyzing and evaluating data to be challenging. Since previous studies have shown group work and peer discussion have positive impacts on student learning, we are investigating how peer discussion may facilitate the acquisition of these skills. We have chosen to explore the individual roles students choose naturally when asked to engage in group discussions, and to characterize these roles and overall style of each group's interactions. In addition, we

will measure whether these roles influence individual learning and the learning of others within each group. In addition to developing a qualitative description of student roles, we hypothesis that with regard to using reasoning, 1)students who provide reasoning during group discussions will make larger gains than those who take on more passive roles, 2)students involved in discussions high in reasoning will have larger gains than those in discussions lacking reasoning and 3)students engaged in more interactive and collaborative group discussions will have larger gains than those in less collaborative groups. We studied 121 students in a first-year Course-based Undergraduate Research Experience (CURE)lab, in which students worked to screen small molecule libraries for novel antibiotics. Over the course of the semester, students engaged in four in-class group assignments focusing on analyzing data similar to their current projects. Thirty-four groups of students agreed to audio record their group discussions, resulting in a data set of 93 total recordings. To measure science skills, we used a subset of 14 questions on data analysis from the Test of Scientific Literacy Skills(TOSLS), pre and post. To measure changes in students' ability to use reasoning, we wrote an open-ended question similar to those used for in-class assignments, and evaluated student use of reasoning both pre and post. The majority of our analysis focused on the individual roles students chose to take during these group assignments. We examined the transcripts from each recorded assignment and used emergent coding to identify the contributions that students made to the discussion (such as analyzing data, using reasoning, and asking questions). Based on these, we created profiles to describe the students' chosen roles. We also quantified the times, turns, and percent participation of each student during discussions. Finally, we characterized the overall style of the group discussion as interactive, constructive, or active. Students showed a significant improvement in data analysis, as measured by the TOSLS (73% avg +/-18% pre - 80% avg +/-14% post). Preliminary characterization of students reasoning ability showed an overall increase in the amount of reasoning used during data analysis: 30% of students went from using no reasoning pre to using at least a single statement of reasoning post. Sixty five percent of students used at least one piece of reasoning both pre and post; we have not yet characterized the quality or overall number of these statements. For student roles during discussion, we have established 14 individual profiles (IRR 79%); these were defined by types of contributions. For example, a student who contributes by analyzing and interpreting data is characterized as an Analyst, while a student who makes multiple claims with reasoning statements is characterized as a Reasoner. In terms of group dynamics, our preliminary assessment of a subset of the data shows that the majority of groups interact in either a constructive or interactive manner, indicative of collaborative learning among students within the group. We will further analyze this data to determine how reasoning and data analysis changed over time, how students interacted with each other in groups, and whether these interactions predicted their performance on the post-assessments and in the course overall.

Paper ID: 10

Augmented Reality as an Effective and Accessible Tool for Teaching Macromolecular Structure and Function

Rou-Jia Sung (Carleton College)*; Andrew Wilson (Carleton College); Stanley Lo (UCSD); Jane Liu (Pomona College)

Using 2-dimensional (2D) images in order to teach about 3-dimensional (3D) molecules inherently limits the ability of students to grasp key visuospatial elements of 3D macromolecular structures, including depth perception and a sense of scale. The lack of simple, accessible, and easy to use teaching tools for visualizing and interacting with (i.e., rotating, translating, zooming) 3D virtual representations of macromolecular structure also continues to be a limitation for biochemistry instructors interested in incorporating more 3D visualizations in their classrooms. To address this current gap in available instructional tools, we developed BiochemAR, a novel app utilizing augmented (AR) technology to easily visualize and manipulate macromolecular structure. The app was implemented over two consecutive years in a junior/senior level biochemistry course as part of two different class discussions: one on the structure and function of the potassium channel and one on catalysis by monomeric G-proteins. Student attitudes were assessed using a pre/post survey analysis. Analysis of student responses following the potassium channel discussion indicate that after using the app, student responses to questions on potassium channel function reflected increased use of terms such as "orientation, pointing, positioning", suggesting an increase in spatial awareness. Significant increases in student confidence towards visualizing the 3D structures of biological macromolecules were also noted. Moreover, in terms of usability, students also found the app significantly easier to use than other visualization software they had previously been exposed to. Overall the results suggest that use of augmented reality technology has significant potential to improve user (student and instructor) accessibility to virtual 3D models of macromolecular structure.

Paper ID: 97

Scrub Envy: Investigating Sources of Self-efficacy and Identity in Anatomy and Physiology Students

Emily Royse (University of Northern Colorado)*; Jessie Sutton (University of Northern Colorado); Emily Holt (University of Northern Colorado); Melanie Peffer (University of Northern Colorado)

Anatomy and Physiology (A&P) courses are foundational biology prerequisites for students wishing to enter allied health fields such as nursing, nutrition, and exercise science; yet, A&P courses historically have high failure rates, requiring students to retake the class before progressing in their academic programs. Little research exists to explain this phenomenon, but Social Cognitive Theory frames how affective factors can impact student learning and academic achievement. Two such factors, self-efficacy and science identity, are understudied in A&P classrooms but can be predictive of academic persistence, or a student's progression through an academic program, in other contexts. Using an explanatory mixed methods design, we addressed the research questions: (1) how do science identity, self-efficacy, and demographic factors best predict course outcomes for students enrolled in A&P courses; (2) what differences in student affect exist between re-takers (i.e. students retaking the course) and first-timers (i.e. students taking the course for the first time); and (3) what experiences inform a student's decision to retake A&P and illustrate how they define science identity and contextualize their own academic and professional goals? I surveyed 84 undergraduate A&P students using validated Likert-style metrics to assess self-efficacy and science identity. Of those participants, five re-takers were randomly selected from the 28 self-reported re-takers and later completed interviews about their affective experiences in A&P courses; the interviews were audio-recorded, transcribed, and thematically coded by two members of the research team. Hierarchical linear regression indicated that while demographic factors alone are not predictive of course grade, science identity and having completed an introductory biology course both contribute significantly to predicting a student's final grade in A&P. However, Mann-Whitney U tests found no significant differences in self-efficacy or science identity between re-takers versus first-timers. Interviews with the re-takers revealed salient themes of valuing their academic communities and strong identification as "biology people," along with fierce anticipation of and identification with allied health careers. Additionally, interview participants often identified external instructor factors, such as accessibility or engagement with students, as important to their success or failure in their current and previous attempts at passing the course. Overall, these results do not reveal differences in affect between re-takers and first-timers, but do provide insight about a link between science identity and performance in A&P classrooms. The significance of completing a biology course prior to enrolling in A&P suggests that the additional preparation may help students succeed in A&P, speaking to both their previous persistence through a program and the persistence through a challenging course. This research encourages future lines of inquiry about supporting student affect in classrooms, highlights potential avenues of collaboration between instructors and students, and endorses how program-wide alterations to prerequisites can help students persist and prepare effectively for future coursework, all to promote success in these gateway courses.

Saturday morning

Mentoring & Career Development

Paper ID: 70

Diagnosing differences in what undergraduates in a fully online and in an in-person biology degree program know and do regarding medical school admission

Logan E Gin (Arizona State University)*; Katelyn M Cooper (Arizona State University); Sara E Brownell (Arizona State University)

Fully online bachelor's degree programs are being increasingly adopted by universities because of the benefits that they can provide to both students and institutions. Specifically, online degrees are championed as a way to broaden access to college. However, will students be prepared for the next step of their career paths after completing their bachelor's degree online? Biology undergraduates often want to become medical doctors, but no studies have explored whether students in a fully online biology degree program are being prepared to be admitted to medical school. In this study, our research questions were: 1) to what extent do students enrolled in a fully online undergraduate biology degree program plan to become medical doctors, 2) are there differences in online and in-person premed students' knowledge of what medical schools consider in admissions, 3) to what extent do online and in-person premed students plan to engage in experiences that will make them competitive for medical school, and 4) to what extent are there differences in the relationships that online and in-person premed students form with others who can give them advice about medical school? Using the theoretical framework of social capital, we predicted that in-person students would develop more social connections, which would lead to them becoming more knowledgeable about medical school admissions. We iteratively developed an open-ended and closed-ended survey that probed students about their career goals and plans to pursue careers as medical doctors, their knowledge of premedical admission criteria, their plans to engage in activities that will allow them to develop and demonstrate competencies for medical school admissions, and who they could go to for help or advice about their future career goal. We used think aloud interviews to refine the questions and we piloted the questions in Spring 2018. We modified the survey and administered the final version to introductory biology students at one institution who were pursuing Bachelor of Science degrees in Biological Sciences either in an online (n = 174) or an in-person (n = 440) program in Fall 2018. The most prevalent career goal for both in-person and online biology students was a medical doctor. Using independent-samples t tests, we found that online students were more confident in their intentions to become doctors than their in-person peers. To determine what medical school admissions committees consider when admitting students into medical schools, we reviewed the websites of 50 randomly selected U.S. M.D.-granting medical schools. When students were asked what medical schools consider when admitting students into medical school, we found that online students named fewer of these criteria. Additionally, using chi-square tests of independence, we found that online premed students were also less likely to plan to become involved in premedical activities such as undergraduate research. Finally, compared to in-person students, fewer online students were able to name science students, academic advisors, and faculty members whom they could talk with about pursuing a career in medicine. This work highlights knowledge gaps between students enrolled in a fully online biology degree and an in-person biology degree that are important for developers of online biology degree programs to understand and rectify to better prepare online biology students for admission to medical school.

Paper ID: 204

"thank u, next": Characterizing negative mentoring in undergraduate life science research

Trevor T Tuma (University of Georgia)*; Lisa B Limeri (University of Georgia); Muhammad Zaka Asif (University of Georgia); Benjamin Bridges (University of Georgia); David Esparza (University of Texas at El Paso); Daquan Sanders (University of Georgia); Alexander Morrison (University of Georgia); Pallavi Rao (University of Georgia); Joseph Harsh (James Madison University); Adam Maltese (Indiana University); Erin Dolan (University of Georgia)

Undergraduate research experiences have been championed for promoting undergraduates' personal and professional growth and development. Mentoring by a more experienced individual (e.g., a faculty member, postdoctoral researcher, graduate student) is considered to be an integral part of undergraduate research, as effective mentorship maximizes the benefits undergraduates realize from participating in research. However, mentoring, like any other interpersonal interaction, can also have negative elements. There has been little, if any, empirical investigation to identify and describe the negative mentoring that undergraduates can experience during their research experiences, even though prior research on

mentoring in workplace settings suggests that negative mentoring experiences are common. In fact, negative mentoring in the workplace has been shown to be more detrimental than having no mentor at all. Understanding the negative mentoring that undergraduate researchers can experience is critical given the widespread recommendations to involve undergraduate STEM majors in research. Furthermore, undergraduate research experiences are pivotal choice points for students, especially students from under-represented or under-served backgrounds, regarding whether to continue to pursue research-related careers or move on to exploring other career options. Here, we report the results of our interview-based phenomenological study to define and characterize the construct of negative mentoring in undergraduate life science research. We collected and analyzed the qualitative accounts of negative mentoring experienced by a strategically-selected sample of undergraduate life science researchers (n=33) experiences with negative mentoring. Using standard deductive and inductive content analysis, we analyzed their responses using prior frameworks of negative mentoring in the workplace and from research on abusive supervision and workplace incivility. Undergraduate researchers in our study reported 19 forms of negative mentoring from their mentors that we classified as either actively harmful behaviors or as the absence of positive mentoring behaviors. Undergraduates perceived that these forms of negative mentoring were detrimental to their psychosocial and vocational development in different ways. Undergraduates reported cross-cutting forms of negative mentoring, such as mentor absenteeism, which ranged from benign neglect (absence of positive) to abandonment (actively harmful). Undergraduates also reported experiencing binds and unclear expectations, which they perceived as compromising both their vocational and psychosocial development. Our results suggest that there are commonalities between the negative mentoring experienced by undergraduate researchers and the negative mentoring that employees experience in the workplace. Our findings also show that undergraduates experience forms of negative mentoring that are unique to their stage of development and the context of academic research. To our knowledge, this is the first study to systematically identify and characterize negative mentoring in undergraduate research and to yield preliminary insight into its impacts. We are now using these results to develop a quantitative measure to study the prevalence and impacts of negative mentoring in undergraduate research.

Paper ID: 121

The Academic Career Readiness Assessment: Clarifying training expectations for future faculty

Laurence Clement (University of California, San Francisco)*; Jennie Dorman (University of California, San Francisco); Richard McGee (Northwestern University)

The lack of diversity of the STEM faculty body is a persistent issue that can have a significant impact on the retention and success of diverse students at the undergraduate level. There is some evidence that, to improve retention and success of future faculty from under-represented backgrounds, interventions should focus primarily on the transition from trainee to faculty. In undergraduate education, developing clear and transparent learning goals and assessment methods has been recommended to improve the retention and success of URM and female students, yet, these practices have been slow to translate to graduate and postdoctoral training. Therefore, one step to improve retention and success of trainees of diverse backgrounds would be to design tools that would help trainees develop an understanding of the training goals that future faculty are expected to attain through their training, and assess their progress towards these goals. In this study, we aimed to develop and validate a framework that would reflect the hiring practices of life science faculty hiring committees at U.S. institutions. We used a mixed-methods approach to develop and validate the Academic Career Readiness Assessment (ACRA). In a first qualitative wave, we first tested face validity of the instrument with career and professional development experts, followed by qualitative interviews with 18 life science faculty members who had hiring experience at 20 different institutions. To ensure that this framework was inclusive of a majority of tenure-track faculty careers, we sampled a wide range of institutions which were categorized using the basic classification of the 2015 Carnegie Classification of Higher Education: research-intensive institutions (R: R1 and R2 Institutions), research and teaching-focused institutions (RT: R3, M1, M2, Baccalaureate Institutions), and teaching-only institutions (T: Associate's Colleges). We then determined the construct validity and discriminatory power of the instrument through a quantitative study with R1 trainees. The resulting ACRA framework includes 14 qualifications, or "scales," each with 5 levels of mastery. For each category of institution, the ACRA identifies the qualifications that are significant contributors to hiring decisions as

well as the minimum mastery level required for this qualification to obtain a faculty position. Our findings show that R institutions in our sample hire candidates exclusively on demonstrated research accomplishments and research potential, and that strong letters of recommendations are necessary to secure a position. In contrast, RT institutions require some teaching experience and a demonstration of teaching potential and evidence-based practices, with productive mentoring experiences and research plans tailored to the student population and resources of that institution. Disciplinary fit and collegiality are primordial at both RT and T institutions. In addition to requiring a significant amount of teaching experience with community college students, T institutions have stringent requirements when it comes to the candidate's commitment and ability to serve diverse students populations, and prioritize these skills in their hiring decisions. We found that, except for the "recommendations" qualification, the ACRA's R scales (publications, research vision and strategy, research independence, funding plan) had the power to discriminate between trainees of different levels of preparation for faculty positions (i.e. trainee status: graduate student or postdoctoral scholar). Trainees' perceived readiness for a faculty position was also a strong predictor of scores on all five R scales. However, we found no positive correlation between trainee status and any other RT or T qualification. In fact, we found negative correlations between teaching experience score and perceived readiness, as well as between teaching potential score and trainee status. Interestingly, female trainees were twice as likely to score one point higher on the teaching potential scale than male trainees. Not surprisingly, the commitment to diversity score was only predicted by URM status. The implications of these results are significant for the diversification of the academic pipeline. First, the ACRA framework provides some transparency to the faculty hiring process in the life sciences for trainees, with the hope of improving equity when it comes to accessing information about expectations of the graduate and postdoctoral training for future faculty. Second, the findings of the study highlight a prioritization of research skills over teaching and mentoring skills, and over the candidate's ability to support diversity, in the R1 faculty hiring process as well as in the future faculty training process. Long-term, these decisions can have significant impacts on the retention and success of URM undergraduate, graduate and postdoctoral students in the life sciences.

Paper ID: 24

Dreams clarify, but strategies don't increase: Exploring the future work selves of lower division and upper division students

Julie F Charbonnier (Florida International University)*; Dania Hernandez (Florida International University); Lisa A Corwin (University of Colorado Boulder); Sarah L Eddy (Florida International University)

Students increasingly enroll in higher education institutions as a pathway to employment as a growing number of entry-level positions require college degrees. Despite this shift in the role of higher education, little research has been done to understand how college influences students' preparation for future careers. Our research is an initial exploration into how undergraduate biology students envision their futures at work, how they plan to make their vision a reality, and how these variables change over their college career. We predict that students entering college will have less elaborate visions of their future careers and knowledge of fewer strategies to help them achieve these visions than upper division students who have experienced 3-4 years of undergraduate curriculum in biology. To address these questions, we use the framework of future possible selves. Future possible selves act as personalized and motivating goals where discrepancies between the current and future self are thought to induce changes in behaviors. Previous research in the vocational literature with children and graduate students has found that salient and vivid future work selves that are linked to concrete strategies are the most motivating, since they act as a detailed road maps. We conducted a cross-sectional study on undergraduate biology majors at an R1 Hispanic serving institution in Southern Florida using an online survey (N=234, 50.7% lower division, 49.3% high division). We used previously published survey instruments and asked students to describe their future work self, to rate the salience (accessibility) of their future work self, and list the strategies they plan to use to achieve their goals. To estimate future work self elaboration, we counted the number of words in the future work self narrative and identified students' career goals from their narrative. We counted and coded strategies as either academic-focused or career-focused strategies using existing code books. Our sample was 74% female and 26% male; 68% identified as Hispanic; and 24% of students were first-generation students, 29% of students were from families with some college, and 46.5% of students were continuing generation students. Future work

self salience was high across students groups (mean=4.316, SE=0.948) and did not differ between gender, upper and lower division, or first generation status. Lower division students were on average 15% less elaborate in describing their future than upper division students (ANOVA, $p = 0.01$), and females were 16.6% less elaborate (ANOVA, $p = 0.01$). These differences in future work self elaboration did not translate to difference in the number of strategies students generated: students wrote an average of 2.4 strategies to attain their future work self. Our work suggests that while students may have salient visions of their future, more elaborate and vivid visions are not linked to more strategies. Since we did not find differences in the number of strategies between lower and upper division students, our study highlights that the undergraduate curriculum may need to be more deliberate in the inclusion of strategies for career preparation. Our study adds to the existing literature on how biology undergraduate students envision their future careers in biology and highlights the need for professors, instructors and staff to help students form concrete strategies to attain their future career goals.

Paper ID: 273

Exploring barriers to graduate mentorship of community college students using the Social Cognitive Career Theory

Ally Hunter (University of California, San Francisco)*; Karen Leung (City College of San Francisco); James Lewis (City College of San Francisco); Naledi Saul (University of California, San Francisco); Laurence Clement (University of California, San Francisco)

One of the barriers to the development of community college undergraduate research experiences (CCUREs) cited by the Community College Undergraduate Research Initiative is “the weak connections to external networks of community colleges and science researchers.” Our group has worked to build such a network between a community college bioscience program and R1 laboratories at a local institution. In the last four years, a formal collaboration between the two institutions has led to the development of two parallel curricula, one focused on the development of the research skills of community college interns and the other on the mentoring skills of R1 research mentors, namely graduate students and postdoctoral scholars (R1 trainees). However, the number of R1 trainees who propose to mentor community college interns remains scarce. The purpose of this study was to identify barriers and affordances for 1) community college bioscience student’s decision to engage in a mentored research experience and 2) R1 trainee’s decision to mentor a community college student. Using the Social Cognitive Career Theory (SCCT) as a framework, we investigated the relationships between cognitive (self-efficacy, outcome expectation, goal setting) and contextual variables (science identity, sense of belonging, campus climate, and sense of community). SCCT is a widely-used theoretical framework that predicts that an individual’s success in their career outcomes is predicted by for core cognitive variables (self-efficacy, outcomes expectations, career interests and career goal setting) and these variables are impacted by individual experiences and environment (contextual variables). More recently, the SCCT has been used to model STEM career trajectories and in URM populations contextual variables such as science identity can predict STEM career attainment or persistence. To our knowledge, SCCT has never been used to identify the factors influencing R1 trainees’ decision to become mentors. A mixed-method, sequential explanatory design was used for both study populations. Preliminary findings from the quantitative wave on R1 trainees ($N=35$) shows that there is a positive relationship between the potential mentor’s sense of belonging at the institution and their intention to mentor an intern and there is a positive relationship between their rating of the campus climate and their intention to mentor an intern. We also found a positive relationship between mentor’s sense of belonging at the institution and their expectation that mentoring a student will have positive outcome on their career (outcome expectation). These findings have important implications for improving community college students’ access to R1 institutions because trainees who have negative experiences that diminish their belonging to and opinion of the institution will be less likely to participate in UREs and CCUREs as mentors. Therefore, community college interns may be more likely to be mentored by R1 trainees who perceive their campus as welcoming. These results are indicative of the potential snowball effect of inclusive practices through generations of scientists. To explain the extent and dimension of the significant relationships, a qualitative wave is underway. In addition, quantitative data analysis ($N=57$) of SCCT variables is in progress for the potential mentee’s and will be followed by a qualitative wave.

Equity & Inclusion in Biology Classes

Paper ID: 254

Cultivating Student Success & Persistence by building a community of support: Relationships in Science Education (RiSE)

Jenny McFarland (Edmonds Community College)*; Deann Leoni (Edmonds Community College); Tom Fleming (Edmonds Community College)

A capable and diverse STEM-educated workforce is required to address current national and global issues, to grow economies and ensure future prosperity. Notwithstanding substantial student interest in STEM careers, US college students continue to leave STEM at high rates. "Talking about leaving" and other work identify common factors involved in decisions to leave STEM pathways, including negative or unsuccessful teaching & learning experiences, lack of a sense of belonging and the "weed out" process of STEM gateway courses. Half of students who enter STEM fields start at community colleges (CCs) but only 3% of biology education research papers include CC students. We describe a 7-year "RiSE" (Relationships in Science Education) project, that set out to "cultivate" CC student success & persistence, in contrast to "weeding". RiSE was designed to increase STEM student success and persistence by engaging students and faculty in a community of support. RiSE involved STEM students at a diverse public, CC that serves about 11,000 students per quarter. In 7 years of this project, 415 students joined the opt-in RiSE project. Of those, 71 RiSE students were also supported by S-STEM scholarships. RiSE elements included STEM support staff, a STEM study room (SSR), peer tutors, faculty advisors, transfer assistance & other activities. We used mixed method analysis, including data from student records, surveys, focus groups and RiSE activity participation records. We tested the hypothesis that participation in RiSE contributed to greater student success (grades) and persistence in STEM. Also, we assessed the impact of one project element, the SSR, on STEM students (RiSE & non-RiSE). Finally, we examined STEM faculty participation in RiSE activities and self-reported impact of RiSE on faculty practice and community. When students joined RiSE, the middle-50 percentile had been enrolled at the college a mean of 10 quarters and their mean age was 24.2 years. RiSE students were predominantly economically disadvantaged: 62% disadvantaged for at least one academic quarter and 31% disadvantaged 90 to 100% of quarters enrolled. The mean GPA for students in the top-10 STEM courses at the college (including Math, Chemistry & Physics) from Sept 2011 – June 2017 for RiSE students was higher (2.89) than non-RiSE students (2.76). In further data analysis we used a propensity score model that resulted in a population of 260 non-RiSE students to compare with 294 matched RiSE students. No standardized mean differences between the matched populations exceeded 0.10. The overall quarter to quarter persistence for this matched population was >.85 for RiSE students and > 0.7 for non-RiSE students. In STEM gateway courses, RiSE students had between 1.2x to 3.5x greater likelihood than non-RiSE students of progressing to pre-calculus 2 at every first-attempt pre-calculus 1 grade level. For example, RiSE students with a 2.0 in their first-attempt in pre-calculus 1 had a persistence probability of 0.85, whereas non-RiSE students with 2.0 or 4.0 had persistence probabilities of 0.4 and 0.7, respectively. Similar persistence patterns were observed for other gateway STEM courses (e.g. pre-calculus to calculus, pre-chemistry prep to general chemistry).The median grade for RiSE students in their first-attempt at precalculus 1 was 1.0, and when RiSE students completed pre-calculus 2 their mean grade was 3.5, indistinguishable from non-RiSE student performance. Thus, persistence observed in RiSE students was often persistence despite early failure. RISE students were 59% more likely to report being part of the college's STEM community than non-RISE students. (RiSE n=27, non-RiSE n=105, $p < 0.0001$). RiSE students were no more likely to report a STEM identity than non-RiSE STEM students. We conclude that RiSE students develop a sense of STEM community (albeit not STEM identity) and this may help explain, in part, why these students persisted past initial failure in gateway STEM courses. This conclusion is also supported by RiSE alumni survey results. The SSR was created through RiSE and was and continues to be open to all students and staffed by peer tutors & STEM faculty. We predicted that (1) students who used the SSR would have an increased sense of belonging or STEM identity and that (2) they would be more successful in their courses than students who did not. Data from student surveys, focus groups, SSR usage data and course grades support these predictions. In 2016-17 >200 students per quarter used the SSR in >1000 visits. Survey responses from 104 students revealed the top 4 reasons students used the study room: to get help from peer tutors (n=81), as a place to study (n=72),

help from instructors (n=63) and white board tables (n=61). From Jan 2016-Dec 2017 the median GPA of students in Biology courses who used the study room (n=116) was 3.0 and that of their classmates who did not was 2.5 (n=446) [p = 0.000067]. A goal of RiSE was to increase faculty collaboration and move faculty practice toward more student-centered, evidence based teaching & learning. During this project, there were 37 full-time faculty and about 68 adjunct faculty in 7 STEM departments. At least 30 faculty engaged in RiSE activities that were not required: monthly core team meetings, 2 multi-day summer retreats, monthly STEM education journal club, and year-long STEM faculty colloquia. Data from faculty survey responses and participation show (1) STEM faculty incorporate evidence-based, active learning methods in their teaching including the most common strategies: think-pair-share, problem-solving group work, mobile white boards, and two-stage quizzes or exams and (2) broad participation from a critical mass of faculty from all 7 STEM (AS granting) departments. Qualitative data from faculty interviews, surveys and reflections support the hypothesis that being part of activities centered on STEM student learning and persistence led to evidence-based changes in their teaching, student-centered activities and course content. Our data reflect significant increases in persistence among RiSE students through gateway STEM course progressions for students at greatest educational risk. These data suggest students should be actively supported through early failure to enable persistence in critical STEM sequences, especially in gateway Math and Chemistry courses. Although there is evidence that particular elements of RiSE (e.g. the SSR) positively influenced both student success and faculty practice, we believe that multiple activities have been critical levers for building communities; we believe that several contribute but none alone would be sufficient. These data have helped to successfully sustain some aspects of the RiSE project beyond the external NSF funding, including a staff position, SSR, a faculty STEM education journal club, and a small amount of faculty compensation for coordinating RiSE activities. Supported by NSF 1068399.

Paper ID: 281

First Year Near-Peer Learning Communities Promote Academic Success and Persistence within the Biology Major

Mike Wilton (UCSB)*

Our R1 university is a large, publicly funded Hispanic-Serving Institution (30% underrepresented minority; URM) with ~40% first-generation students. As observed at comparable universities, at our institution URM and first-generation biology majors have a 20% retention differential after the first two years of study when compared to their continuing-generation peers (Hurtado et al., 2012). Furthermore, the cumulative science GPA of URM students (the strongest predictor of student retention over four years identified by logistic regression) is also significantly lower (continuing generation 3.1 vs URM 2.0, p<0.001). Although the biological sciences major is the largest at our institution with >1100 incoming first year students/year approximately 50% of incoming freshmen leave this major within the first two years of study. Further, underrepresented minority and first-generation students leave the major at a disproportionately higher rate approaching 70%. This loss of majors, and in particular URM/first generation students, likely stems from how the major is designed wherein students do not enroll in a biology course until their second year while participating in prerequisite large-enrollment chemistry, math, and physics in their first year; therefore, we sought to design and implement first year seminars that promoted the establishment of near-peer learning communities that discussed topics in metacognition and biology. Using the models established by the Colorado Learning Assistant Program and the UCI EASE program (Alzen et al., 2018; Xu et al., 2018), we structured these 35 student seminars to utilize trained upper-division learning assistant mentors who help students navigate the university environment while inculcating participants with equity-promoting growth mindsets and reflective metacognitive approaches (Claro et al., 2016). Instructed by biology faculty, these courses are offered in parallel to the large-enrollment introductory chemistry, math, and physics series, facilitating the establishment of a more intimate community environment for biology majors. Given the importance of the first two years of study, we analyzed the impact of these seminars on participating students throughout this time period by tracking quantitative metrics (including science course grade, retention in the major) and qualitative methods (surveys, grounded theory interviews) to assess the effectiveness of these courses. Surveys and interviews were conducted within the first week of class, then subsequently at the end of the quarter. Multilevel linear regression analyses of chemistry grade and cumulative science GPA identify participation in the LA-

mentored seminars as a significant variable. Further, enrollment in the seminars are associated with significantly higher chemistry grades when students were matched for incoming demographic and academic variables. Logistic regression reveals that participants in the seminars are retained at a higher rate than their non-participating peers at the end of their second year of study. Initial surveys and focus group interviews suggest participant and non-participant students had comparable levels of awareness of metacognition, employed similar study strategies, and had no preconceptions of what enrollment in the first-year seminars entailed. Subsequent interviews and surveys through the quarter suggest that participants value the mentorship and academic insights provided suggesting that students may feel a greater feeling of belonging to the major. Subsequent analysis promises to further our understanding of how this seminar series is perceived and influences URM, continuing generation, and first-generation student affective domains in STEM at a large-enrollment public institution.

Paper ID: 23

The self-advocacy experiences of students with learning disabilities and ADHD in undergraduate STEM courses

Mariel Pfeifer (University of Georgia)*; Julie Dangremond Stanton (University of Georgia)

Students with disabilities (SWD) are underrepresented in science, technology, engineering, and mathematics (STEM). Previous studies of SWD in college link academic success to self-advocacy. Self-advocacy is acting to access and adjust academic accommodations by communicating accommodations needs to disability resource staff members and, possibly, STEM instructors. One barrier to self-advocacy in college is a shift in the legislation that guides the accommodation process. In high school, faculty and staff are responsible for accommodating SWD. In college, SWD themselves must self-identify and register with the campus disability resource center to access accommodations. At initial accommodation meetings, SWD often establish their academic accommodations with limited experience in college courses. If later in their college career, their accommodations are not sufficient, SWD must then self-advocate to adjust their accommodations. Thus, self-advocacy is an essential skill that few SWD practice until college. Self-advocacy is a crucial factor for the academic success of SWD, but little is known about how self-advocacy is practiced by specific groups of SWD in specific academic disciplines, such as STEM disciplines. We asked the research questions: (1) what are the self-advocacy experiences of students with learning disabilities (SLD) and/or attention-deficit/hyperactivity disorder (ADHD) in undergraduate STEM courses, and (2) how do self-advocacy experiences compare in lecture and active learning STEM courses? The conceptual framework of self-advocacy is comprised of four dimensions, knowledge of self, knowledge of rights, communication, and leadership. We used the self-advocacy framework to develop a semi-structured interview protocol. Semi-structured interviews were conducted with 25 participants from a large research-intensive university in the southeast, who receive academic accommodations for SLD/ADHD and have taken at least one STEM course in college. Interview transcripts were analyzed using content analysis by a diverse research team, including a STEM major who is a student with SLD/ADHD. We found that, contrary to existing research of SWD, many participants report aspects of self-advocacy to be easier to practice in college than in high school. For example, many participants said that arranging to take extended-time exams is easier in college than in high school because there is one clear process to arrange extended-time exams in all their courses. This experience differed from their experience in high school where the process to arrange extended-time tests varied from teacher to teacher. Also, participants describe being more likely to practice self-advocacy in active learning STEM courses compared to traditional lecture STEM courses because they are more comfortable discussing their disability and accommodations with their active learning STEM instructor. Many participants perceived STEM active learning courses to be better for their learning than STEM lecture courses. However, participants report that if an active learning STEM course requires a high amount of pre-reading to prepare for each session, they perceive the pre-reading as a significant barrier to their learning, even if using accommodations, such as alternative-format textbooks. This research provides novel insight into how students with SLD/ADHD practice self-advocacy in STEM courses. We offer evidence-based suggestions for instructors who want to enhance self-advocacy and learning for students with SLD/ADHD in their courses.

Paper ID: 140

From Belief to Reality: Characterization of Sex/Gender Beliefs in Undergraduates

Katherine E Ray King (University of Louisville)*

Despite calls to infuse cultural competencies into all levels of health science curricula, most biology classes adhere to a binary categorization of human sexes. This categorization ignores human variation in sexual development and minimizes the interactions between genes and environment while positioning sex/gender diverse individuals (SGD) as "others". In textbooks, this is often evident in an essentialist portrayal of the sexes, the situation of the male body as the normative form to which others are contrasted and solely procreative view of sexual intercourse. Because cultural competency extends to SGD individuals (who experience health disparities) and essentialist view of sex/gender can affect student learning and the retention of students in STEM, we sought to characterize the beliefs about sex/gender that are present in our university undergraduate population. We approached this as an exploratory project and used new materialist feminism as a theoretical frame. The heterodoxy espoused by new materialists promotes inclusivity in science by welcoming the lived-in bodies of LGBT* people through recognition that sociocultural factors can be written on the body, (and thus influence health). New materialists would describe sex and gender as inseparable. We used a card sorting activity called the Q-sort that combines qualitative and quantitative methods to enable researchers to identify and describe shared ideologies in a population, in this case, beliefs about sex/gender among undergraduate college students. Because the Q-sort is used in characterizing beliefs rather than measuring the prevalence of them, small sample sizes are typical. Thirty-seven students from 22 different undergraduate majors participated in the q-sort. During the q-sort, subjects were shown the research question ("What do you believe about sex and gender?") and asked to sort statements about sex/gender onto a forced-choice distribution. A post-sort interview was conducted to allow participants to expand on their sort. Results of the q-sort revealed many students hold strongly essentialistic beliefs about sex/gender and lack knowledge of biological processes related to sex/gender development. Two factors emerged from the analysis and are described as: "sex trait continuum" and "science says". Participants that represent Factor 1, the "Sex Trait Continuum" (n=18), view sex and gender as distinctly different but related concepts where both are non-binary and exist along a continuum of characteristics. In the interviews, exposure to transgender, intersex, and LGBT* people were cited to justify the beliefs seen in factor 1. Factor 2 "Science Says" (n=14) reflects the prevailing presentation of sex as biological and gender as social. These participants see sex as a binary, biologically determined set of physical characteristics. They rely heavily on the authoritative power of science to justify their beliefs in binary sex categories, while describing an aversion to gendered stereotypes. Individuals associated with both factors displayed a lack of understanding or were uncertain about biological processes involved in human development and the role of hormones in human bodies. Our next project will use the Q-sort results to design an educational intervention that aims to offer a non-binary view of the human body, with a goal of improving the LGBT* cultural competency of undergraduate health science students.

Paper ID: 172

Uncovering the Perspective of Underrepresented Students in an Active Learning Environment

Ashley N Harlow (University of California, Irvine)*; Brian Sato (UC Irvine)

There have been a number of calls to improve the quality of STEM instruction, particularly for first-generation college students and students of color who are leaving STEM disciplines at higher rates than their traditionally-represented peers (PCAST, 2012). One beneficial practice is the implementation of active learning instructional strategies, which have been demonstrated to improve student engagement and learning, particularly for underrepresented students (Haak et al., 2011; Freemen 2014, Eddy and Hogan 2014; Preszler, 2017). While some work has uncovered surface level findings regarding the student perspective of active learning (Braxton et al., 2000; Wawrzynski, 2005; Lea et al., 2010), little is known about the mechanism for why underrepresented students may especially benefit from these practices. This study seeks to answer the following questions: 1. How do first-generation college students from underrepresented backgrounds perceive active learning instructional strategies? 2. What trends about perceptions of active learning instructional strategies, if any, are present for students of differing ethnicities? 3. How do students "talk" about their learning and how does this differ in an active

learning versus a traditional classroom? To explore these research questions, interviews were conducted with ten students enrolled in an active learning course at an HSI and AANAPISI doctoral-granting institution. The course was a 400+ student enrollment 2nd-year biological sciences course that incorporated active learning and utilized a high-structure format. Participants were recruited based on their status as a student of color or a first-generation college student. In addition, we interviewed two undergraduate learning assistants from the course. The interviews were transcribed, and the research team used an inductive and deductive process based on previous research to create a comprehensive codebook. Field notes from classroom observations were also taken and incorporated into the analysis of the interview data. Briefly, the analyses uncovered a variety of beliefs regarding active learning in the classroom and its impact. Many students valued the active classroom as a way to be "forced" to learn the material, noted the environment made learning more enjoyable and directly compared themselves to their traditional classroom peers by reporting that they retained the material for longer. Students particularly highlighted the importance of the "student voice" they consistently saw in every class, which allowed them to share their thoughts without fear of being chastised for mistakes. This collaborative environment was particularly important for the Latinx students interviewed as most highlighted a desire to work with peers from the same culture. These interactions increased the Latinx students' level of comfort and lowered their insecurities, which was manifested through their use of "Spanglish" and other cultural resources to help them make connections with the material. Another major theme from the interviews was the contrast in students' definition of learning in active and traditional course formats. While students reported that active classrooms provided many benefits to learning mentioned above, they noted that a traditional lecture enabled them to succeed in other areas, including increasing the number of concepts they memorized, the quantity of notes produced, and the amount of material covered, all hallmarks of learning from their perspective. In this presentation, we aim to elaborate on these themes to highlight the previously unexplored underrepresented student perspective to active learning and how it relates to their previous notions of what it means to learn.

Student Affect: Anxiety & Motivation

Paper ID: 87

The Student Anxiety Experience: Clarifying the Causes and Modeling the Mediators

Ben J England (The University of Tennessee)*; Jennifer Brigati (Maryville College); Beth Schussler ("University of Tennessee, Knoxville")

Student anxiety in Biology classrooms can arise from student-centered pedagogy and impact student persistence in the major. However, in our introductory Biology classes, students only attribute about 1/3 of their anxiety to student-centered pedagogies. Informed by Pekrun's Control-Value Theory of Achievement Emotions, this research explores what other factors may contribute to student anxiety in our classes. In addition to student demographics and levels of general anxiety and difficulty, we investigated three other factors related to anxiety, which are positioned as antecedents to or mediators of anxiety in Pekrun's Theory: student self-compassion (SC, the ability of a student to forgive oneself for making a mistake), instructor autonomy-supportive practices (AS, how much choice the students perceive the instructor gives them), and instructor non-verbal immediacy (NVI, body language and behavior of the instructor). Our question was which factors may be most impactful to student anxiety so that anxiety interventions may be developed. In fall 2018, we used online surveys to collect student demographic factors, including gender, year in school, AP courses taken, and ethnicity. We also included Likert-scale items to measure the following: general anxiety, communication anxiety, perceived difficulty of the course, SC, AS, and NVI. These data were collected at week 4 and 14 of the semester. Pre- and post-responses were matched across seven sections of introductory courses (3 cellular and 4 organismal biology sections). Multiple linear regression models using forward hierarchical model selection were built with two dependent variables: general anxiety at week 4 and delta anxiety (change in anxiety, week 14 – week 4). This was done for all lectures combined and then each lecture section. In spring 2019, we asked students an open-ended question about what factors contributed to their anxiety. Categories were created from these responses, and the frequency of each tallied. There were 768 matched responses to the surveys. Mean general anxiety at week 4 was 2.98 (on a 1-7 scale). The best-fit regression model predicting week 4 general anxiety found perceived difficulty, communication anxiety, SC, AS, and NVI were significant predictors ($R^2 = 0.51$). Freshmen, non-Caucasians, and those with 0-1 AP courses were more likely to report higher anxiety. Delta general anxiety (week 14 – week 4) was -0.06. The best-fit model included perceived difficulty, communication anxiety, and AS ($R^2 = 0.35$). For individual sections, the R2 values ranged from 0.322 – 0.65 for the week 4 models, and 0.183 – 0.510 for the delta models. Perceived difficulty was a significant predictor of anxiety in every model except one. There were no other clear trends. Spring 2019 responses (N = 254) revealed that the material being hard (28% of respondents), the amount of material and pace of class (12%), lack of preparation (7%), and poor instruction and size of class (5% each) contributed to student anxiety. These results suggest that perceived difficulty, perhaps related to amount, pace, and how hard the material is perceived, is a significant predictor of anxiety and could be an intervention focus. While certain instructor practices (such as AS or NV) were related to student anxiety in some classes, no two instructors were alike, suggesting customized interventions in terms of how instructors relate to their students.

Paper ID: 47

The impact of student research anxiety on undergraduate biology students' intentions to pursue a scientific research career

Katelyn M Cooper (Arizona State University)*; Logan Gin (Arizona State University); Sara E Brownell (Arizona State University)

Participating in undergraduate research has been shown to lead to numerous benefits including increased persistence in science. However, there are still many undergraduate researchers who choose not to pursue a science-related research career. While studies have demonstrated that the increased length of a student's research experience and a student's positive relationship with their mentor are predictors of a student's persistence in science, it is unclear what other elements of a student's research experience influence their choice to pursue a science-related research career. In this study, we explored to what extent student research anxiety influences undergraduate biology students' intentions to pursue a science-related research career. Specifically, our research questions were whether students' demographics predicted their research anxiety and whether student/mentor rapport moderated the relationship between research anxiety and student intention to pursue scientific research. We used the Yerkes Dodson Law as a theoretical framework to guide our study. The Yerkes-Dodson Law suggests that student performance in undergraduate research should increase with mental arousal (stress and anxiety), but only up to a certain level; high levels of anxiety negatively impact students. We iteratively designed a survey with closed and open-ended questions. Questions were vetted using think aloud interviews and piloted with 126 biology students at a single R1 institution in Fall 2017. We revised the survey and sampled from 26 public R1 universities in Fall 2018. We measured student research anxiety using an adapted version of the Revised Attitudes Toward Research Scale and we measured student-mentor rapport using the Advisory Working Alliance Inventory mentorship scale. Students also answered open-ended questions about what elements of their research experience increased and decreased their anxiety. Our final dataset included 750 biology majors from 26 R1 institutions who had participated in an academic year research experience. Using structural equation modeling, and controlling for students' intentions to pursue a science-related research career before they entered their undergraduate research experience, we explored the relationships between student demographics, student research anxiety, student/mentor rapport, research productivity, student-perceived difficulty of the research project, and students' current intentions to pursue a science-related research career. We found that, compared to students with low research anxiety, students with high research anxiety were less likely to publish or expect to publish a paper from their undergraduate research experience and were less likely to report intentions to pursue a science-related research career. We also identified that student/mentor rapport moderated the relationship between research anxiety and student intention to persist in a science-related research career. Finally, using open-coding methods, we coded students' responses about what increased and decreased their research-anxiety. We found that student confidence, perceived ability, mentorship, and relationships with others in the lab impacted their anxiety. Overall, this work identified research anxiety as important for biology students' intentions to pursue a science-related research career and identified ways in which research mentors can decrease research anxiety to create a more inclusive scientific community.

Paper ID: 134

For broadening participation in introductory biology, tackle test anxiety

Sehoya Cotner (University of Minnesota)*; Ryan Laffin (University of Minnesota); Kendall Edstrom (University of Minnesota); Mark Jokinen (University of Minnesota)

Among the factors proposed to explain attrition in science is lower performance in introductory courses. Thus, we focus on the "introductory course problem," whereby gateway courses effectively "weed out" students—disproportionately women, minorities, and first-generation college students. Specifically, we highlight the impact of test anxiety on these traditionally underrepresented students. Two lines of work provide the theoretical underpinning for the current investigation: one, we and others continue to find evidence supporting the "course deficit model," whereby instructional and administrative choices can raise or lower barriers to participation in STEM; and two, we have discovered that test anxiety negatively and disproportionately impacts the performance of women, minorities, and first-generation-college students, specifically on the high-stakes tests that constitute much of students' grades in introductory courses. We report on a mixed-methods, observational study linking test anxiety and test-anxiety mitigation strategies with categorical descriptors of identity. Specifically, we analyzed grades, institutional data on student demographics (gender, race/ethnicity, and generation in college), test anxiety (using items from Pintrich's Motivated Strategies for Learning Questionnaire, or MSLQ), and student-reported test-anxiety reduction strategies in response to different prompts (e.g., "What helps to reduce your test anxiety, if anything?" and "Does this instructor do anything to reduce/increase your test anxiety?" We used in vivo coding to establish consensus categories (e.g., Course Structure, Professor Attributes, and Exam Features) and subcategories (e.g., for Course Structure, subcategories are Grading System, Office Hours, and Relevant Study Materials), and then two individuals worked separately to assign codes to subcategories. All reported assignments reflect consensus. Relationships between demographics, test anxiety, and anxiety-mitigation strategies were analyzed using two-factor t-testing for equal proportions. We hypothesized that: 1. Test anxiety would negatively predict performance; 2. Test anxiety would negatively correlate with anxiety-reduction strategies; and 3. Test anxiety and anxiety-reduction strategies would vary as a function of student characteristics. We found support for all three hypotheses, both replicating earlier findings and contributing new knowledge. Specifically, we advance understanding by demonstrating that first-generation-college students and minorities cite significantly fewer test-anxiety reduction strategies and report significantly greater overall test anxiety. On the other hand, women cite more test-anxiety reduction strategies, compared with their male peers, yet also report higher test anxiety. We conclude by suggesting simple instructional choices that can minimize test anxiety, give underrepresented students more tools to help themselves in future courses, and, ultimately, mitigate some of the introductory course problem that serves as a barrier to full participation in STEM.

Paper ID: 125

A Critical Synthesis of the Literature on Motivation to Learn in Postsecondary Biology

Michael E Moore (Baylor University)*; Amanda Sebesta (Saint Louis University); Grant E Gardner (Middle Tennessee State University)

Research Problem Student motivation in STEM fields continues to be an important factor in student outcomes. This work synthesizes the scholarship on student motivation in undergraduate biology through a comprehensive literature synthesis. Motivation is a multi-faceted construct, conceptualized as a "force" driving individuals to engage in and sustain behaviors regarding their learning and performance, and is context-specific. We used an organizational framework from psychology to categorize studies based on the theory referenced. 1. Social cognitive theory centers on self-efficacy, or one's beliefs in their abilities to succeed at academic tasks, which determines engagement with a task. 2. Expectancy-value theory relates motivation to expectancy of success on, and the perceived value of, a learning task. 3. Individual and situational interest tie motivation to the perceived relevance of biology. 4. Self-determination theory claims intrinsic/extrinsic motivation is driven by an individual's perceived competence, autonomy, and relatedness. 5. Achievement goal theory states that motivation can be situationally driven by students' goals toward learning. 6. Attribution theory claims that humans are motivated to apply causes to their actions, and also aligns with mindset theory. Research Design We searched databases for peer-reviewed studies done in the context of undergraduate biology, from 1980-2018, using keywords like

"undergraduate," "biology," and specific motivational constructs. After screening papers for suitability, we identified which theory the study addressed, the biology course/level that was studied, and whether the motivational construct was a predictor or outcome variable. Finally, we iteratively discussed the findings under each theory and identified common trends among the studies, regarding how motivation related to performance or persistence in the context of undergraduate biology. Analyses and Interpretations Out of the 1,300 literature search results, we found 50 that matched our review criteria. Of the 50, all 6 theories were represented. However, several studies did not clearly represent a theory, based on how the construct was defined in the framework (theory named with no reference to sources aligned to that theory, and/or provided definition not consistent with a theory). Roughly equal numbers of studies were done in the context of introductory versus upper-level biology courses. Nearly equal numbers of studies regarded motivation as an outcome versus a predictor variable—this reflects a construct-centered approach in measuring one motivational construct for an individual. We discussed a shift from assessing motivation using a construct-centered approach to a student-centered approach, where one investigates several different motivational constructs concurrently. As many motivational constructs are perceived as overlapping, this student-centered approach provides a more holistic view of how students' motivations shape their perceptions of, and engagement in, their learning. One can then analyze which constructs are significant predictors or outcomes, and which constructs overlap, in different contexts. Contributions Our review provides researchers and practitioners a primer on how motivation has been studied in the context of biology education, suggests future directions for research, and informs instructors how to target students' motivations to support their learning of biology.

Paper ID: 233

Self-regulated learning strategy approaches and exam performance in undergraduate introductory biology

Amanda Sebesta (Saint Louis University)*; Elena Bray-Speth (Saint Louis University)

Under social cognitive theory, self-regulated learning (SRL) is defined as metacognitive, motivational, and behavioral engagement in one's own learning, and is often associated with higher academic achievement. Characteristics of self-regulated learners are that they tend to (a) set learning goals; (b) plan, monitor, and evaluate their progress; (c) possess adaptive motivational beliefs that facilitate engagement in their learning; and (d) implement specific, context-appropriate strategies to reach their goals. Our previous work with introductory biology students showed a significant association between higher course exam grades and frequent use of certain SRL strategies. While SRL strategies are only one component of a learner's approach to studying, their use can reflect whether a student is approaching learning at a surface or deeper level, in a given context. With this study, we aimed to identify potential patterns of strategy use associated with high performance on exams, and with exam grade improvement, in our course. In a large-enrollment, learner-centered undergraduate introductory biology course for majors (n=410), we surveyed students about their use of study strategies after each of the first two course exams. We applied exploratory factor analysis (EFA) with the first survey to condense similarly used strategies into overarching study approaches. We then determined if the resulting factors were associated with exam grades, and with improvement in grades from Exam 1 to successive course exams. To identify students who improved their performance, we used standardized exam grades. Among the 17 strategies surveyed, the EFA identified 10 strategies that significantly clustered into three factors and accounted for 82% of the variance. We identify the three emerging factors as housekeeping practices (e.g., rehearsing and memorizing information), studying from course materials (e.g., reviewing the textbook), and metacognitive strategies (e.g., monitoring understanding). These factors align with a proposed model of learning, which outlines a progression from using surface strategies to acquire and consolidate knowledge, to using deep strategies to evaluate one's understanding and fill gaps in knowledge. Higher Exam 1 grades were significantly associated with greater frequency of studying from course materials and using metacognitive strategies; higher use of metacognitive strategies maintained a significant relationship with higher grades on Exam 2. Use of these strategies reflects course demands to review graded work for feedback, check understanding, and use provided resources to review content. Finally, students who improved their grades from Exam 1 to successive exams reported a significant increase in studying from course materials. Improving exam grades may be associated with a willingness to change study approaches to meet course demands. In addition, adjusting use of surface strategies that consolidate information may be easier than adjusting deep, metacognitive strategies, which require more

effort. With insight on the overarching strategy approaches that students adopt in our course, and which approaches correspond to higher exam performance, we can mentor our students in adopting effective study approaches to support their performance and learning in our course.

Saturday afternoon

Course-Based Undergraduate Research Experiences

Paper ID: 114*

It's Not a Red Herring! Exploring Student Beliefs About Research Authenticity in an Introductory Biology Killifish CURE

Emma C Goodwin (Portland State University)*; Vladimir Anokhin (Portland State University); MacKenzie Gray (Portland State University); Yelisey Gurzhuy (Portland State University); ERIN E SHORTLIDGE (PORTLAND STATE UNIVERSITY)

Course-based Undergraduate Research Experiences (CUREs) differ from inquiry lab courses namely by engaging students in novel research with unknown outcomes. The CURE model immerses students in five key experiences: use of scientific practices, discovery, relevance, collaboration, and iteration (Corwin Auchincloss et al., CBE-LSE 13.1, 2014). In choosing to scaffold these experiences in labs, instructors often intend to provide a "real" research experience; however, the degree to which undergraduates and experts agree on what constitutes real research has not been thoroughly explored. We sought to learn: 1) if students in a CURE believe they are participating in real research, 2) if there is alignment between student and expert beliefs of what makes a research experience "real", and 3) if beliefs about research authenticity differ between CURE and inquiry lab students. We designed a CURE, which was piloted in four sections of an introductory biology lab course at a large urban research university. Guided by a faculty member's research, students conducted experiments testing how biotic and abiotic factors impact the likelihood that Austrofundulus limnaeus (Annual Killifish) embryos enter Diapause I, a profound state of metabolic dormancy and developmental arrest. To address our first two research questions, we administered weekly reflection questions to the CURE students. Three researchers inductively developed a codebook to analyze 776 open-ended responses from 74 students and coded responses to consensus. Analyses reveal that 76% of our students felt they conducted real research, while 18% felt it was "maybe" real research, and 10% did not believe they did real research. We compared student explanations of why their experience felt real to expert definitions of authentic research (Rowland et al., CBE-LSE 15.4, 2016), and found agreement that using scientific practices (35% of CURE students), student autonomy (22%), discovery (15%), collaboration (12 %) and project relevance (11%) are important components of real research. Students additionally expressed beliefs that experiencing failure (60%) and iteration (37%) were real research components, both which were less prevalent in expert definitions. To explore our third research question, we surveyed students in the CURE sections (n=45), and students in 17 non-CURE lab sections (n=201), who participated in a 3-week inquiry lab sequence in place of the CURE curriculum. We compared perceptions of collaboration, discovery, and iteration using the Laboratory Course Assessment Survey (LCAS; Corwin et al. CBE-LSE 14.4, 2015). We found that CURE students perceived higher degrees of collaboration, discovery, and iteration (t-tests, all $p<0.01$). Further, we conduced focus groups with both CURE and inquiry students to more deeply explore perceptions of real research. Analysis of focus groups substantiate that CURE students recognize more "real research" elements than inquiry students. We found significant overlap between expert and student explanations of what constitutes a real research experience. Through this research, we highlight that experts should consider that student experiences of failure and iteration could strengthen the perception that they are participating in real research. CURE students are cognizant of a higher degree of authenticity in their class than inquiry students, and the benefits students may gain by being metacognitive of experiencing real research should be further explored.

Paper ID: 43

Two sequential research-based courses afford students opportunities to develop scientific coping skills

Lisa A Corwin (University of Colorado Boulder)*; Joseph Harsh (James Madison University); Michael Ramsey (University of Colorado, Boulder); Elizabeth Woolner (University of Colorado, Boulder); Stevie Ellis (University of Colorado, Boulder); Nina Gustafson (University of Colorado, Boulder)

Course based Undergraduate Research Experiences have been lauded for involving more students in undergraduate research and providing students with opportunities to achieve positive outcomes that they may not achieve in traditional laboratory settings. One such outcome, which is yet underexplored, is the development of an ability to navigate scientific obstacles both cognitively and emotionally. This outcome is important as the ability to navigate obstacles is considered a hallmark of a scientific disposition and has been hypothesized to increase students' persistence in STEM. Research-based courses such as CUREs offer unique opportunities for students to achieve this outcome by providing authentic windows into "doing science" that may afford opportunities for practicing how to navigate scientific challenges and failures in a supportive environment. Our study uses both qualitative and quantitative approaches to investigate how students develop this disposition during participation in two sequential research-based laboratory courses. We ask three research questions a) What coping mechanisms do students employ when faced with a scientific obstacle in a research-based course; are these likely to be adaptive or maladaptive? b) What emotions do students report as a result of experiencing a scientific obstacle in a research-based course? (qualitative investigations), and c) Are there correlative relationships between the types of coping students report, their background characteristics (e.g., race, gender), and whether they are in the first or second research-based course in the two-course sequence? (quantitative investigation). Drawing upon well-vetted models of coping previously used in in education, healthcare, and entrepreneurship studies (e.g., The structure of coping, Ellen Skinner), we make predictions about the adaptive vs. maladaptive quality of coping responses in STEM contexts and describe these alongside common student emotions. We also specifically address how instructors can facilitate students' learning from failures and errors based on previous work from the K-12 literature. We collected data from 656 students in 19 laboratory sections of two research-based introductory biology laboratory courses based on DNA barcoding taught at a large comprehensive university. Students responded to six open-ended questions reporting on their feelings, behaviors, and learning experiences after experiencing scientific challenge or failure (e.g., not succeeding in extracting DNA). We used open-coding to analyze this data with inductive codes describing students' emotions and a-priori codes based on known coping mechanisms and CURE outcomes. Despite 83% of students reporting negative emotions associated with experiencing scientific obstacles, 93% of students reported the use of proactive adaptive coping to deal with scientific obstacles including direct action, seeking support, and emotional regulation. Only a small subset of students (6%) report the use of maladaptive coping mechanisms such as displaying helplessness or opposition (e.g., blaming others). Frequently reported emotions and coping strategies show notable trends with regard to whether or not students were in the first or second course in the two-course sequence. Confusion was reported more frequently by students in the first course than in the second and these students were more likely to report seeking support in response to obstacles. Students in these second class were more likely to report metacognitive reflection during troubleshooting and emotional regulation in response to obstacles. Overall, results suggest that participating in sequential research-based courses may have provided students opportunities to practice coping with scientific obstacles and subsequently improved their ability to navigate such obstacles. Future efforts will use this work to inform the development of targeted instructional strategies to help students better navigate scientific obstacles.

Paper ID: 177

Longitudinal Assessment of Student Self-efficacy, Future Goals and Science Identity in a Series of CUREs Designed to be Progressive in Science Skills Development

Allison Martin (California State University, Sacramento)*; Heather Fletcher (California State University, Sacramento); Thomas Landerholm (California State University, Sacramento); Kelly McDonald (California State University, Sacramento)

Course-based undergraduate research experiences (CUREs) are purported to provide undergraduate students with many of the benefits associated with traditional apprentice-style research experiences. At our comprehensive teaching institution, the Sustainable Interdisciplinary Research to Inspire Undergraduate Success (SIRIUS) Project is addressing another important goal of CUREs - to provide a greater percentage and diversity of students with research experiences. SIRIUS CUREs run from introductory to capstone courses, coordinated around three scientific threads focused on the health of an important river system flowing through the campus. Using the CURE framework and guided by situated learning theory, the SIRIUS courses were designed to promote a community of practice that would enhance students' self-efficacy, science identity and interest in pursuing a career in science. In two lower division SIRIUS biology courses, we previously demonstrated improvements in students' laboratory self-efficacies and evidence of the development of science identity, but no notable changes to students' plans to pursue a career in science. Here, we present findings from re-designed upper-division biology courses, three intermediate and three capstone. We hypothesized that students' self-efficacies, science identities and desires to pursue a career in science would increase as they engage in a greater number and more advanced SIRIUS courses. Self-efficacy and future goals were measured using a Likert-like survey and science identity was measured with open-ended survey questions. All curriculum was evaluated using the Laboratory Course Assessment Survey (LCAS). A summative lab confidence score (LCS) was calculated by combining student answers to the self-efficacy survey items. Pairwise Wilcoxon ranked sum tests with Benjamini Hochberg adjusted p values revealed significant differences between the post-course LCS scores of Introductory to Capstone ($p=0.026$) and Intermediate to Capstone ($p=0.026$), but not Introductory to Intermediate courses ($p=0.936$). Individual item analysis revealed 16%-25% of students, depending on the course, disagreed or strongly disagreed that they felt confident communicating their findings to their professors/other scientists, and reading, writing and interpreting data from scientific papers persistently ranked among items for which students reported lower confidence – even in capstone courses. Previously, lower division students reported high levels of undecidedness related to pursuing a career in science. This trend continued for the students in the three intermediate courses; however, capstone students reported 62%, 64%, and 100% (in one course with a small sample size) agreement that they would pursue a career in research, with some indecision related to graduate work. The Science Identity and LCAS surveys collectively indicated that students across the upper division courses recognized engaging in authentic research experiences through collaboration and the discovery of novel and relevant findings. In two of three capstone courses, over 98% of students indicated they were engaging in authentic research, with explanations aligned with the CURE design elements. LCAS data also reflected major curricular improvements made in a course during the first two implementations. Collectively, these results indicate students are achieving the desired benefits of the SIRIUS project and provide insights for additional curricular improvements.

Paper ID: 267

The Effect of Project Ownership on Student Approaches to Writing in Laboratory Courses

Lisa M McDonnell (University of California San Diego)*; Anqi Yang (University of California San Diego)

Course-based research experiences offer not only the opportunity to engage students in aspects of research, but also other important scientific thinking and process skills such as written communication. Engaging in authentic scientific writing would involve writing from a place of understanding (a “top-down” approach) rather than relying heavily on given ideas and information to dictate how to write and what is written (a “bottom-up” approach). Indeed, students perceptions of authorial identity have previously been shown to vary and be affected by course structure (such as rubrics) and the approaches they take to writing. Our previous work suggests that approaches to writing may be influenced by the sense of ownership students have over a project. Although previous research has explored how student descriptions of their research experiences can reveal concepts of ownership, we do not have a clear idea of how students perceive ownership in a lab class setting. In addition, we do not have a clear idea of how approaches to writing are related to perceptions of ownership, particularly in a course-based research setting. This led to our current questions: 1) How do students perceive ownership in a lab course? 2) How does an increase in project ownership affect students’ approaches to scientific writing? To address these questions, we used qualitative analysis of student responses to questions administered as a survey, and during interviews. Students were surveyed from a specific upper-division laboratory course where they engage in multiple lab modules, one of which is considered to have a low level of inquiry (little choice over design, predictable outcomes, and they are not addressing a sophisticated research question), and another module which has greater inquiry (students have choice over the experimental design, the outcomes of their experiment are unknown to the students and the instructor, and the research question is more sophisticated). Students write short journal article-style reports about each project. Students were provided with an opportunity to take a survey or participate in an interview, both of which asked various questions about how they defined ownership, their sense of ownership over the lab projects, and how they approached their writing for the two projects. Using a grounded theory approach for the analysis of 140 survey responses and 13 interviews, we found that students have varying perceptions of ownership, despite working on the same projects. Common themes that emerged including ownership meant contributing ideas, doing the work, being responsible for outcomes, as well as relationships between ownership and understanding of the project. Student approaches to writing were largely considered “bottom up” as opposed to the “top down” approaches associated with a greater sense of authorial identity. These findings provide insights about how course design can impact not only a student sense of ownership, but how this sense of ownership influences the type of scientific writing they do. In particular, despite efforts to increase ownership, other course structures may reduce the sense of authorship students have and demonstrate. If our goal is to provide research, including writing experiences through a course-based laboratory setting, we need to carefully consider how scientific writing is incorporated, as well as how course structure supports the development of a sense of ownership and authorship.

Paper ID: 152

Faculty Experiences during the Implementation of a Developed CURE Curriculum at Primarily Undergraduate Institutions and a Community College

Nicole Scheuermann (Georgia Southern University); Sue Ellen DeChenne-Peters (Georgia Southern University)*

Course-Based Undergraduate Research Experiences (CUREs) are laboratory curricula designed to provide undergraduate students authentic research experiences while completing classes required by their institution’s degree path. CUREs expand the opportunity for students to participate in authentic research, especially those students who may not otherwise have the networking or resources to pursue such opportunities outside of their required courses. These qualities mean CUREs are a potentially invaluable tool for primarily undergraduate institutions (PUIs) and community colleges (CCs) to achieve desired student outcomes. Faculty are pivotal in both the decision-making process and the execution of implementing a CURE, yet faculty data is relatively absent from published CURE literature when compared to student outcomes. We studied the role and experiences of faculty members involved in

implementing a previously developed CURE curriculum with NSF grant support from resources outside of their institution. We provided professional development (PD) for faculty members, as well as ongoing support throughout implementation, for a developed CURE curriculum at three PUIs and one community college. The CURE was taught by six experienced faculty members, who were interviewed at three points: before PD, after first implementation, and during second implementation. Interviews were qualitatively analyzed using Roger's Theory of Diffusion of Innovation to 1) characterize how biology educators become aware of CUREs, 2) describe factors which influence faculty to adopt or reject a CURE curriculum, 3) identify barriers to CURE implementation across institutions and the necessary resources to overcome them, and 4) describe how the faculty experience evolves between the implementation and sustainment phases of an adopted CURE. Analysis of faculty interviews shows that the decision to implement a specific CURE and the success of implementation rely on a number of complex, often interrelated, factors including student outcomes, the impact of teaching the CURE on the faculty members themselves, and consideration of institutional and departmental systems. Faculty become aware of CUREs through professional channels such as colleagues and educational journals. Instructors' decision to adopt or reject the developed CURE curriculum was influenced by the ongoing financial and technical support resources provided by the grant, as well as the degree to which the curriculum could be adapted to their individual institutions. Faculty reported time, unfamiliarity with the organism, and managing student group work as some of the top barriers to implementation of this CURE. Instructors reported that modifying the curriculum was necessary for sustainment, and expressed interest in sustainment due to beneficial student outcomes. CUREs have been demonstrated to be potentially beneficial in terms of both student outcomes and faculty experience. Understanding what characteristics make a CURE successful from the perspective of experienced faculty members will allow PUI's and CC's to anticipate and meet the needs of their instructors, enhancing the opportunities and experience for students and staff alike.

Issues in Instructional Implementation

Paper ID: 56

Using a Fidelity of Implementation Framework to Understand the Impacts of Two Research-Based Instructional Strategies in High School Biology Classrooms

Grant E Gardner (Middle Tennessee State University)*; Jennifer Parrish (U. of Northern Colorado)

Developing evidence-based instructional strategies (EBISs) to promote student learning is a priority in STEM education (PCAST, 2012). Peer Instruction (PI) and Process-Oriented Guided Inquiry Learning (POGIL) are two EBISs with data supporting their positive impacts on student learning outcomes (Mazur, 1997; Ferrell et al., 2008). The efficacy of PI and POGIL have been studied in postsecondary settings but not in K-12 classrooms (Fagen et al., 2002). Differences between K-12 and postsecondary settings may require instructors to adapt strategies that balance implementation fidelity with contextual constraints which can reduce their pedagogical effectiveness (Offerdahl et al., 2018). This NSF DRK-12 project studied the efficacy of PI and POGIL in secondary school biology classrooms, evaluated the strategies impact on student and teacher outcomes, and supported teacher fidelity of implementation through the following research questions: What changes occurred in participants' knowledge and expert-like thinking related to biology following instruction? Are there significant differences between participants' knowledge and expert-like thinking between the PI and POGIL treatments? What was the fidelity of implementation of the strategies and how might this have effected outcomes? A total of 51 new PI ConcepTests and 16 new POGILS were developed for the project. Participants were high school biology teachers from 32 area high schools randomly assigned to the PI condition (n = 22); the POGIL condition (n = 24); or the control group (n = 6). Complete student data was collected for Year 1 (n = 207) and Year 2 (n = 332). Teachers attended multiple workshop where they were introduced to and engaged with the PI and POGIL respectively. Knowledge of biology was measured using a researcher-designed Cells & Heredity Biology Concept Inventory (24 items) (Bowling et al., 2008; Fisher et al., 2011; Tsui & Treagust, 2009). Expert-like thinking related to biology was measured with the CLASS-Bio instrument (32 items) (Semsar et al., 2011). Observation data of teachers' implementation was also collected with a research-designed tool utilizing a fidelity of implementation framework (Vickery et al., 2015). Questionnaire data for teachers was at three time points (pre-Year 1, post-Year 1, post-Year 2). Student data was collected at the beginning and end of the school year over both years. Changes in relevant variables were analyzed using dependent t-tests

and two-way repeated measures ANOVAs where appropriate. There was no significant effect for time (F = 0.172, p = .695, n2 = .033) or treatment (F = 0.385, p = .562, n2 = .071) for the teacher content knowledge. There was a significant interaction effect (F = 8.448, p = .034, n2 = .628). On the CLASS-Bio there was a significant effect for time (F = 8.701, p = .031, n2 = .442). There were learning gains across all students [Pre-mean = 5.09 (SD = 1.56); Post-mean = 7.01 (SD = 1.95); t(160) = 10.63; p < .0001]. The POGIL treatment demonstrated a significant increase in student knowledge as compared to the PI treatment (F = 20.056, p < .0001, n2 = .501). There was a slight difference (t = -2.17, df = 43, p = .036) in the two groups' expert-like thinking about science with the POGIL groups' expert-like thinking being slightly higher (PI M = 4.20, SD = 0.36; POGIL M = 4.40, SD = 0.28). In general, participants implemented POGIL with much more fidelity than PI, which may explain some of the quantitative outcomes.

Paper ID: 247*

Investigation of the role of lab instructors in mediating group conflicts in an undergraduate inquiry based introductory biology lab.

Sukhada Samudra (University of Georgia)*; Peggy Brickman (University of Georgia); Destiny Williams (Mount Holyoke College); Aarati Shah (University of Georgia)

The use of group work in student centred collaborative learning in STEM courses is widely increased over the past decades. There are significant evidences available throughout the literature about the benefits of group work in terms of student learning, peer acceptance, student achievements and retention of knowledge. However, group work is not beneficial if the groups are not structured strategically. There are conflicting evidences in the literature what type of group structures proved to be more productive for positive learning experience. There is significant gap in the literature about how to compose groups by students or instructors in order to maximize the cognitive engagement, performance, satisfaction and minimize the interpersonal conflicts. There are limited views in the literature about laboratory instructor intervention which will promote cognitive conflicts and reduce interpersonal conflicts. In order to understand the role of lab instructors in mediating groups conflicts, we needed more information about group dynamics in undergraduate inquiry based introductory labs. One of the goals of our study is to understand impact of the group selection methods on student network formation in association with group dynamics and conflicts that arise. The second research question focuses on intervention strategies instructors use to handle these conflicts. Our investigation is based on socio- cognitive perspective in combination with the frame work of cooperative learning. We conducted a longitudinal study in five sections of an undergraduate inquiry- based biology laboratory (n=74) over the summer and 35 sections (n=800) in Spring semester. Our data is collected over 3-week period in form of 7 surveys over the summer semester and over 7 weeks in the Spring semester. The data from first four surveys in each of the semester was analyzed quantitatively by social network analysis. The qualitative data was collected to identify student's perception of a good and bad group member. The remaining three surveys were designed based on Jehn and Mannix's work to identify different types of conflicts arising in the groups. Qualitative data of self-reported intragroup conflicts was collected. The preliminary results from summer semester of these analyses show that students select their group members during the first two labs and sociographs reveal that URM students cluster together in self-selected groups.
Surveys successfully identified two types of conflict: relationship and cognitive conflict, and the level or reported conflict changed over time. Students report using observed behaviours in class as the primary factor influencing their definition of a student they work with as a "good" group member. The most frequent reported good behaviours were "engagement in class", "preparedness", "active communication" and "participation /contribution". The more robust social network analysis of the data from Spring semester is currently being done. Regression analysis to quantify the conflict analysis is currently under process. Along with the surveys we observed graduate lab assistant's behaviour during one lab period in order to understand correlation between GLA immediacy and cognitive conflicts in the lab period. In the Spring Semester, we used LOPUS2.0 to record the observations. We also interviewed the GLAs in summer(n=3) and will interview rest of them(n=8) at the end of Spring semester. Preliminary interviews indicated that GLAs were not sure about how to intervene in real time when intrapersonal conflicts arise. (n=3) After completing both the qualitative and quantitative data analysis, we are aiming to design instructor intervention strategies for the group work in an inquiry based undergraduate labs.

Paper ID: 268

A computational modeling approach to teach the regulatory principles of cellular respiration

Christine S Booth (University of Nebraska-Lincoln)*

Understanding biological phenomena from a systems thinking perspective is important in undergraduate education because it provides students with an analytical approach that focuses on how the components of the system interact, and how these interactions support the function of the system. The potential transformative power of this perspective in biology is widely appreciated. Because students are asked to draw on their critical thinking and problem-solving abilities when taking this perspective, the ability to use modeling and simulation is established as a core competency for life science education. To date, however, few studies have addressed whether this approach will work in a biochemistry classroom. The goal of this research was to ask: does using computational modeling and simulation lead to improved learning about the dynamics of complex biological systems while simultaneously increasing core biochemistry knowledge? Using the computational modeling platform, Cell Collective Learn (https://learn.cellcollective.org), we developed a computational learning assignment called "Regulation of Cellular Respiration". Students are asked to build specific regulatory connections in the system and/or relate the interactions between specific components to the effects seen within the larger system by performing simulations. In this three-part assignment, each model's scope specifically focused students' attention on (1) glycolysis; (2) integration of glycolysis and the tricarboxylic acid cycle (TCA), and (3) integration of glycolysis, TCA cycle and the electron transport chain (ETC). We developed an accompanying four-part assessment to evaluate student learning gains. Three of the parts assess biochemistry content (glycolysis, TCA, ETC), while the fourth part (systems) assesses students' ability to analyze and predict the behavior of biological systems. Students completed the full four-part pre-assessment up to one week before receiving the first part of the assignment. Every two weeks, students completed a new part of the assignment along with the matching post-assessment. After six weeks, students completed the systems post-assessment and a survey we designed to measure perceived learning. We compared two classes: one that used the assignment (n=85) and one where only traditional lecture was used (n=101). The pre- and post-assessments were distributed along a similar timeline and both classes were well aligned regarding the pace of content delivery. We found that students significantly increased their content knowledge in all three areas. Conversely, no significant difference in content knowledge was found in the traditional class. Although the assignment class showed increased learning gains in the systems assessment compared to the traditional class, neither group showed a statistically significant increase. In the assignment class, around half of the students self-reported increased understanding of various aspects of systems thinking and content after engaging with computational models. Overall, our results suggest that the use of this computational systems perspective approach is effective in increasing students' understanding of upper-level biochemistry. Dynamic processes cannot be reflected in traditional readings or diagrams, and the use of these computational approaches could open up this new realm of instruction.

Paper ID: 136

Classroom discourse patterns of biology faculty in undergraduate STEM courses

Active learning strategies increase student-instructor interactions, creating opportunities for rich classroom discussions. Most observational protocols used in undergraduate STEM classrooms, like the Classroom Observation Protocol for Undergraduate STEM (COPUS), focus on classroom behaviors, but they are not designed to measure the ways in which instructors initiate classroom discussions [teacher discourse moves (TDMs)]. Previously, we developed and validated a new instrument, the Classroom Discourse Observation Protocol (CDOP), with a coding scheme and associated matrix that allows observers to reliably characterize TDMs in 2-minute time intervals over a class period. In this study, we explored the spectrum of classroom and discourse behaviors enacted by instructors teaching biology courses in college STEM active learning environments by comparing COPUS and CDOP data. The guiding questions for this study were: 1) How do TDMs vary across instructors teaching in college STEM active learning environments? and 2) Does an increase in student-instructor interactions as measured by COPUS create more opportunities for pedagogically-rich classroom discussions as measured by CDOP? We compared classroom observation data collected from 20 instructors teaching 58 class sessions across three institutions and five departments. We used COPUS to quantify instructor behaviors and

CDOP to quantify instructor discourse behaviors. Individual COPUS codes were collapsed according to Smith et al. (2014), while individual CDOP codes were collapsed according to the theoretical framework for productive discussions by Michaels & O'Connor (2015). The 15 codes that make up CDOP were collapsed into five goals that focused on how instructors: 1) communicate content to students, 2) prompt students to share content, 3) help students connect content to broader context, 4) help students deepen their reasoning, and 5) help students engage with each other's reasoning. The COPUS results of these classroom observations show that instructors guided student learning (mean: 76.4±2.2%, range: 42.1-97.4%) almost two times more than they presented information (mean: 38.5±3.1%, range: 0.0-83.8%). The collapsed CDOP results of these observations show that instructors used discourse behaviors from Goal 1 (mean: 58.1±1.2%, range: 38.5-75.4%) at least twice as much as they used discourse behaviors from Goal 2 (mean: 25.7±1.0%, range: 10.8-40.8%). Additionally, instructors used discourse behaviors from Goal 3 (mean: 1.2±0.3%, range: 0.0-9.0%), Goal 4 (mean: 2.6±0.4%, range: 0.0-10.4%,), and Goal 5 (mean: 1.4±0.3%, range: 0.0-8.1%) on a less frequent basis. On an individual CDOP code basis, sharing (mean: 35.9±1.1%, range: 19.6-59.0%), evaluating (mean: 16.6±0.8%, range: 6.8-27.0%), generative (mean: 14.6±0.9%, range: 0.0-25.5%), checking-in (mean: 7.9±0.8%, range: 0.0-23.6%), and clarifying (mean: 3.2±0.4%, range: 0.0-10.2%) were the most frequent discourse behaviors used by the biology instructors. These data suggest that even biology instructors interacting more with their students may not be having pedagogically-rich classroom discussion but are spending most of their class session communicating content to students. In addition to these results, we will show comparative results between COPUS and CDOP data. Our study indicates that discourse observation data can be used to improve student learning in undergraduate STEM learning environments by promoting more pedagogically-rich classroom discussions.

Paper ID: 82

What do we mean when we say "random call"? Investigating why and how college biology instructors use random call

Alex Waugh (University of Georgia)*; Tessa C Andrews (University of Georgia)

Random call refers to an instructional strategy that uses a stochastic approach to select a student or group of students to share their thinking with the class. Random call can address gender gaps in who volunteers answers in large biology classes. It can also hold students accountable for participating in discussions, and can even increase student willingness to volunteer answers. However, other work indicates that random call can result in high levels of anxiety among some students, potentially impacting their ability to learn. A key gap in our current knowledge is how random call is actually being implemented and why instructors choose to use it. Without additional clarity regarding the specific ways in which random call is implemented, we cannot empirically weigh the potential benefits and costs for students. We sought to understand why biology instructors choose to use random call, or not, and the specific ways in which they implemented it. This work was grounded in a model of teacher thinking that posits that instructor thinking influences instructor practices in the classroom, which influence student outcomes. We conducted semi-structured interviews with 23 college biology instructors about their use of random call, and strategically included random call users and non-users. We asked them about their rationale for choosing to use or not use random call, and asked random call users to describe, in depth, how they implemented the strategy. We conducted a highly iterative, collaborative, and systematic qualitative content analysis of interview transcripts to characterize instructors' rationales and practices related to random call. Both random call users and non-users viewed the strategy as valuable for improving student accountability to work during class. Random call users commonly aimed to increase the variety and representation of student voices in class discussions. Some described random call as an important approach for keeping their own implicit biases in check when selecting which student voices would be heard. For non-users, concerns about student anxiety outweighed perceived benefits of random call. Notably, random call users were just as concerned about student anxiety as non-users, but had developed strategies for implementing random call that they saw as substantially mitigating student anxiety. Looking closely at the ways in which random call users implemented the strategy revealed both commonalities and variation. Most random call users explicitly directed students to discuss a question with each other before anyone was selected to talk in front of the class. It was also common for them to ask students to share what a group was thinking, de-emphasizing the focus on an individual student.

Random call users discussed using the strategy early and often in a course so that students knew what to expect. Random call users differed in how they selected a student, whether they called on individuals or groups, and how much they discussed their rationale for using random call with students. This work systematically elucidates the decisions instructors make about how to implement random call. This will be useful to future research because it indicates what elements of random call need to be attended to in studies that aim to determine the its impact on students. Our results may also be useful to instructors as they consider whether and how to implement random call in their own classroom.

Student Learning

Paper ID: 229

Comparison of Service learning and Research Projects in an Introductory Biology Class

Amy Kulesza (Center for Life Sciences Education)*; Kelsie M Bernot (North Carolina A&T State University); Safa Imtiaz (North Caroline A&T State University); Judith S. Ridgway (The Ohio State University)

In Kolb's experiential learning framework, he intended learners to cycle continuously through four stages: concrete experiences, reflective observations, abstract conceptualization, and active experimentation, as they developed expertise. Inquiry-based laboratory modules often progress through these stages once; however, students have difficulty translating these experiences outside of the classroom. We added an inquiry-based service-learning activity to an honors introductory biology class, grounding it in Kolb's framework by guiding students through community experiences, reflective observations, hypothesis creation, and future active experimentation. Students interacted with one of three organizations (cancer organization, Red Cross, or community garden) to complete service- and related-learning activities, designed to support students' recognition of the connection between class concepts and community issues. Because multiple sections of honors introductory biology were offered, some students alternatively completed an inquiry-based research project (RP) in which they qualitatively and quantitatively studied osmosis / diffusion in potatoes or antibiotic resistance in soil. Through participation in these SL and RP projects, we hypothesized that students would experience increases in 1) their motivation to learn biology, 2) their scientific literacy skills, 3) their understanding of the relevance of biology to their everyday lives, and 4) their perceived gains in course learning outcomes. Over 7 semesters (11 sections), 287 consenting students (n= 136 SL; n=151 RP) participated in this research, a participation rate of 68%. In this quasi-experimental study, students did not know which sections were SL vs RP when enrolling in the course. We compared students in SL and RP sections using pre-/post-tests to assess 1) student motivation to learn biology (Science Motivation Questionnaire-II, Biology - SMQ-II) and 2) gains associated with scientific literacy (Test of Scientific Literacy - TOSLS). In multivariate tests controlling for gender and chemistry grades, no significant differences in gains between SL and RP were found between the courses on post-TOSLS scores, or the five SMQ factors. We also used the end-of-term Student Assessment of Learning Gains (SALG) survey to compare perceived student learning gains associated with biology content. RP students reported significantly higher gains on three SALG items including their understanding of the process of science, likelihood of participating in research in the future, and the group research paper. Finally, we compared the students' perceptions of the relevance of biology to their lives through evaluation of open-ended responses on the SALG. Codes for open-ended responses were developed by a combination of empirical analysis and published literature. Coding by two individuals with interrater reliability of 0.68 revealed that both RP and SL students recognized gains in scientific communication – research papers and posters, respectively. Additionally, codes for novelty and piquing students interest co-occurred in both groups; however, SL students more frequently mentioned connections between course work and their SL project. We will present our results from the four research questions comparing students in these two activities. Recommendations for future modifications of our SL and RP models will be discussed.

Paper ID: 274

Retrieval practice for jargon terms enhances definition responses but not conceptual questions

James Cooke (UC San Diego)*; Steven Pan (UCLA); Mark McDaniel (Washington University, St. Louis); Timothy Rickard (UC San Diego)

Jargon terms are discipline-specific terms that are either novel for students (eg: depolarization), or are terms that are used differently in a discipline-specific context than they are for lay people (eg: adaptation). Mastery of jargon terms is an important part of student learning in biology, but jargon can have a negative impact on student learning of core course concepts. Retrieval practice (or the 'test-enhanced learning'), is considered one of the most effective study approaches uncovered to date. This method involves students taking one (or a series) or low-stakes quizzes or tests, and results indicate that this generates improved memory for the subject(s) tested compared to a similar amount of time spent studying. The literature also suggests that retrieval practice may enhance transfer of information from one domain to another, such as definition-level tests aiding students in application-level problem solving. This raises the question: can retrieval practice be used to overcome jargon-induced reduction in student learning? Students enrolled in two sections (A and B) of the same upper division human physiology course were given 10 jargon terms with definitions on Fridays of alternating weeks (Week 2, 6, 9 for section A; week 3, 5, 10 for section B). The Monday following, the students that had been assigned the jargon terms were given a 10-minute low-stakes quiz with feedback on those same jargon terms using in-class clickers. Quizzes were administered prior to conventional course instruction in which the jargon terms were used. The section not assigned weekly definitions (eg: Section B on week 2) had reading from the textbook that did not involve being told to memorize any key terms. Students in both sections had similar GPAs (M = 3.06 in both), SAT Math scores (M = 663 vs. 678), and ACT Composite Scores (M = 28.8 vs. 29.0). Any student not participating in the clicker quizzes or the exams were excluded from our data. As a result, we had 117 students in section A, and 160 in section B for a total of 277. Midterm and final exam questions were identical for section A and B, and were graded by the same person for both sections. For example: question 1a-c from both Section A and B were all graded by the same instructional assistant. Instructional assistants were not aware of the ongoing study when grading. Analyses of midterm and final exam data were restricted to questions on the topics from weeks 2-3, 5-6, and 9-10, during which the quizzing versus control manipulation occurred. Paired samples t-tests were separately performed for the definition-focused and conceptual questions. On high-stakes midterm and final exams occurring up to 9 weeks later, we observed improved student performance on questions that targeted recall of previously quizzed jargon terms and their definitions, relative to questions on jargon terms that were not quizzed. Benefits of jargon quizzing did not consistently generalize, however, to exam questions that assessed conceptual knowledge but not necessarily jargon knowledge. Overall, this research demonstrates that a brief and easily implemented jargon quizzing intervention, deliverable via in-class platforms, can yield substantial improvements in students' course-relevant scientific lexica, but does not necessarily impact conceptual learning.

Paper ID: 64

Going around the evidence-based design wheel to develop a digital assessment of undergraduate biology students' graphing ability

Elizabeth Suazo-Flores (Purdue University); Stephanie M Gardner (Purdue University)*; Joel Abraham (CSU Fullerton); Susan Maruca (SimBio); Eli Meir (SimBio)

Modern undergraduate biology curricula are designed to teach biology through science practices, requiring students to engage in the complex integration of biology knowledge with quantitative approaches. Graphing is a common practice used by scientists to explore and analyze data, make inferences, and communicate findings. The long-term goal of our project is to develop a digital graphing assessment tool (DGAT) for early-stage undergraduate biology students that will 1) provide feedback about their graphing practices to instructors, and 2) create opportunities to learn graphing practices in authentic biological contexts. Our first step has been to build a DGAT that assesses graphing capabilities through performance on an authentic biological graphing task with multiple variables, and with data characteristics that allow for different representations and data forms. To do this, we adopted the Evidence-Centered Design (ECD) framework for digital assessment development (Mislevy, 2013). ECD

requires development of a theoretical model of student knowledge in a domain, which guided development of DGAT features and data collection focus. In this talk, we describe our experiences building this DGAT using ECD to characterize student graphing practices. The development of the DGAT involved cycles of evidence-based design focused constraint of student actions within the DGAT to make those actions more interpretable while reducing prompting by the tool. As examples of constraints, students can choose from only three common graph types and do not have full spreadsheet manipulation capabilities. Starting with early prototypes, existing research data, and our own teaching experiences, we are now developing our fourth iteration of the DGAT. The second DGAT version was tested for both usability and validation with 22 undergraduate biology students of varying class standings from two different Midwestern institutions, through interaction with the tool and its embedded questions and semi-structured interviews. We repeated a similar testing process with the third version with a different set of 26 undergraduate students from the same universities, as well as several more experienced graphers. We focus our talk on the constraint decisions we made during each cycle of development and how those helped and/or hurt our ability to interpret graphing skills from users of the DGAT. We also discuss some early patterns we have seen with the tool which would be difficult to detect without a performance-based assessment. The initial pilot of the DGAT indicated a need to reduce students' cognitive load of learning a new scenario, understanding features of the DGAT, and making decisions around data analysis and graphing. During subsequent rounds of testing, we learned that student confusions between hypotheses and predictions made interpretation of certain skills more difficult. We also adjusted our constraints to allow additional mistakes we commonly saw in non-digital graphing. Among patterns we have been able to discern that students who pay attention to the hypothesis/prediction tend to make better graphs, and that students may learn to make a better graph as they explore the data. Our fourth iteration is designed to improve the quality of validity evidence for the assessment through the addition of multiple graphing tasks for each student. Our development process may be informative for others developing performance-based assessments of complex science skills.

Paper ID: 59

Exploring Plant Blindness and Botanical Literacy in an Undergraduate Botany Course

Kathryn M Parsley (University of Memphis)*; Jaime L Sabel (University of Memphis); Laura Zangori (University of Missouri); Jason Koontz (Augustana College)

Plant blindness is the lack of awareness of plants in an environment, which can lead to the naïve point of view that plants are not important. There are four components of plant blindness: attitude, attention, knowledge and relative interest. Students demonstrate botanical literacy when they are able to apply knowledge to make scientifically sound decisions regarding societal issues like food ethics, climate change, and plant conservation. Interventions have been suggested to combat plant blindness, but before we can determine what is helpful, we need information on students' current level of plant blindness and botanical literacy. Valid measures of plant blindness and botanical literacy currently do not exist, so we developed and piloted two instruments: the Plant Blindness Index (PBI) and the Botanical Literacy Inventory (BLI). The PBI measures the presence of all four aspects of plant blindness. The BLI is a concept inventory that includes core concepts published by the American Society of Plant Biologists and that align with Vision and Change. The purpose of this research is to ensure students have the knowledge to make scientific decisions about plant-related socioscientific issues such as food production & ethics, climate change, conservation, etc. With these goals in mind, we developed the following 3 research questions: How are plant blindness and botanical literacy affected when students take part in an active learning botanical curriculum? How does student use of human links in causal maps change after an active learning botanical curriculum? What ideas do students portray about plant blindness and botanical literacy? In each semester of this study, we tested the instruments in a pre-post model with students in a required undergraduate botany course at a small liberal arts college in the Midwest. We identified students from a range of plant blindness scores and invited them to interviews. The interviews explored why plant blindness occurs, and the factors that affect students' levels of plant blindness and botanical literacy. All students in the study were asked to complete a causal map before and after the course took place. Casual maps are similar to concept maps but they demonstrate cause and effect relationships rather than other connections included in a concept map. We developed a scoring rubric

that measured student performance on causal maps in 5 areas: plant links, human links, ecosystem links, causal reasoning and systems reasoning. In this study we are focusing on student use of human links reasoning as a way to identify SSI-based reasoning. If students are able to identify human effects on an environment using human-specific concepts such as pollution, we reason they will also be able to see human impacts on plant-related SSIs. In both semesters, we performed a one-way repeated measures ANOVA to evaluate student performance on the PBI and BLI and found that students' overall scores on the PBI, BLI, and the attention and knowledge aspects of the PBI increased significantly ($p < 0.05$). In the second semester, in addition to the previously reported increase in scores, we found that relative interest in plants also increased significantly ($p < 0.05$). We repeated this process for the human links scores and found that students did not increase their ability to reason using human links in either semester. More detailed information on the interview data will be presented.

Paper ID: 214

Which Components of Evidence-based Teaching Impact Student Learning?

Mary Pat Wenderoth (University of Washington)*; Sungmin Moon (University of Washington); Mallory Jackson (University of Washington); Jennifer H Doherty (University of Washington)

Background/Methods There is extensive evidence that active learning or evidence-based teaching [EBT] is more effective for student learning than passive traditional lecture. However, there is little research on what intensity, duration or elements of EBT are most effective at enhancing student learning and if there is a differential impact on student groups. We were interested in determining the level of EBT used by faculty across one science department at a research university and how this level of EBT impacted student learning. We posed two research questions: (1) Were there any meaningful patterns in EBT practices across Biology classes, and (2) Were there any significant achievement gaps in exam performance among different patterns of EBT practices and different student groups? Data were collected from 33 faculty members across multiple academic years including class videos, exam data, and student demographic information. Three to four videos were randomly selected from across the course term from each of 40 courses (some faculty taught multiple courses). These videos were coded by trained coders using the Practical Observation Rubric to Assess Active Learning [PORTAAL]. PORTAAL consists of 15 dimensions of best practices in EBT identified from the education research literature based on their documented improvement of student learning. These elements are observable and quantifiable in an active learning classroom, making the tool quick and relatively easy to learn. Pairs of researchers independently coded each class before working together to reach consensus on coding. Ten of the most frequently coded elements were selected to determine meaningful patterns of EBT practices using latent class analysis [LCA]. Results/Conclusion We found that there were variations in implementing EBT practices across the 40 Biology courses and these variations emerged as two distinct latent classes. Specifically, each latent class was different in the implementation of ten EBT practices (i.e., high and low EBT implementation classes). There were no academic achievement gaps on exam performance in the courses clustered within the high EBT implementation class. However, achievement gaps based on gender, underrepresented minority status, and socioeconomic status were found in low EBT implementation classes. We conclude that high EBT implementation contributed to reducing achievement gaps between different student groups. EBT elements with the greatest difference between LCA groups included: student time providing answers to questions, students explaining their reasoning, use of random call, and total student activity time. Building on what we have learned about EBT implementation, our goal is to create and document an affordable, scalable, sustainable, and evidence-based teaching framework for universities across the US for promoting innovative and effective teaching practices on their campuses.

Sunday morning

Evolution & Science Acceptance

Paper ID: 207

The Age of Science Denial: How can science instruction foster science acceptance?

Rebekka Darner (Illinois State University)*

Science denial is an unwillingness to consider empirical evidence that contradicts one's desired conclusion. The scientific community is gravely concerned with a gradual migration of science denial from the periphery toward the center of our society. Science denial is a form of pseudoscience, is a threat to our democracy, and an enormous barrier to educating a science-informed citizenry. The converse of science denial, science acceptance, is the willingness to engage in critical evidence evaluation, despite potential to contradict one's preferred conclusion. This talk will explore literature on conceptual change, scientific argumentation, the backfire effect, motivated reasoning, and self-determination theory to put forth fresh ideas on how science instruction can foster science acceptance. These literatures, briefly summarized below, provide several insights into instructional strategies that might foster science acceptance. The conceptual change literature has defined theories as cohesive mental models that explain causal relationships among several related phenomena; students' theories are resistant to change, even when confronted with anomalous evidence. Theory change is more likely when a student is confronted with multiple lines of convergent evidence, and when the student is provided an alternative theory that explains the anomalous evidence. While the conceptual change literature is useful in fostering conceptual change about scientific phenomena, it is not solely sufficient in dealing with the science denial that educators encounter in their classrooms. When science denial occurs, natural phenomena are not merely being misconceived; often, learners can fully comprehend a natural phenomenon but still find its explanation to be implausible. In the case of science denial, empirical evidence is rejected due to its undesirable conclusions, even if the scientific explanations are comprehended. Therefore, conceptual change approaches alone are not likely to be effective when trying to foster understanding of controversial topics that are subject to science denial, because they do not address why students are unwilling to engage in critical evaluation of evidence. Literature on the backfire effect begins to explain a science denier's unwillingness to engage in evidence evaluation. The backfire effect occurs when unscientific claims become more entrenched when confronted with counter-evidence due to the counter-evidence, or its delivery, threatening one's identity or worldview. Literature on the backfire effect reminds us that science denial is an issue of personal identity, and emotions that arise from conflicts between students' personal ideologies and scientific evidence plays an important role during evidence-evaluation and decision-making. The scientific argumentation literature has taught us that when argumentation productively fosters conceptual growth, students simultaneously seek both consensus and accurate sense-making. Striking a balance between these potentially opposing goals necessitates social and communication skills that allow for dissention, friendly disagreement, a desire for accuracy, and preservation of a student's sense of competence when s/he is found to have made an inaccurate claim. This highlights the cultural norms we should seek to establish in our classrooms when attempting to foster science acceptance. People do not generally begin evidence evaluation from a neutral position; instead, individuals exhibit motivated reasoning, which is when evidence evaluation is biased by whether or not the evaluator wants to believe its conclusions. Directional goals motivate people to come to a desired conclusion, despite contradictory evidence, while accuracy goals motivate people to be accurate in their conclusions. The theory of motivated reasoning indicates that if we are to foster science acceptance in our classrooms, we must motivate accuracy-oriented reasoning. Self-determination theory (SDT) provides ample instructional guidance on how accuracy-oriented reasoning can be motived in the science classroom through the support of students' three basic psychological needs: a sense of autonomy, a sense of competence, and a sense of belonging. SDT also has explanatory power when trying to understand why emotion plays such an influential role during evidence evaluation. Drawing from motivated reasoning and self-determination theories, this talk will put forth a theoretical model of how negative emotions, thwarting of basic psychological needs, and the backfire effect interact to undermine critical evaluation of evidence, leading to science denial. The model guides the proposal of several design principles for creating instruction that is likely to foster science acceptance. I will suggest the evidence-

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laden narrative (ELN) as an exemplar method that applies these design principles. I will then present data from a study that investigated the effects of a “bare bones” ELN on college freshmen’s (N = 116) acceptance of the scientific consensus on vaccination. The ELN, which took an average of 10.3 minutes to complete, significantly increased students’ acceptance of the scientific consensus, except when students experienced negative emotions (e.g., anger, frustration, incompetent, confused) during evidence-evaluation. These data serve as preliminary support for the theoretical model as well as inspire new questions and opportunity for the development of creative instructional practices. I will suggest further lines of research that seeks to improve our understanding of science denial and how it can be dealt with in the classroom, as well as invite colleagues into collaboration on these efforts. This talk will conclude with brainstorming both further research ideas and instructional methods that facilitate motivation toward accuracy goals by fulfilling basic psychological needs as students engage in accuracy-oriented reasoning during evidence evaluation.

Paper ID: 130

Five years of evolution acceptance – Are general students different than biology students?

Ryan Dunk (Syracuse University)*, Jason Wiles (Syracuse University)

roblem Recent work has shown that many different factors are significantly related to acceptance of evolution, including religiosity, understanding the nature of science, and political affiliations. Here, we seek to use historical data, as well as some recently gathered data, to extend this model and address an important question: is the pattern of factors related to evolution acceptance robust across time and population, or are there differences in the association of certain factors to evolution acceptance across time or groups? Research Design Students were surveyed for at the beginning and end of the fall semester between 2012 and 2017, excluding the fall 2015 semester. In fall 2012–2016, surveys were administered to students in the Introductory Biology course. For the fall 2017 data, students were enrolled in a First Year Experience course run across many sections throughout the university. Acceptance of evolution was measured by the Measure of Acceptance of the Theory of Evolution (MATE). In addition, participants answered questions regarding their gender, age, ethnicity, rurality of childhood home, childhood science exposure, religious affiliation, religiosity, political views, and political party affiliation. Multifactorial linear models were generated for the pre-course and semester-long change data with acceptance of evolution as the dependent variable and demographic variables as independent variables. Analysis and Interpretation (i) Pre-course linear modeling. The most important factors that seem to affect evolution acceptance across all time points is ethnicity, religious affiliation, religiosity, and prior science exposure, which is in line with other studies both in this population and others. In addition, there is quite a high interaction between ethnicity and type of data collection, manifest in a strong divergence between those years where data was collected in introductory biology versus the year that included general freshman. These findings show that population selection is very important in studies of evolution acceptance, and trends that are found in a select population may be different when looking at a more general student population. (ii) Semester-long linear modeling. Similar to the model in part i, a model was run with many different demographic variables to explore their relationship to acceptance of evolution. Here, however, we explored how the variables were related to the change in MATE score over the fall semester. We found very few of the variables have a significant relationship with change in evolution acceptance. However, religiosity does show an effect. In addition, the change throughout the semester differs between those semesters where the population was only intro bio students versus all first year students. This is not surprising as it shows that taking the course seems to have an effect on students’ acceptance of evolution. Contribution and General Interest This baseline will allow further research of ours and others to explore the similarities and differences between different groups in acceptance of evolution (such as between students at different types of institutions, and ideally, between undergraduate students and different segments of the general population). Additionally, several potential outcomes from this research will have direct applications to curriculum development and conceptual change research.

Paper ID: 238

Teaching Nature of Science in General Biology: Impacts on Students' Acceptance of Evolution

Jeremy D Sloane (University of Virginia)*; Lindsay Wheeler (University of Virginia); Jessamyn Manson (University of Virginia)

Biological evolution is considered to be the unifying theme of all of biology. However, despite decades of educational reform efforts, acceptance of evolution is still considerably lower among members of the general public as compared to the 98% of scientists who accept it. Understanding of Nature of Science (NOS) has been identified as a key predictor of acceptance of evolution; however, no studies have examined the influence of NOS instruction on evolution acceptance among college students. The present study examined whether NOS instruction influences evolution acceptance during an evolution unit taught by the same instructor in two sections of a general biology course at a mid-size research-intensive university in the mid-Atlantic U.S. The "control" section (n = 313) received standard instruction for this unit, while the "treatment" section (n =314) engaged with most of the same instruction plus three NOS-themed classes. NOS instruction used an explicit, reflective approach on three key aspects of the Nature of Science—theories vs. laws, observation vs. inference, and empiricism. Students in both sections completed a pre-/post-survey that included Likert questions from the Measure of Acceptance of the Theory of Evolution (MATE), Understanding of Science instrument, and Student Understanding of Science and Scientific Inquiry (SUSSI). Sum scores and change scores were calculated for each instrument. Exam scores and reflection assignments were also collected. No differences existed between sections on pre-survey scores or demographics. Independent samples t-tests revealed significant differences in post-MATE scores between treatment and control groups for participants who had high acceptance levels ($p = .038$). No significant differences were observed between groups for participants with low or moderate acceptance. No differences existed in NOS between the treatment and control groups. Further, changes in MATE scores were significantly greater for women than men in the treatment group ($p = .016$), but no differences in the control group. We conclude our NOS intervention was sufficient at improving evolution acceptance for those who already had high acceptance, but not for those who began the semester with low or moderate acceptance. We also conclude that women's shifts in acceptance of evolution were significantly greater than those of men among students who were enrolled in the treatment group. We recommend that future attempts to improve evolution acceptance using NOS instruction be more extensive and highlight additional aspects of the NOS, including the sociocultural influence on science, creativity and imagination of scientists, and tentativeness of findings. Further analyses will focus on exploring relationships between gender, NOS, and evolution acceptance and identifying differences in exam and reflection data between groups.

Paper ID: 157

The influence of misconceptions in evolution on students' ethical arguments

Kristine L Callis-Duehl (East Carolina University)*; Mohammad Fraha (East Carolina University); Emma Rae Wester (Ea)

Many studies have made interesting connections between a student's religious beliefs and their acceptance of evolution (Dagher et al 1997, Alters and Nelson, 2002, Moore et al 2009). However, little has been done looking at how student's metaethics, arguably the foundation for religious, non-religious and moral beliefs, both influence their understanding of evolution and are influenced by their (mis)understanding of evolution. Understanding misconceptions of evolution and natural selection in the context of student's perceived ethics and morals will help us better address these topics. We used a validated a set of questions (Callis-Duehl et al, in prep) to target the intersection of evolution and natural selection misconceptions with student's moral and ethical beliefs in the context of disease treatments. Introductory biology students were asked one of four versions of a question about whether or not they would recommend treating sickle cell with a theoretical, approved, drug that allowed them to live "full and healthy lives" even though there was a "risk of increasing the allele frequency of sickle cell in future generations". Variations in the question included a change in location of the treatment – east Africa, America or Germany – and a change in wording to change "individual" to "children." The location variable was included to look at the influence of geographic, cultural or racial biases. The second variation was to look at sympathetic/empathetic bias. Students were then asked a follow-up question about their

recommendation to continue insulin treatment for patients with genetically inheritable Type I Juvenile diabetes. There were no variations in the question. Preliminary results the distribution of students that choose not to treat the individuals with sickle cell is higher than expected. In classes where the students are biology majors and over 85% are "pre-med," 70.1% of students chose to not the sickle-cell individuals treat the individuals (n=87) while only 12.6% of the same students would terminate insulin treatments for Type 1 diabetics. The three most common explanations from students for their choice in terminating a life-saving treatment for sickle-cell included misconceptions of natural selection along the lines of "we should not disrupt natural selection", misunderstanding of population genetics and inheritance, for example "not treating sickle cell means that eventually the disease will die out," and a lack of understanding around genetic diseases and treatment, such as "we shouldn't give a treatment, only a cure," and "we should only treat people with medicine for which we have long-term data." Students who selected to treat both diseases and students who chose to not treat sickle-cell patients but treat diabetes patients both used the principal of nonmaleficence and principal of benefice as their ethical stances. The choice to not treat sickle cell (and treat diabetes) was always based on a scientific misconception, and students used these misconceptions to validate their ethical stance, thus demonstrating the incorrect use of scientific misconceptions to support ethical and moral decisions. When reflecting on discrepancies in their treatment choice, students often brought up ideas of justice, that we should only treat diseases where everyone has access to the treatment ("such as with diabetes") but since everyone doesn't have access to the new sickle-cell treatment, no one should. Through the refining of the emergent themes we are developing an online version of the questions that can be more widely distributed. Through this online version, we want to look at differences in demographics that may also influence student answers.

Paper ID: 174

A comparison of the reconciliation model in a biology and theology classroom

Danny Ferguson (Brigham Young University)*; Ethan Tolman (Brigham Young University)

Our research has shown that the application of a reconciliation model in general biology classes at religiously affiliated universities increases the acceptance of evolution among students without decreasing their religiosity. The purpose of this study is to compare the effectiveness of this same reconciliation model in a theology classroom versus a biology classroom. A reconciliation approach to teaching evolution allows students to consider evolution without feeling like their worldview is being threatened, allowing them the chance to accept evolution when they feel it makes logical sense, instead of dismissing it due to conflict. We predicted that the reconciliation model would allow students to increase in acceptance of evolution without affecting their religiosity in both environments. At Point Loma Nazarene University we tested the effectiveness of the reconciliation model in 2 theology classrooms (N=16, N=85), and a biology classroom (N=85) using the Generalized Acceptance of EvolutioN Evaluation (GAENE) as a measure of acceptance along with an initial survey of religiosity. This was important to determine as religiosity has been shown to be a large predictor of acceptance. Surveys were given to students before the reconciliation intervention and after. Classes displayed differences in religiosity with one theology class being higher ($p<.001$) and one lower ($p<.001$) than the biology class. Classes also showed differences in initial acceptance, with one theology class having higher initial acceptance ($p<.02$). The impact of our intervention was not consistent. In the biology class we saw a significant gain in acceptance of evolution ($t(84) = -7.35$, $p<.001$); In the theology classrooms, however, we saw no change: Theology instructor 1 (N=16) ($t(15) =-.91$, $p =.38$),Theology instructor 2 (N=85) ($t(84)=-1.47$, $p=.15$). Interestingly, both Theology instructors chose to administer the religiosity survey post intervention and neither saw any differences in religiosity due to the intervention: $t(15)=-.63$, $p=.54$ and $t(84)=-.99$, $p=.33$. However, neither saw acceptance gains. We suggest three potential explanations for a difference of effect in biology and theology classrooms. First, reconciliation in a biology classroom is accompanied by the acquisition of knowledge about evolution. Knowledge of evolution has been shown to be an important factor, at least for students without a religious barrier, in evolution acceptance. However, with religious students, knowledge is not always sufficient. With our results, we suggest that reconciliation is not sufficient without knowledge. A second explanation is that reconciliation in a biology classroom is also accompanied by discussions about the nature of science. A correct understanding of the nature of science has been tied to an increase in acceptance. So, again, it is possible that reconciliation without an understanding of the nature of science is not sufficient. Thirdly, it is possible that students simply did not view theology instructors as a person of authority on evolution and therefore the impact on acceptance was mitigated.

Implications of our research are that exposure to evolutionary science, deemed a non-factor in evolution acceptance in some studies, may be a necessity in evolution acceptance even when a reconciliatory approach is used.

Reading & Writing in Biology

Paper ID: 259

Expert-novice differences in generating arguments based on complex data

Shannon R Butler (University California, San Diego); Stanley M Lo (University of California San Diego); Lisa M McDonnell (University of California San Diego); Ella Tour (UCSD)*

Critical analysis of complex data and generation of evidence-based scientific arguments is one of the core components of the process of science; teaching these skills is an important component of scientific teaching practices (AAAS, 2011; Couch et al., 2015). Argumentation (Toulmin, 1958; Biggs 1979) provides a useful framework for examination of this process: scientists use data (evidence) to propose a claim (hypothesis, conclusion) about the biological meaning of the data, while also articulating the reasoning that connects the evidence to the claim. In this study, we sought to understand the differences between the ways that experts (biology faculty) and novices (biology undergraduates) construct scientific arguments based on complex data. A survey of existing literature indicates the need for better understanding of these differences. We know that, when analyzing complex data and generating scientific arguments, expert scientists are able to identify hidden patterns in data, integrate data from multiple sources, and propose multiple alternative explanations for observations (Chi et al. 1979; Donovan et al. 1999). Development of argumentation skills in K-12 education offers useful insights (Osborne et al. 2004; Aufschnaiter et al. 2008; Clark and Sampson 2008), but we are only beginning to understand how biology undergraduates build scientific arguments based on complex data derived from original scientific investigations (Zagallo et al., 2016). To better understand expert-novice differences in building such arguments, we conducted qualitative analysis of written arguments by faculty (n= 9) and undergraduate students (n= 9). The prompts for the argument included two figures from scientific articles, where each figure presented data from multiple lines of investigation. We followed up the written arguments by interviewing participants to elucidate the thought process that they used during data analysis and argument construction. Several expert-novice differences emerged from our analysis. 1) All experts, but only one novice analyzed all data presented in the figure. Students chose to focus on the data they could easily understand; this selective data analysis resulted in incomplete scientific arguments 2) All novices, but only some of the experts proposed an explanation (reasoning) to connect the data to the claims they made. 3) Most of the experts, but none of the students noted the correlative nature of the data and adjusted their claims to reflect this. Moreover some of the faculty, but none of the students offered additional criticisms or evaluations of the data. 4) Most of the faculty, but only one student suggested additional experiments to follow up on this study or to test for causative relationship between the observed phenomena. Our current results indicate that students are able to grasp the structure of a scientific argument and to generate evidence-based claims, supported by reasoning. However, we identified several deficiencies in students' abilities to construct argument from complex data. Students rarely: 1) use all available evidence to construct an argument, which results in premature closure of arguments (Biggs 1979), 2) recognize the difference between or implications of correlational and causational data, and 3) recognize that scientists routinely evaluate the validity of data, consider alternative explanations for the observed data, and propose experiments to test which of these explanations are correct (AAAS, 2011). Our results suggest aspects of data analysis and argument-building that need to be addressed in curriculum that aims to improve students' abilities to apply the process of science.

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Paper ID: 262

Figure Facts leads novice students to engage in more expert-like practices and improved interpretation proficiency when reading primary scientific literature

Jaclyn Dee (University of British Columbia)*; Warren J Code (University of British Columbia); Bridgette Clarkston (University of British Columbia)

Learning to read, synthesize, and evaluate primary scientific literature is crucial both for learning content while pursuing an undergraduate degree in Biology and for becoming an informed citizen. At the outset, however, novice readers struggle with interpreting data and research methods. As a result, unlike expert readers, novices tend to avoid the results and methods sections of papers and they do not feel that those sections promote their understanding of a paper. In a small, upper-division seminar course, a structured reading activity directing students to figures and data, named 'Figure Facts', was previously shown to improve students' ability to interpret data and reduced student anxiety when reading the primary literature. The extent to which Figure Facts might foster expert-like reading strategies and attitudes or enhanced data interpretation abilities has not been assessed in a larger, lower-division, lecture and lab-based course. As Figure Facts encourages students to read papers through a data-centric lens, we predicted that a greater proportion of students who completed the Figure Facts template would make the effort to independently analyze figures than students who wrote a structured summary. Moreover, we expected that the tabular structure of the Figure Facts template would focus student attention on one paper component at a time, thus reducing cognitive load and enabling students to better understand the readings and ensuring that they did not overlook important data. We also predicted that gaining a deeper understanding of the readings through successful figure interpretation would lead students to realize that interpreting data is a helpful activity rather than something that should be avoided. Using a crossover design with random assignment to two activity types, we compared reading behaviors and understanding of three assigned scientific papers between students who either completed the Figure Facts template or wrote a structured summary of the paper. Students self-reported reading behaviors via an online survey, and we explored Figure Facts template usage further via think-aloud interviews. In class, after each reading assignment, we posed four multiple-choice questions to assess understanding of the results, methods, and conclusions of the assigned research paper. In each assignment, we found that the students assigned the Figure Facts template were more likely to interpret figures than those assigned to write a summary. In addition, while completing the first assignment, only 4% of students who completed the Figure Facts activity reported spending most of their time on the paper's abstract, while 23% of students who completed the structured summary spent most of their time on the abstract. Furthermore, students who did the Figure Facts activity achieved higher scores, on average, on the in-class questions. During the think-alouds, we observed that the Figure Facts activity led students to read a paper in a more data-focused, expert-like, non-linear fashion. Finally, our qualitative data suggested that Figure Facts helped students persevere through difficulties in data interpretation and demonstrated how figure analysis could enhance their understanding of a paper. We conclude that employing an adaptable, low time-investment, data-centric activity like Figure Facts can give students much-needed practice and feedback with data interpretation. In turn, practicing data interpretation can help students develop more expert-like approaches and attitudes when reading the primary literature.

Paper ID: 216

Reframing the lab report: Epistemologically-oriented redesign of a laboratory course improves students' lab reports

Julia Gouvea (Tufts University)*

Writing a lab report can present students with an opportunity to think scientifically and practice constructing scientific arguments. However, students' lab reports often fail to contain evidence of having reached this potential (e.g. Holmes & Bonn, 2016; Xu & Talanquer, 2012). We argue that a reason for this is that students have learned to write in the genre of the "school lab report," the main purpose of which is demonstrating competence and canonical understanding to an instructor at the expense of proposing or defending one's own scientific ideas (Keys, 1999). The question we examine in this talk is how to shift students out of this "school" mode of writing and engage them in more substantive scientific thinking in their writing and in the laboratory activities that precede it.   The theoretical rationale for our study builds

on prior research that has demonstrated the role of epistemological framing in influencing how students approach learning activities in science classrooms (e.g. Scherr & Hammer, 2009). Epistemological framing describes the process by which students interpret the knowledge construction and evaluation practices that are appropriate in a given setting. For example, students may frame their role as knowledge “tellers,” and focus on demonstrating what they know to their instructor for the purpose of evaluation. In contrast, students may frame their role as knowledge “constructors,” understanding that they should propose, defend and refine their own ideas (Bereiter & Scardamalia, 1987). Framing has increasingly become a target of instructional design because it is dynamic and therefore can be shifted. If the learning context shifts, students’ framings may also shift, leading them to behave differently (e.g. Berland & Hammer, 2012). Our central design conjecture was that if we could shift students’ epistemological framing of a laboratory course, we might be able to shift the way students approach learning and writing within it. We conducted a multi-year design experiment targeted at shifting the epistemological framing of a laboratory course by 1) communicating to students that instructors valued their scientific reasoning over procedural competence or canonical conclusions and 2) creating opportunities to encounter theoretical uncertainty during the laboratory investigation so that students would perceive a need to think deeply. These changes were made in a stepwise manner. The first design iteration focused on reframing roles and assessments while the second design iteration introduced uncertainty. To evaluate our design conjecture, we conducted a rhetorical analysis of the Discussion sections of students’ lab reports. We used a modified version of the Structure of Observed Learning Outcomes (SOLO) Taxonomy (Biggs and Collis, 1982) because the three dimensions of this taxonomy relate to students’ epistemological framing. "Scope of Knowledge" evaluates the extent to which a report includes knowledge beyond what was given. We predicted that knowledge “telling” framings would limit the scope of knowledge because students would be unwilling to offer potentially wrong or tangential ideas, whereas “construction” framings would encourage creative use of prior or outside knowledge. "Structure of Connections" evaluates how evidence and claims are related. We predicted that knowledge “telling” framings would foster simple argument structures whereas “construction” framings would induce more complex arguments structures. "Consistency and Closure" refers to the degree of certainty with which claims are presented. We predicted that “telling” framings would result in certain claims (e.g “we proved”) whereas “construction” framings would be more appropriately qualified or left open-ended. Using the SOLO dimensions, we created four levels of quality in students’ Discussions. Level 1 reports relied on given information, used simple or tautological logic and closed on a certain conclusion. Level 2 reports used a subset of the data provided to argue for a one-sided claim that was presented without qualification. Level 3 reports used a larger subset of the data to examine conflicting claims, though they eventually settled on one conclusion. Level 4 reports integrated data with abstract concepts or outside knowledge to make complex arguments often resulting in appropriately qualified or open-ended conclusions. We selected a random subset of lab reports from across three implementation years of the lab curriculum: a baseline year, design implementation 1, and design implementation 2 and excised the Discussion section from each report for blind coding. Each report was coded by two coders. Initial levels of inter-rater agreement, calculated using Cohen’s weighted Kappa (Cronbach, 1968), were found to be 0.73, corresponding to a “good” level of agreement. All discrepancies were resolved through discussion until a consensus level was assigned. We found an increase in the quality of students’ lab reports across course iterations. For each year we calculated the number of reports scored as Level 1, 2, 3, 4 respectively: Baseline year ($N = 49$), 11, 27, 9, 2; Design Year 1 ($N = 45$), 1, 8, 26, 10; Design Year 2 ($N = 51$) 0, 0, 22, 29. The distribution of reports was significantly influenced by year, as measured by a Kruskal-Wallis test ($H = 64.7$, $df = 2$, $p < .0001$). Pairwise comparisons calculated using the posthoc Dunn test showed a difference between baseline and first iteration ($Z = 4.74$, $p<.0001$) as well as between first and second design iteration ($Z = 3.27$, $p = .003$). These results suggest that the first design iteration – focused on elevating students’ ideas – improved the quality of students’ reports and that the second design iteration – focused on increasing the uncertainty in the labs – further increased lab report quality. Across the iterations, students included a broader range of biological ideas, made more complex arguments, and were more likely to appropriately qualify their claims rather than simply presenting arguments confirming what they expected. These findings are consistent with our design conjecture: that shifting the epistemological framing of the lab can shift how students approached writing their reports. More specifically they suggest that while positioning students as authors can get them to be more thoughtful about their writing, having them make arguments about theoretically uncertain data produces better quality arguments. This suggests that an important design principle for inquiry laboratories is to design in opportunities for students to encounter theoretical uncertainty (Manz, 2015). More broadly, the general principle demonstrated in our design experiment is that specifically targeting the aspects of a learning environment that are contributing to unproductive "school" framings can unlock the potential for different patterns of behavior, and ultimately richer learning experiences (Bronfrenbrenner, 1979).

Paper ID: 119

To question or not to question: The impact of teaching students to write higher quality questions.

Pavan Kadandale (University of California Irvine)*; Vivian Chi (University of California, Irvine); Flora Myint Myat Thu (University of California, Irvine); Harleen Muhar (University of California, Irvine); Tiffany Ng (University of California, Irvine); Sarah Alkhatib (University of California, Irvine); Bonnie Cuthbert (University of California, Irvine); Steven Chabolla (University of California, Irvine)

Most teaching strategies emphasize skills that help students figure out answers to instructor-generated questions, scenarios, or problems. Work on teaching students to ask questions generally focused on reading comprehension, metacognition, or learning by construction of knowledge. In addition, previous work indicates that a staggering majority of student-generated questions are based on shallow features of the concepts being taught. There is scant literature on the effect of intentionally training students to write deeper questions on their learning in a Biology class, or the development of their higher order (as defined by Bloom's taxonomy) thinking skills. In this study we investigated three questions related to engaging students in writing questions in a lower division large-enrollment Biology class. (a) Does teaching students to write questions result in an improvement in the quality of student-generated questions, (b) Does writing better questions result in better performance on the class exams, and (c) Does the method of instruction on writing better questions impact student performance. We addressed these questions by having students in different sections of the class write questions based on a prompt at the end of every lecture. At the beginning of every lecture, instructors discussed examples of student-written questions from the previous lecture either by lecturing about the questions, or by engaging students in an activity discussing the quality of the examples presented. Multiple graders scored the quality of these questions, and using linear regression, we checked whether question quality improved over time. We used quantile regression to assess whether quality of questions impacted student performance, and whether mode of instruction impacted any of the variables studied. We find that writing better questions does, indeed, result in higher exam scores. However, students did not get better at writing questions throughout the quarter, and the mode of instruction (lecture-based vs. active discussion) had no impact on student question-writing. We will discuss possible reasons for these results, and how are findings might impact teaching techniques in large classes.

Paper ID: 279

The hidden effects of writing in science classes: examining self-efficacy, science identity, and differential demographic effects

Benjamin E Carter (Duke University)*

Mounting evidence has established that writing has positive effects on student learning gains. Writing-to-learn (WTL) pedagogy is a student-centered teaching strategy that uses writing activities to improve student understanding of concepts. The specific mechanisms by which student learning gains are made through the implementation of WTL warrant further exploration. We use a combination of pre-post student survey data, assessment data, and peer review engagement data to perform an in-depth exploration of how these variables change in response to a student-centered writing-intensive ecology course. We used paired t-tests to examine pre-post changes in quiz scores as well as changes in writing self-efficacy, science practice self-efficacy, and science identity. We found significant positive gains in assessment scores, self-efficacy in writing, and science identity. We used regression models to explore which groups might have had different learning gains than their peers, different gains in writing self-efficacy, and self-efficacy in science practice. The model explaining learning gains included their first quiz score, variables related to engagement in peer review, sex, and under-represented minority (URM) status. The overall model was significant, with URM status as the only significant individual component. A follow-up t-test

indicated that URM students were more likely to have higher average learning gains compared to their peers. The writing self-efficacy model included initial writing self-efficacy, URM status, and sex. It was also significant overall, with URM status the only significant individual component. A t-test showed greater gains in URM students' writing self-efficacy compared to their peers. Finally, we modeled self-efficacy in science practice by their initial science practice self-efficacy rating, URM status, and sex. This time, the only significant individual component was sex, and a follow-up t-test showed that female-identifying students showed significantly lower gains in self-efficacy in science practice compared to males. Our investigations indicate a number of positive effects on students. First, learning gains on conceptual assessments were significant across the whole class. Second, learning gains were significantly greater in URM students than in non-URM students. Third, of all subgroups examined, only one had significant gains in self-efficacy in writing, URM students. No group experienced significant gains in self-efficacy in science practice, but female-identifying students experienced significantly lower gains than males. This research provides evidence that instructors should expand the use of writing assignments in ecology courses. Since we measured many potential mediating variables, this study offers a peek inside the black box of how learning gains are achieved. Self-efficacy in writing may indeed be linked to the significantly greater learning gains achieved by URM students. Importantly, we have found that female students self-assess as having lower self-efficacy in science practice, despite being equally capable in terms of learning. In order to address this issue, we recommend using a pedagogical approach that specifically highlights diversity in science, and features the contributions of female scientists in particular. Finally, we are planning to use similar methods to expand our study across subjects and universities to shed more light on the inner workings of student learning in STEM.

Faculty Professional Development & Change

Paper ID: 45

The Effects of Instructional Discourse Practices on Students' Engagement: A Qualitative Case Study

Abdi Warfa (University of Minnesota)*; Petra Kranzfelder (University of Minnesota)

Student-teacher interactions are an essential feature of active-learning environments that lead to increased frequency of classroom discourse. However, the extent to which teachers are able to engage students in a dialogic discourse depends on how they employ instructional moves. For instance, discourse patterns of the form Initiate-Response-Evaluate (IRE) are known to limit student content engagement whereas those in the form of Initiate-Response-Feedback (IRF) enhance student engagement levels. Thus, a growing body of literature conceptualizes teacher discourse moves (TDMs) as epistemic tools for knowledge generation. This qualitative case study contributes to this body of literature by examining the discourse behavior of two biology instructors and the types of student responses invoked by their moves. Using extant coding protocols as well as the grounded theory approach (Strauss & Corbin, 1990) to identify emergent codes, our analyses relied on transcript data of classroom videos from the two instructors teaching in Active Learning Classrooms (N = 125 students). Our findings suggest that these two instructors employed both student-centric [e.g., constructing, explaining, and requesting] and teacher-centric [e.g., sharing, evaluating, and forecasting] discourse moves. These moves either avoided students' opportunities to discuss the biology content in much deeper levels or limited their content engagement. While the incidence of student-centric TDMs were overall lower (12%), more than 50% of student responses in those instances included reasoning, explanations or justifications. In contrast, when employing the teacher-centric TDMs, which were the dominant form of the discourse we observed, 67% of the student responses were of single phrase utterances or responses with limited justifications or explanations and only 30% included reasonable explanations. These findings suggest: 1) there is co-relation between TDMs and students' levels of reasoning; and, 2) TDMs can be used to orchestrate productive student-teacher interactions, especially in active-learning environments. This work highlights how attending to student-teacher interactions can result in better understanding of how faculty TDMs foster the development of students' content knowledge.

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Paper ID: 86

The role of departmental climate and self-efficacy in shaping early-career faculty teaching practices

Nathan Emery (Michigan State University)*; Diane Ebert-May (Michigan State University); Jessica Maher ("Delta Program in Research, Teaching, and Learning")

The need to better prepare faculty to excel at undergraduate biology teaching is a national issue that spurred the implementation of several large-scale professional development programs including the Faculty Institutes for Reforming Science Teaching IV (FIRST IV) program. FIRST IV focused on professional development of postdoctoral scholars from 2009-2012 who created research-based course designs and learner-centered teaching approaches in biology. FIRST IV postdocs demonstrated gains in learner-centered instruction during and immediately following the program (Ebert-May et al., 2015; Derting et al., 2016). We are investigating whether those same individuals, now as early-career faculty at new institutions and departments, sustain effective teaching practices initiated by professional development. We use the Theory of Planned Behavior (Ajzen, 1991) to frame our research and seek evidence of long-lasting behavioral change in how FIRST IV faculty teach, and the internal (self) and external (department) factors that contribute to ongoing teaching practice. Our study uses a longitudinal, paired design in which data on teaching approaches and observed practice are collected from 40 pairs of FIRST IV faculty and a matched comparison faculty in their department. We found that teaching approaches and practices, as measured by the Approaches to Teaching Inventory (ATI; Trigwell and Prosser 2004) and the Reformed Teaching Observation Protocol (RTOP; Sawada et al. 2002), developed during the FIRST IV program persist among faculty program alumni. FIRST IV faculty also demonstrate more learner-centered approaches and teaching practices than their comparison colleagues ($p = 0.032$; $p < 0.001$), even up to six years following their completion of the professional development program. We also collected data from the departments of the study participants, using the Survey of Climate for Instructional Improvement (SCII; Walters et al. in review) to assess how all faculty in these departments perceive support, resources, and leadership in teaching. We found that while the teaching practices of comparison faculty were positively correlated with perceptions of departmental support for teaching, collegiality, and leadership, the FIRST IV alumni teaching practices had no significant relationship with these subscales. Additionally, FIRST IV faculty had higher teaching self-efficacy (Connolly et al. 2018) than comparison faculty (F statistic = 5.39, $p = 0.023$). These findings suggest that the FIRST IV faculty might be empowered to be resilient to a broad range of teaching climates in academic departments.

Paper ID: 142

Teaching Professional Development: A Trajectory Toward Effectively Fostering a Focus on Student Thinking

Paula P. Lemons (University of Georgia)*; Jill McCourt (University of Puget Sound); Patricia Zagallo (University of Georgia); Michelle Smith (Cornell University); Jenny Knight (University of Colorado, Boulder); Tessa C Andrews (University of Georgia); Kevin Haudek (Michigan State University); Robert Idsardi (Eastern Washington University); Claire Meaders (Cornell University); John Merrill (Michigan State University); Ross Nehm (Stony Brook University); Karen N Pelletreau (University of Maine); Luanna Prevost (University of South Florida); Mark Urban-Lurain (Michigan State University)

There have been many calls for college biology instructors to integrate evidence-based practices that facilitate student learning of core concepts. To achieve this goal, instructors must learn to make student thinking - the mixture of normative and non-normative ideas that students build upon to develop biological expertise - central to their instruction. Instructors need support to orient their teaching toward student thinking. Professional development (PD) efforts, such as the Summer Institutes for Scientific Teaching, have enabled thousands of college biology instructors to increase their awareness of evidence-based practice. However, no PD model exists in higher education that explicitly trains college instructors to focus on student thinking. Our work has addressed this problem. The situated cognition perspective on learning asserts that instructors develop teaching knowledge through authentic experiences and collective inquiry with colleagues. Guided by this perspective we pursued the following research questions. • What factors motivate college biology instructors to persist in a long-term PD? • What are

the distinct personas that exist in a PD community? • What type of PD model could increase the focus of college biology instructors on student thinking? We investigated these questions using a community of 20 biology instructors at six R1 institutions who were part of a five-year national initiative providing professional development for users of Automated Analysis of Constructed Response (AACR) assessments. These instructors met three times per semester in cross-institutional learning communities. They used AACR constructed-response assessments, which are scored using computer-based analysis to quickly generate reports of student thinking. We gathered classroom observations using COPUS and conducted multiple semi-structured interviews with each instructor. We analyzed interview data through inductive and deductive coding and persona creation. What factors motivate college biology instructors to persist in a long-term PD? We drew upon expectancy-value theory to investigate this research question. Expectancy-value theory explains individuals' motivation to engage in an activity, such as PD, based on expectation of success and the value of the activity. All members of the AACR PD community exhibited motivation for long-term persistence in the community. Three sub-themes further illuminate instructors' motivations. First, instructors enjoyed the dynamics within their local communities. They respected the facilitators and enjoyed the diverse views their colleagues brought to each meeting. Second, instructors admitted that without the AACR PD community they might never talk with their colleagues about teaching. Finally, instructors worried about spending too much time in PD given competing demands on their time. Yet they agreed the low time commitment and convenience of the AACR PD made their ongoing involvement sustainable. Despite these encouraging findings, classroom observations revealed no increase in participants' use of student-centered pedagogies, unless participants were collaboratively developing an active-learning lesson. We worried that faculty were enjoying their time together without experiencing growth in their ability to use data on student thinking to inform their teaching. We next wanted to gain a clearer picture of the diverse blend of thinking, contexts, and practices of our participants. For this we used a well-established ethnographic approach that is novel in biology education research: persona creation. What are the distinct personas that exist in a PD community? Personas are fictional characters that represent characteristics of a population based on data from that population. Persona creation facilitates user-centered product design. If we think of PD as a product and instructors as PD users, personas provide a concrete tool that PD designers can reference as they plan and implement PD. We created personas using an established six-step process, which included standard qualitative techniques and quantitative cluster analysis. We also characterized the teaching practices of each persona based on COPUS observations. These methods revealed four distinct personas. Emmitt the Expert sees himself as the subject-matter expert in the classroom and values his hard-won excellence in lecturing. Emmitt uses didactic teaching approaches. Ray the Relater also primarily uses didactic teaching, but focuses on relating to students and considering their point-of-view, particularly their level of comfort with innovative pedagogies. Carmen the Coach coaches her students by setting goals for them and considering how she can use class time to help them achieve the goals using primarily interactive pedagogies. Beth the Burdened owns the responsibility for her students' learning. This sense of responsibility weighs her down, especially when she considers that students still struggle despite her tireless efforts to implement evidence-based practice. All four personas seek instructional materials and assessment ideas from PD. Yet beyond these commonalities, each persona needs unique PD. For example, Emmitt and Ray both want to build greater knowledge of student thinking, while Carmen and Beth appear to already possess this knowledge. The personas also allow us to see how Emmitt, Ray, Carmen, and Beth could benefit from PD tailored to their specific needs. What type of PD model could increase the focus of college biology instructors on student thinking? Given our research findings, we determined that a new PD model is needed. This model would capitalize on instructor motivation, acknowledge the diverse personas among PD participants, and help instructors make more progress in their development as practitioners who focus on student thinking. No such model exists in higher education, but K-12 education provides multiple possible models. Thus, we held a conference among experts from K-12 and higher education to define design principles of a new college biology faculty PD program. We determined that the new program should include the following design principles: a central focus on student thinking, participant engagement in video-based analysis of practice and opportunities for practice with feedback, 50+ hours of engagement over two years, small local groups with a trained facilitator, and instructor access to data on student thinking and shared lesson plans and assessments, and leadership development for PD facilitators. The body of work described in this abstract refines biology education research by producing a new, user-centered PD model derived from data. We will implement this model and investigate its feasibility and efficacy in the next phase of our

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research. This talk will be of broad interest to SABER attendees because it focuses on widening the use of evidence-based practice through an improved model of PD.

Paper ID: 188

The Ecology of Change: A longitudinal study of departmental transformation toward Vision & Change

Erika Offerdahl (Washington State University)*; Gita Bangera (Bellevue College); Steven Byers (Helping Human Systems); William Davis (Washington State University); Alyce DeMarais (University of Puget Sound); Ginger Fitzhugh (Education Development Center); Christine Goedhart (University of British Columbia); Nalani Linder (NP Linder Consulting); Carrie Liston (Education Development Center); Jenny McFarland (Edmonds Community College); Joann Otto (Western Washington University); Pamela Pape-Lindstrom (Harford College); Carol Pollock (Univeristy of British Columbia); Gary Reiness (Lewis and Clark College); Stasinos Stavrianeas (Willamette University)

The Partnership for Undergraduate Life Sciences Education (PULSE) is one of several national initiatives aimed at improving undergraduate life sciences education. PULSE comprises faculty (PULSE Fellows) from across the nation, and represents all institution types. PULSE Fellows work with department teams to support organizational aligned with the recommendations of Vision and Change (V&C). Within this national organization, the Northwest (NW) Regional PULSE Network was formed. With support from the NSF, the NW PULSE Fellows created a program consisting of (1) a three-day, team-based workshop on how to apply systems-thinking approaches to organizational change and (2) a mentored execution of department-transformation plan. Over the past five years, this program has engaged faculty teams from over 40% (63/148) of institutions in the NW region (AK, ID, MT, OR, WA, WY as well as one institution each from CA, UT, and NC), including 27 community colleges, 15 liberal arts, and 11 masters granting, 9 doctoral granting and one professional-degree granting institutions. Here we report on the short (7 month) and long (2-3 year) term outcomes reported by participants from the 45 institutional teams that formed the first three of five cohorts. Specifically, we employed a mixed-methods approach to (a) understand the ways in which NW PULSE supported departmental implementation of V&C recommendations, (b) identify strategies used by departments in their transformation efforts and the relative efficacy of those strategies, and (c) determine emergent practices that could be explored for other departmental transformation efforts nationwide. For each of the three cohorts from 2013-2015, pre- and post-surveys were administered prior to and immediately following the workshop and 6-7 months later. In 2018, an external evaluation team surveyed individual participants and conducted targeted interviews with Cohort 1-3 workshop teams to determine long-term effects of participation. Fifty-seven percent of the 138 individual participants responded to the survey; respondents represented 87% (39 of 45) of Cohort 1-3 institutions. Particularly successful and less successful schools were determined by survey responses to questions regarding the overall impact of the project on their institution, as well as reported use and success of various strategies. An outlier sampling approach was subsequently used to select 12 institutions (7 particularly successful and 5 less successful) to further examine the factors that contribute to departmental/institutional transformation. The selected institutions represented the range of institution types that participated in NW PULSE. Semi-structured interviews were conducted with faculty and administrator participants by the evaluation team. Fifty four percent of individual respondents indicated involvement in NW PULSE had made at least a moderate difference in their department. Participants identified particularly useful strategies for departmental transformation, including seeking faculty input, fostering a faculty learning community, and (re)designing curriculum. Other strategies that were implemented less frequently, but still had positive results, included changing faculty reward systems, engaging external partners, and using data sources other than student data. Having a systems thinking orientation was also associated with stronger impacts. The more often participants reported using systems concepts they learned through NW PULSE, the more likely they were to report that NW PULSE had made a moderate to large difference in their department. Further analysis revealed a number of mediating factors that appear to help or hinder the use and the effectiveness of transformation strategies. These mediating factors include: (1) the percentage of faculty involvement (more involvement was associated with greater reported NW PULSE impact), (2) presence or absence of administrative support (active administrative support was associated with more extensive and sustained efforts), (3)

departmental and institutional culture (organizations with a pre-existing tradition of embracing change or evidence-based decision making were positioned to consider changes more quickly), (4) department size (smaller departments sometimes had more flexibility and/or ability to engage all faculty in the effort), and (5) time to devote to the effort by NW PULSE team members and other faculty in the department (and having time often required administrators to make the effort a priority, funding for release time). Results from the first three cohorts will be of interest to the broader SABER community because they provide insight into potential “better practices” for supporting biology education reform initiatives. First, our data support the recommendation for systematic and inclusive engagement of faculty, especially faculty that represent the composition of the department (e.g., adjunct faculty, tenure-track, instructors) and those that have decision-making power or influence in the department (e.g. department chair, curriculum committee chair). Further, while a critical mass of faculty is needed for successful transformation, our data indicate that effective transformation can happen without the involvement of all department faculty members. Second, our data underscore the importance of providing a range of resources and support. Not surprisingly, there is no “one-size-fits-all” approach because each institution has its own unique context. That said, our data reveal that many strategies were reported to be effective across all institution types. Finally, our data demonstrate the efficacy of applying systems thinking to department transformation efforts. These data corroborate findings from the larger body of organizational change literature that encourage applying multiple levers (e.g., political, structural) across levels within the organization (e.g., individual faculty, department, college) to catalyze change.

Paper ID: 222

A Close Look at Change: Understanding Factors that Shape Instructor Evolution during Instructional Reform Efforts

Katelyn Southard (University of Arizona)*; Jonathan Cox (University of Arizona); Young Ae Kim (University of Arizona); Jazmin Jurkiewicz (University of Arizona); Lisa Elfring (University of Arizona); Paul Blowers (University of Arizona); Vicente Talanquer (University of Arizona)

Cognitively engaging students in content material is valuable and productive for student learning. This is often accomplished through the use of in-class instructional tasks (or active-learning activities), particularly in large-enrollment undergraduate STEM courses. As instructors begin using these instructional tasks in the classroom, it is important to understand what it takes to facilitate and sustain long-term adoption of constructivist and evidence-based teaching strategies to guide student learning. In order to aid instructors in the transition from traditional lecturing toward adopting these instructional tasks, we must better understand the individual and contextual strengths and challenges that impact an instructor’s reform efforts. By understanding factors that influence change during the process of transforming one’s classroom, we can better design professional development for navigating this complex and challenging transition. This study presents a close description of change through a microgenetic case study analysis as an instructor engages in instructional reform efforts. We explored factors that facilitated change and created barriers in her evolution from traditional lecturing toward building an active-learning classroom. Specifically, we investigate her evolution of perspective and practice in three key areas: 1) designing and implementing high-quality instructional tasks, 2) engagement in formative assessment, and 3) collaborating and communicating with her instructional team of graduate TAs and undergraduate learning assistants. Data were collected through in-class observations and audio recordings, pre/post-semester interviews, archiving of team email communications, and observations and/or recordings of team and professional-development meetings. Data were analyzed through a triangulated analysis: 1) a three-tiered descriptive timeline of key evolution events, including descriptions of change in context, nature of tasks, and motivations for change; 2) a cross-semester task analysis based on 5 key literature-based task dimensions; 3) a question-driven analysis of interview transcripts that examined perspective changes in the three key areas of investigation, and 4) an emergent coding analysis of instructor-team email communication data. Preliminary results indicate that the micro-community created by the instructional team played an important role in providing and promoting “space” to collaborate on improving the design, implementation and reflection of instructional tasks. These micro-communities uniquely reside at the intersection of pedagogy and discipline-specific content, an intersection not often found in other forms of teaching-community support (e.g., faculty learning communities). These micro-communities can provided frequent, detailed feedback to the instructor about student thinking. Additionally, we discovered that the drive for increased student engagement was a powerful motivator of change. However, learning-focused features (e.g., learning objectives and making student thinking visible) more significantly shaped evolution of task elements toward creating productive learning environments. Overall, the aim of this talk is twofold: 1) to characterize factors that potentially facilitate change and remove barriers during instructional-reform, and 2) to provide suggestions for addressing some of the challenges in designing and using in-class instructional tasks in large-enrollment STEM courses.

Sunday afternoon

Biology & Quantitative Literacy

Paper ID: 73

Is struggle necessary?: Exposure to R statistical programming and the effect on associated quantitative skills and values in biology

Emily Weigel (Georgia Institute of Technology)*; Timothy O'Sullivan (Georgia Institute of Technology)

Undergraduate biology students must develop mathematical and programming abilities to keep up with today's big-data world. Due to the explosive pace of technology, however, the quantitative skills and pedagogical practices of their instructors often lag behind current methods. Although inquiry labs are now somewhat common, students rarely have the opportunity to simultaneously design authentic experiments and quantitatively (statistically) analyze them with the current tools of the practice. This is all despite numerous calls for improving quantitative skills at the national level and increased need in the workforce. In short: we expect our students to value and learn these quantitative skills without giving them truly authentic experiences using them. To address this problem, we set out to assess whether exposure to a statistical programming language via guided tutorial (swirl in R) led to quantitative skill and value gains in students. We used a population of undergraduate students at a large southeastern R1 university enrolled in an optional, lower-division Ecology Lab course (N=64) which ran alongside a required Ecology Lecture (N=91). Students enrolled in lab (and lecture combined) were trained in R via the instructional package called "swirl", which included customized lessons aligned with course content; as a pseudo-negative control, students enrolled only in lecture received no training in swirl (N=27). While the lecture met three times a week and was taught in an active-learning format, the lab met once weekly and was taught as guided inquiry. We assessed quantitative skills and values via established assessment tools (Assessment Resource Tools for Improving Statistical Thinking [ARTIST], delMas et al 2007- 33 items; Math Biology Values Instrument [MBVI], Andrews et al 2017- 11 items) before and after a semester of instruction of R with swirl. We had three aims: to determine 1) whether students enrolled in lab had greater value for and were more skilled in statistics from the beginning of the semester, 2) whether laboratory courses that include swirl can be an avenue to learning and improving student values towards these skills, and 3) whether mere exposure to such concepts in lecture, but without a hands-on lab component, can be 'enough' alone to impact student skills and values toward mathematics. Our findings show that: Students were no more likely to take lab based on their abilities or value for quantitative skills (Welch's t-test, $p > 0.05$ in both cases) and students taking only lecture appeared to gain neither ability nor value of quantitative skills across the semester (GLMM, $p>0.05$). However, across the semester, students in lab did in fact increased in their quantitative skills (GLMM, $t = 4.4943$, $df = 39$, p-value = 3.042e-05), but did not appear change their values, which trended negatively, even when compared relative to previous semesters with the same coding tasks conducted 'by hand' without using swirl (GLMM, $p>0.05$). Although gender and racial diversity was low, these results appear to hold regardless of demography and prior coursework. These findings support that the use of swirl may decrease the cognitive load experienced by students, allowing for more meaningful practice with quantitative skills as compared to direct instruction. However, our findings suggest that making such tasks more approachable may have no affect and could actually 'backfire' for impressing upon students the value of such skills.

Paper ID: 51

Improving students' conceptual and statistical understanding of biological variation in a laboratory context

Jenna Hicks (University of Minnesota)*; Jessica Dewey (University of Minnesota); Maxwell Kramer ("University of Minnesota, Department of Biology Teaching and Learning"); Yaniv Brandvain (University of Minnesota); Anita Schuchardt (University of Minnesota)

Variation is an important concept that underlies experimental design and data analysis; skills students need to interpret scientific data and succeed in laboratory classes, directed research, and future careers. A lack of conceptual understanding of variation can preclude students from comprehending how to set up experiments to manage organismal and experimental variation, rendering data analysis meaningless. Despite the obvious linkage between variation and the study of biology, variation is seldom the subject of explicit instruction in the classroom, and reports show that students at all levels of education (from primary to undergraduate) struggle with the concept of variation in biology. Similarly, while students are taught to perform calculations of statistical quantities such as standard deviation, they fail to identify these calculations as a way to express variation. This lack of connection potentially hinders their interpretation of statistical analyses of experimental results. We developed a novel multiple-choice assessment (Biological Variation in Experimental Design and Analysis; BioVEDA) to probe students' understanding of variation at the intersection of biology, experimental design, and statistical analysis. The BioVEDA assessment was validated for use in introductory biology lab courses through expert review and student think-aloud interviews. Classical Test Theory item analysis of 431 student responses across two semesters was conducted. Investigation of student answer choices revealed several areas of difficulty, including interpretation of mathematical expressions of variation within a data set. We found that while 62% of students correctly identified a math expression of variation, only 42% of those students correctly interpreted the same math expression. A curricular intervention was designed based on student-centered model development theory to target areas of difficulty associated with variation in biological experimentation and data analysis. These areas of difficulty were identified from the literature and from preliminary BioVEDA assessment data. The curriculum consists of five activities, each targeting the concept of variation at different points throughout the experimentation process (experimental design, data collection, data representation, and data analysis). The curriculum was implemented in half of the sections of an introductory biology laboratory class using a quasi-experimental design, while in the remaining sections, instruction proceeded as usual (14 sections, 138 students). Student understanding of variation was assessed using the BioVEDA instrument before and after the laboratory skills portion of the course. Preliminary findings for one semester show that this curriculum is effective. Students who participated in the curricular intervention have significantly higher normalized gains on the BioVEDA assessment than those taught using the traditional curriculum (two-tailed t-test; $t(1, 136) = 2.28$, $p = 0.024$, moderate effect size of 0.39). These activities can be implemented in other courses to aid in developing students' conceptual and quantitative models of variation in the context of biology experimentation. The BioVEDA assessment will be a useful tool in a variety of classroom settings to determine what concepts related to variation, experimental design, and statistical analysis students are struggling with, and to assess curricula that target these areas of difficulty.

Paper ID: 156

Students' perceptions of the purpose of commonly used mathematical expressions in biology

Linh Chau (University of Minnesota)*; Anita Schuchardt (University of Minnesota)

Biologists use mathematical expressions in a variety of ways. Mathematical expressions can be used to make predictions, analyze data, calculate numerical answers, express scientific phenomena, etc. However, not much is known about students' thinking on the purpose of mathematical expressions in the classroom. It's important to understand students' view towards how mathematical expressions are used because, according to the resource framework by Elby and Hammer (2010), students' perceptions guide what tools or skills are appropriate in particular situations. Therefore, how students use mathematical expressions is influenced by students' views of the purpose of the mathematical expression. For example, if a student believes that the population growth expression is only used for data analysis, they are unlikely to use the expression to make predictions. This study investigated students' perceptions of the purpose of

five specific mathematical expressions commonly used in biology. We also examined the effect of different instructional factors on students' perceptions of use. Students from first and second semester introductory biology courses for majors (N = 657) were asked to complete a survey designed to assess students' perceptions of the purpose of five specific mathematical expressions associated with biology for different types of scientific practices. We chose five mathematical expressions that varied in their relevance to biology or statistics (e.g. Hardy-Weinberg equilibrium vs. T-test) and timing of instruction in the two-semester course sequence. Students were asked to indicate whether each of the selected mathematical expressions were useful in making predictions, data analysis, calculating a numerical answer to a problem, and expressing a scientific phenomenon. Cluster analyses, a tool used to find latent groupings within a dataset, was used to further investigate students' responses. Student cluster profiles differed based on the type of mathematical expression: biological (Hardy-Weinberg, Inheritance Probabilities, Population Growth) versus statistical expressions (T-test, Percent Error) (□2df = 5=2542, p <0.001). For biological expressions, student responses clustered into groups that included making predictions as a purpose and did not include data analysis. For statistical expressions, student responses tended to cluster into groups which included data analysis as a purpose for statistical expressions. When we compared cluster profiles between students in the first and second semester of an introductory biology sequence, we saw significant differences between students in the first and second semester (□2df = 10=369.65, p <0.001). For example, students in semester 1 fell into one cluster that responded population growth was useful in making predictions, calculating answers, and expressing scientific phenomena; while students in semester 2 fell into three clusters with different combinations of purposes for population growth. In the talk, we will present how students' perceptions of mathematical expression change over time. Preliminary results show that students' use of mathematical expression is dependent on type of expression and level of biology (semester 1 or semester 2). These results suggest that students may benefit from instruction targeted towards purpose depending on instructional goals and the mathematical expression.

Paper ID: 109

Students' perceptions of the extent to which mathematical expressions contain meaning predicts problem solving accuracy

Anita Schuchardt (University of Minnesota)*; Linh Chau (University of Minnesota); Fangfang Zhao (University of Minnesota)

The increasingly quantitative nature of biological research and medicine has sparked calls to increase instruction in quantitative biology at the introductory level. Observational and interventional studies have suggested that when students connect a mathematical expression to a physical phenomenon (Sensemaking) they are able to more effectively solve complex or novel quantitative problems. Students' confidence in quantitative problem solving is also thought to influence their success. However, the effect of both sensemaking and confidence on problem solving has not been investigated. The research questions for this study are: 1.What influence does Sensemaking (SM) and Confidence (Conf) have on students' quantitative problem-solving accuracy (Correctness)? 2.How do Conf and SM influence one another? This study included a cohort of undergraduate biology majors (N=259) who answered a Likert-scale survey at the end of both the first and second semesters of an introductory biology sequence. Students were asked about their sense of confidence (Conf), perception of biological meaning (biological sensemaking, BSM), and perception of mathematical meaning (mathematical sensemaking, MSM) for mathematical expressions associated with 3 biological topics; Hardy-Weinberg and Inheritance (HW, IN, covered in Semester 1) and Population Growth (PG, covered in Semester 2). Students were asked to solve either a novel or complex inheritance problem. Psychosocial factors such as Science Identity (SI) were assessed. Structural Equation Modeling (a technique that allows for investigation of causality and coordination of multiple factors impacting an independent variable) was used to analyze the impact of student survey responses on Correctness. Models were generated based on theory and preliminary regression analyses and refined based on goodness of fit, parsimony and elimination of nonsignificant connections. Preliminary regression analyses revealed that SI, Conf, BSM, MSM and ACT Math scores could influence Correctness. Therefore, initial models included these 5 variables. Semester 2 responses were predicted to be influenced by Semester 1 responses. A summary of the best fitting model for each mathematical expression will be presented here. All 3 models had acceptable fit indices (RMSEA=.04-.05, CFI=.97-.98). Because they are highly correlated, the best fitting model had BSM and MSM combined

into one factor (SM). ACT Math did not play a significant role in any model tested. SI did not affect correctness but was correlated with SM. For all models, Semester 1 SM predicts Semester 2 SM (ß=.5-.6, p<.001) and Semester 1 Conf predicts Semester 2 Conf (ß=.5-.6, p<.001). For IN, SM but not Conf was a significant predictor of Correctness (ß=.3, p<.01). However, for HW, Conf but not SM was a significant predictor of Correctness (ß=.4, p<.01). For HW, but not IN, Semester 2 Conf was also predicted by Semester 1 SM (HW: ß=.3, p<.01). Interestingly, because unlike HW and IN, PG does not represent genes, the best fitting PG model mimicked IN, with Correctness predicted by SM but not Conf (ß=.3, p<.01. These results suggest that students' Sensemaking is a significant influence (either direct or mediated by Confidence) on Correctness. Moreover, the HW results suggest that Sensemaking at time 1 can impact student Confidence at time 2. Thus, development of student Sensemaking of mathematical expressions should be an important part of instruction and future research.

Evolution Instruction

Paper ID: 148

Teaching sexual selection: factors and approaches affecting conceptual understanding of sexual selection theory in undergraduates.

Sarah H Spaulding (University of Louisville)*

Sexual selection (SS) is commonly taught in introductory and upper-level biology courses. The way that SS is understood has changed; originally the "classic" view envisioned fixed sex roles like female choice and male competition. A new, "expanded" understanding of SS recognizes variability in behaviors and the role of social and environmental context in promoting flexibility in what were originally thought to be "sex-specific" behaviors. College evolutionary biology textbooks present mainly the classic view of SS. This not only presents an inaccurate depiction of SS that is not supported by empirical data, but also promotes biological gender essentialism and encourages students to believe that sex roles are fixed- factors that are linked to stronger self-stereotyping.   We examined the relationship between how students understand SS and their beliefs about gender stereotypes associated with gender essentialism. Our research questions were: (1) What misconceptions do students hold about SS? (2) Does the presentation of classic vs. expanded examples of SS influence student understanding of the basic theory? (3) Is the ascription to gender stereotypes and essentialism related to student understanding of the classic vs. expanded versions of SS? To address conceptual understanding, we created content assessment questions and a series of examples for the corresponding instruction method treatments (classic vs. expanded SS; a natural selection treatment was included as a control). We used validated instruments to measure gender essentialistic beliefs, views on sex roles (traditional vs. egalitarian), and gender self-stereotyping. We coded and qualitatively analyzed student responses to open-ended questions on the assessment. We used quantitative analyses to examine scores on the assessment and the relationship between these scores and measures of gender stereotypes and essentialism. We had 448 undergraduate student participants.   The most common misconceptions about SS included the beliefs that sex roles are fixed and that SS acts on males, but not females. We found that the sequence of classic and expanded examples did not influence total scores on assessment, indicating that teaching the more complex expanded examples does not hinder understanding of SS theory. This is important because it shows that textbooks and classes can use more complex, contextual and realistic examples without risking the loss of understanding SS in general. According to scores on the instruments, 89% of students supported egalitarian views on sex roles, 33% of students endorsed social gender theory, and 21% endorsed biological gender theory; however, these scores were not related to conceptual understanding of SS. The application of gender stereotypes in open-ended responses was ubiquitous and occurred regardless of student demographics or the manner in which SS theory is presented. This suggests that these misconceptions and stereotypes are subconscious and may arise from long-term reinforcement of sex role stereotypes that students are exposed to prior to attending university. Results from our study will be used to (1) inform which types of examples of SS should be presented to students, and (2) increase awareness of gender stereotypic representations and their effect on student gender role perceptions.

Paper ID: 153

The Impact of Constructivism and Active Learning on a Curriculum That Increases Evolution Acceptance, and the Concepts That Matter Most

Clint Laidlaw (Brigham Young University)*

The entire field of biological science is unified by the theory of evolution. Without evolutionary theory, biology becomes a tangential assemblage of facts; biology is often regarded as such by students today. This may be at least partially due to the fact that evolutionary theory is often brushed over or avoided completely out of concern that it will be rejected by students. Many studies have shown that acceptance is not inherently connected to instruction. When students do not accept evolution they tend not to apply it outside of the contexts presented in class or to remember what was taught, making its continued instruction difficult to justify. This leads us to ask a few important questions: 1) Can we create a curriculum that increases evolution acceptance? 2) Does the pedagogical style implemented influence acceptance? 3) Can we isolate examples/concepts that were most influential? To determine if we could create a curriculum that increases evolution acceptance we designed a curriculum where evolution is not merely a unit that is covered and then left behind, but a constant theme of the course which is tied into every aspect of instruction. The first half of instruction focused on the nature of science, genetics, and the mechanisms of evolution. The second half focused on Phylogenetics and organismal diversity taught in a phylogenetic context. At no point were evidences of evolution presented in the context of "evidence for evolution", but it was simply the overarching theme of the course as a whole. This curriculum was then taught to students enrolled in freshmen-level introductory biology for non-majors from a large open-enrollment public university with high levels of religiosity using a variety of pedagogical styles. To assess whether this curriculum generated acceptance gains, all students completed the Measure of Acceptance of Evolution (MATE) instrument at the beginning of the semester (before instruction) and again at the end of the semester (after instruction). The MATE consists of 20 questions scored on a six-option Likert scale where each option is scored from 0-5 with a total score ranging from 0-100. We observed an average increase in acceptance of 15.294 points on the MATE ($p>.001$). This increase was in excess of one full standard deviation (13.497) and confirmed that our curriculum was adequate to increase acceptance of evolution. To determine if the pedagogical style in which the curriculum was taught was influential in generating acceptance gains as a result of instruction, we presented the curriculum utilizing a variety of pedagogical styles. As active learning and constructivist pedagogies are frequently hypothesized to influence acceptance, we tested both of these techniques and the interactions between them. Classes were randomly assigned to be either active classrooms or lecture classrooms. Both were then randomly assigned to be either constructivist (where evidence was provided in an exploratory manner and conclusions were subsequently drawn from the evidence), or behaviorist (where conclusions were provided and the evidence was provided subsequently to confirm those conclusions). This resulted in four treatments: behaviorist/active, behaviorist/lecture, constructivist/active, constructivist/lecture. Additionally, we were interested in the impact on acceptance of keeping a reflexive journal detailing how the concepts that students learned in class related to evolution if/how they altered students' perception of evolution. Given that reflexive journals have been shown to increase learning and acceptance in other fields, this might be a way to increase acceptance without forcing instructors to completely redesign their courses. As journaling may have a greater impact on some combinations of treatments over others, each of the four treatments were randomly assigned to either keep a journal or not keep a journal, resulting in eight total treatments including all possible interactions of the three variables. All eight treatments were presented with the same curriculum and taught by the same instructor. We were surprised to find that none of our experimental treatments had a significant impact on acceptance. There was no significant difference in acceptance increase based on whether the class was taught as active or lecture ($p=.586$), using a pedagogy based on constructivism or behaviorism ($p=.247$), or whether students were or were not keeping a reflexive journal about evolution ($p=.839$). Additionally, no interactions were significant. The curriculum was highly successful in increasing acceptance of evolution (from a mean MATE score of 60.68 to 75.32), but the differences between the gains were not significantly different between pedagogical approaches. In addition to testing if keeping a reflexive journal impacted acceptance of evolution, the journals gave us a look into the thoughts of the students related to which concepts made an impact on their position on evolution. Journals were selected for thematic analysis for all students that scored 59 or lower on the MATE before instruction (i.e., were not accepting) and that completed the MATE following instruction. Journals were coded by five raters with an inter-rater reliability greater than

85% for each individual comparison (not an average, no comparisons were below 85% identical). Journals were coded by the themes from the course that the students reported to have altered their position on evolution, and then analyzed to determine which themes had a correlation between being mentioned as influential and a change in acceptance of evolution. We found multiple emergent themes that had a significant influence on change in evolution acceptance. Some were positively correlated with acceptance (sexual reproduction, vertebrates to land, birds are dinosaurs), and some were negatively correlated with acceptance (constructing phylogenetic trees, the relationship between humans and other organisms). Some of these themes were very surprising, especially those that negatively impacted acceptance. Previous research has shown that constructing phylogenetic trees can actually introduce many misconceptions. Those misconceptions may impede acceptance. And a focus on our relationship to other organisms may have triggered some defensiveness from some students and reduced the likelihood of increasing acceptance of evolution. Overall, we were able to develop a curriculum that increases acceptance of evolution through instruction using a wide-range of pedagogical styles. We were also able to identify a few key topics of study that influenced, positively or negatively, acceptance of evolution among students that were initially unaccepting of evolution. Such knowledge could play an important role in shaping the way that we teach biology, especially evolution, with the intention of increasing acceptance among our students.

Paper ID: 228

Testing the Effect of Human Examples When Teaching Evolution

Daniel Grunspan (Arizona State University)*; Ryan Dunk (Syracuse University); Jason Wiles (Syracuse University); Elizabeth Barnes (Arizona State University); Sara Brownell (Arizona State University)

Recommendations to use human examples when teaching evolution are becoming more common in the literature. Several reasons have been provided for why human examples may provide advantages for teaching evolutionary concepts. One of the more common reasons given is that human examples will be more relevant to students and result in higher intrinsic motivation to learn. However, there is little evidence of the benefits to using human examples in evolution instruction, and evidence that does exist is often limited to instructor self-report or studies without appropriate comparison populations. Further, empirical studies in this area have yet to account for potential discomfort that could be introduced when using human examples of evolution. To address these gaps in the literature, we tested the impact of using human examples compared to animal examples on students learning evolution. Our research questions were: 1) Do human examples increase students' motivation to learn evolution content? 2) Do human examples increase student perceived relevance of evolution content? 3) Do human examples lead to increased learning gains for evolution content? 4) Do human examples lead to greater discomfort for students learning evolution? And 5) does a students' perceived conflict between evolution and their own religious beliefs moderate any of the above associations? We performed our study in a large split-section introductory biology course for majors at a R1 institution in the Northeast. We designed a completely isomorphic lesson, where students analyzed molecular data and answered questions about the resulting phylogeny. The only difference between these lessons were that one lesson labeled the species as humans along with other primates, and the second lesson labeled the species as various species of badgers and weasels. Students completed this activity in a single day, with each section receiving one of the two isomorphic lessons. Before the class day, students completed surveys about the biology class that measured how relevant they perceived course content to be, motivation in the class, comfort levels in the class, and the Tree-Thinking concept inventory. After the activity, the students completed the same surveys, except they were directed to specifically consider the phylogeny lesson they experienced. The students also completed surveys on their perceived conflict between evolution and religion, their own religiosity, and their acceptance of evolution. We ended up with a final dataset that included 85 students who completed all surveys in the human condition and 89 students who completed all surveys in the non-human animal condition. Multiple linear regression models were used to test the impact of the human example activity compared to the isomorphic animal example activity on relevance, motivation, learning gains, and discomfort, while controlling for responses on their pre-survey. We further tested whether perceived conflict between one's religion and evolution moderated relationships between the example used and outcomes of interest. Students in the human section scored significantly higher in their concept

inventory post score compared to students in the animal section, controlling for scores on their pre-test. The difference amounts to a half a letter grade higher on the concept inventory between students who scored equally on the pre-score. However, human examples did not result in any differences in students' report of relevance of the content or motivation during the activity. Further, in the human condition, students who perceived greater conflict between their religion and evolution reported greater discomfort compared to those in the animal condition. We discuss the implications of this research, how it informs best practices in teaching evolution, and important future steps in considering the use of human examples in evolution instruction.

Paper ID: 61

Implementing the Teaching for Transformative Experiences in Science Model in Introductory Biology for Non-Majors

Rachel A Sparks (Illinois State University)*; Rebekka Darner (Illinois State University)

Evolution is the basis for all biological processes and fields of study. Thus, a comprehensive understanding of evolution is necessary to properly learn, practice, and apply life sciences. Unfortunately, education literature reveals that naïve conceptions about evolution exist in all groups of students, particularly non-scientists. Common naïve conceptions include individuals adapting to their environment, individuals developing mutations that can be passed on to offspring, and evolution as an intentional process of an organism or population, among many others. Students' naïve conceptions are rooted in preexisting conceptual frameworks based on prior knowledge and experiences. They are often robust and resistant to change, making it difficult for conceptual change to occur. The classic model of conceptual change suggests that students must experience cognitive dissonance with their preexisting framework before being exposed to other plausible frameworks. Since naïve conceptions are so deeply rooted, conceptual change strongly emphasizes the student and their experiences. If students do not perceive content as relevant and worthy of retention and further use, conceptual change is unlikely. Therefore, it is necessary to make material relevant to students' lives to access their preexisting frameworks and have the opportunity for conceptual change. The Teaching for Transformative Experiences in Science (TTES) model asserts that quality science education should be related to students' daily lives and uses transformative experiences to foster these connections. Transformative experiences occur when students actively use a concept in their lives, which enables them to understand an aspect of the world and develop an appreciation for the content. The TTES model was used in prior literature to encourage transformative experiences in undergraduates with limited biology backgrounds, resulting in significantly higher transformative experiences and significantly greater post-test scores on a conceptual change instrument than the comparison group. Based on this literature, we developed the TTES model as an instructional framework for an introductory non-major biology course taught through an evolutionary perspective. This course was structured as a flipped classroom, with evolutionary principles taught in conjunction with general biology concepts. A conceptual knowledge assessment designed to diagnose naïve conceptions was given at the beginning, middle, and end of the course, along with the Likert-scored Transformative Experience Survey (TES) given at the end of the course. The TES showed that after the course, students applied evolutionary theory to their lives to a moderate degree, indicating that the TTES model can lead to a greater appreciation for evolution in non-biology majors. Nonparametric analyses of variance of student scores on the pre-, mid-, and post-course assessments showed that conceptual understanding of evolution significantly increased in students in the TTES group [$\chi2(2) = 6.06$, $p = 0.0483$], while students in a conventionally taught section experienced a nonsignificant change. Analysis of the individual evolutionary concepts of adaptation, variation, inheritance, speciation, domestication, and extinction showed positive trends of increased understanding of these concepts. Further analyses will elucidate how the incidence of specific naïve conceptions changed throughout the semester as a result of TTES-based instruction.

Instrument Design & Implementation

Paper ID: 93

Exploring the role of learning assistants in the classroom: Development and use of a social supports survey

Dania Hernandez (Florida International University)*; Gema Jacomino (Florida International University); Sarah L Eddy (Florida International University)

Active learning strategies are being adopted in a growing number of university STEM classrooms. One way instructors implement active learning in large classrooms is by recruiting and training undergraduates to serve as learning assistants (LA). LAs facilitate classroom learning through one-on-one discussions with and coaching of students during in-class activities. LAs have been shown to improve student performance on exams and the quality of student conversations. Currently, we do not fully understand how LAs influence these outcomes for students. In this study, we explore how the social supports provided by LAs influence students' self-reported engagement and buy-in to active learning in six introductory chemistry classes. Social support theory suggests that instructors can provide multiple spheres of social support that contribute to students' motivation, engagement, and academic success. Social support is the perception that one is cared for and has assistance available from other people. In large classrooms, LAs could provide this support. Four categories of social supports are thought to be relevant to the classroom environment: emotional (making students feel valued), appraisal (constructive feedback), informational (clarify class goals and norms), and instrumental (clear advice and instructions). Provision of these four social supports has been linked to a positive relationship between the provider (in this case, LAs) and the receiver (students) which ultimately enhances the receiver's engagement. However, the majority of the work on social supports has been done in K-12 settings and undergraduates may react to these supports differently. We addressed this gap in the literature by first developing a social support survey for use with undergraduates in active learning classrooms that captures emotional, appraisal, informational, and instrumental supports from LAs. We deployed this survey and three scales capturing engagement in in-class activities across six introductory chemistry classes ($n = 827$ students) required for the biology major at a large Hispanic-serving institution. The engagement scales included deep engagement, surface engagement, and buy-in from an instrument developed by Dr. Brian Couch and colleagues. We established the structure of the survey by splitting the initial full sample into two samples. We ran exploratory factor analyses on one and confirmed the final factor structure with the second sample. We found strongest support for a 3-factor solution. This structure was confirmed by the CFA, yielding the final factors of 1) emotional & instrumental, 2) appraisal, and 3) informational support (CFI=0.94, RMSEA=0.066 [(90% CI: 0.06 - 0.07]; SRMR=0.036). Finally, using linear mixed-effects models we found some supports were more predictive of engagement than others. Informational support predicted engagement on two of three engagements scales (buy-in [$\beta=0.46 \pm 0.097$, $t=4.8$, $p<0.0001$] and deep engagement [$\beta=0.24 \pm 0.078$, $t=3.1$, $p=0.0023$]). Emotional/instrumental support also predicted deep engagement ($\beta=0.19 \pm 0.096$, $t=1.9$, $p=0.0543$). Appraisal did not predict any type of engagement. This study suggests that student engagement is most impacted when LAs provide informational supports around the value of active learning and how to engage in it and possibly when they provide emotional & instrumental supports. These findings have implications for how we train and coach LAs about their roles in the classroom.

Paper ID: 62

Student reasoning about matter and energy transformation across contexts: psychometric evaluation of cognitive coherence using Rasch analysis

Gena C Sbeglia (Stony Brook University)*; Ross Nehm (Stony Brook University)

Matter and Energy Transformation (MET) is one of five core concepts of biological literacy highlighted in Vision and Change (AAAS, 2011). Although Open Educational Resources (OER) exist for many areas of biology, they remain underdeveloped for MET. Our project (MEDAL: Matter and Energy Digital Assets for

Learning) is developing an OER library containing: (1) a formative assessment database; (2) interactive, web-based simulations; (3) a video library; and (4) active-learning materials. Here we report on Phase I of our project: development and psychometric analysis of a formative assessment database and evaluation of what these items reveal about cognitive processes about MET. Our assessment database was developed using established cognitive principles, in particular, evidence that students' biological reasoning is often fragmented and situated (e.g., impacted by taxon and scale). Our cognitive framework for MET item development included five different features: (a) movement of matter, (b) movement of energy, (c) organismal context (e.g., mouse, fungus, plant), (d) life stage (e.g., living tree, dead log), and (e) biological scale (e.g., individual to population). A group of five experts in biology and education established content validity vis a vis our cognitive framework. We piloted 50 items in a large and diverse population (URM = 23%, n = 505) of biology undergraduates. We explored three research questions (RQs) about our MET formative assessment database: (RQ1) Using Rasch analysis, do items display acceptable reliabilities and fit statistics? (RQ2) Does student reasoning display cognitive coherence across item features? And (RQ3) Does student reasoning display different difficulties across matter, energy, plant, and animal contexts? For Phase 1 of our study, we classified items into a MET subtopic (matter vs. energy), an organismal (animal vs. plant) context, and removed integrative combinations. Rasch analyses of the 42 remaining items indicated that: students had substantial difficulty in overall reasoning about MET ($\bar{X}$ = 30%), items displayed moderate but acceptable reliabilities (Item/Person separation = 0.66, 0.59), and 97% of items had acceptable Rasch fit statistics (0.5-1.5). We investigated item multidimensionality (MET subtopic, organismal context) by comparing uni- and multidimensional Rasch models using a likelihood ratio test. The item set was unidimensional ($\chi 2$ = -24.87 and -55.04, df = 2, $p > 0.05$). When we analyzed item difficulty measures, differences were apparent across features. Specifically, using a linear regression model that included MET subtopic, organismal context, and interactions thereof, we found that matter items were more difficult than energy items (β = 1.19, $p < 0.05$), but the precise relationship depended upon whether the item was about a plant or animal (β = -1.44, $p < 0.05$). The most difficult items were about matter in animals and the easiest items were about matter in plants. Overall, our Phase 1 findings indicate: the item set functions well within a Rasch framework, undergraduate students have great difficulty with MET, and students do not think coherently about MET across contexts. We will discuss the implications of our findings for teaching and assessing MET in undergraduate education.

Paper ID: 66

Development and National Validation of the BioSkills Guide: A Tool for Interpreting and Teaching Core Competencies

Alexa Clemmons (University of Washington)*; Jerry Timbrook (University of Nebraska-Lincoln); Jon Herron (University of Washington); Alison Crowe (University of Washington)

To be successful in modern STEM careers, biology majors need training in a range of transferrable skills, and yet skills training is often a relatively underdeveloped facet of the undergraduate curriculum. To address this discrepancy, we have elaborated the core competency framework from Vision and Change into measurable learning outcomes which can be more easily interpreted and implemented by faculty. The resulting resource, called the BioSkills Guide, was developed and then validated using input from over 500 college biology faculty from a range of institution types, biology subdisciplines, and course levels. To reach consensus among a variety of stakeholders, we used a mixed-methods approach, including a five-phase iterative process of learning outcome review and revision. After preliminary draft development at our home institution, we gathered external feedback from college biology educators using a combination of surveys, interviews, and workshops. Survey respondents (n=93 across five phases) rated each outcome on a 5-point scale indicating (1) clarity and (2) importance of the outcome for a graduating general biology major. Respondents were also asked to comment on their responses, suggest missing outcomes, and evaluate outcome categorization. For outcomes with low consensus, we triangulated our quantitative survey data with qualitative faculty feedback collected using semi-structured interviews (n=14) and small workshops at regional and national meetings (n=115 across five phases). Throughout this process, we monitored faculty demographics (e.g., institution type, biology subdiscipline) to ensure the content of the guide was representative of perspectives of the broader college biology educator community. After each of our five phases of review, revisions were made by committee, cumulatively considering both quantitative and qualitative feedback. We gathered evidence of the

BioSkills Guide's construct validity using a national survey of undergraduate biology faculty. Respondents (n=397) again rated the importance of each outcome for a graduating general biology major, and had the opportunity to comment on their responses and suggest missing outcomes. Across the 77 outcomes in the final draft, individual outcomes had between 73.5% and 99.5% support (rating of 'important' or 'very important') among respondents. Only four outcomes had <80% support, and 54 had >90% support. Our national sample included faculty across a range of course levels taught, subdisciplines of biology taught, and institution types. We therefore conclude that the learning outcomes in the BioSkills Guide are generally representative of the priorities of undergraduate biology faculty. We envision the guide helping with a range of applications in undergraduate biology, including: backwards design of individual lessons and courses, competency assessment development, curriculum mapping and planning, and facilitation of ongoing conversations among faculty, especially about less well-defined competencies (i.e. Modeling & Simulation, Interdisciplinary Nature of Science).

Paper ID: 89

Tools for change: Bio-MAPS assessments measure student conceptual understanding across different undergraduate biology programs

Michelle Smith (Cornell University)*; Cole Walsh (Cornell University); Sara Brownell (Arizona State University); Brian Couch (University of Nebraska-Lincoln); Katharine Semsar (University of Colorado, Boulder); Alison Crowe (University of Washington); Natasha Holmes (Cornell University); Jenny Knight (University of Colorado, Boulder); Christian D Wright (Arizona State University); Mindi Summers (University of Calgary)

Program-level assessments, administered at multiple points throughout an undergraduate curriculum can be powerful tools to measure student learning. Assessing students at this level can motivate faculty to agree on the essential learning outcomes of their program and consider how students will achieve them. These assessments can also assist departments in determining the cumulative impact of their courses and pinpointing areas for improvement. Assessing student achievement requires that departments have access to instruments that align with their learning goals. Until now, biology departments have had few options. Many concept assessments measure student understanding of a specific topic, but few gauge understanding across the major. It can also be challenging for faculty to choose particular assessments for their departments if they do not align well with the broader learning goals of the department or if a data set of results from other institutions does not exist. To meet these needs, we developed a suite of freely available instruments called Biology-Measuring Achievement and Progression in Science (Bio-MAPS). These assessments measure conceptual understanding at key time points: 1) beginning of introductory biology, 2) end of introductory biology, and 3) just before graduation. There are separate assessments for general biology, molecular biology, physiology, and ecology/evolution. Each question stem presents a scenario, followed by a series of statements that students evaluate as true/false or likely/unlikely to be true. This multiple-response format allows the rapid collection of fine-grained information on student understanding across many concepts, while retaining the convenience of automatic grading. We followed established methods of assessment development, including optimizing response validity through student interviews, ensuring technical accuracy through expert review, pilot testing at a variety of institutions, and addressing any potential item biases favoring particular demographic groups. To support faculty in using these assessments for large-scale evaluations, we designed a web portal that builds on existing portals in physics education research. Instructors fill out a brief survey (average time 4.3 minutes) and then receive a web link that they share with students. Students complete the assessment online, outside of class (average times for assessments range from 20-30 minutes), which eliminates the need to devote class time to administering the assessment. After student access to the instrument has closed, the portal returns a report to the instructor, which provides aggregated information on overall student performance and by each Vision and Change core concept. Here, we report on the use of the Bio-MAPS assessments since the portal creation in January, 2019, including information about the number and types of departments (thus far, >1500 students from eight classes). We will also discuss features of departments that plan to use these data to monitor student performance and identify trends such as when a particular concept shows little growth, and how our interdisciplinary collaboration led to advances in biology assessment practices. While the impact of a college education cannot be fully captured by a single instrument, Bio-MAPS assessments enable departments to more easily measure student learning across key time points and make data-driven decisions about their undergraduate curriculum.

POSTER INFORMATION

Saturday

#1-29--- 2nd floor white boards

#1 **How instruction with multiple equations promotes knowledge coordination in physiology** Paper ID 38 Matthew Lira (University of Iowa)*

#2 **Validity of the Revised Student Process Questionnaire (R-SPQ-2F) in Undergraduate Anatomy & Physiology Students** Paper ID 40 Staci N Johnson (Clemson University)*

#3 **Using NeuroNotebooks to Improve Students' Understanding of Developmental Neurobiology, Attitudes Toward Research, and Experimental Design Competency** Paper ID 110 David Esparza (University of Texas at El Paso)*; Nayeli Reyes (University of Texas at El Paso); Karina Leon (University of Texas at El Paso); Anita Quintana (The University of Texas at El Paso); Jeffrey T. Olimpo (The University of Texas at El Paso)

#4 **Alluvial diagrams track student reasoning pre- and post-instruction as assessed by the Electrochemical Gradients Assessment Device (EGAD)** Paper ID 111 Jack Cerchiara (University of Washington)*; Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington)

#5 **Oaks to Arteries: Principle-based Reasoning Varies with Physiological Context** Paper ID 113 Jack Cerchiara (University of Washington)*; Emily Scott (Univ. Washington); Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington)

#6 **Impact of out-of-class video presentations for content review in an allied health pathophysiology course** Paper ID 169 Kristen L Walton (Missouri Western State University)*

#7 **A learning progression characterizing how students use mass balance reasoning to understand physiology** Paper ID 195 Emily Scott (Univ. Washington)*; Jack Cerchiara (Univ. Washington); Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington)

#8 **Assessing the impact of "Osmotion": an active learning module focused on improving comprehension of osmosis and diffusion for underrepresented minority students** Paper ID 165 James Boyett (University of Alabama at Birmingham); Sebastian Schormann (University of Alabama at Birmingham); David Esparza (University of Texas at El Paso); Jeffrey T. Olimpo (The University of Texas at El Paso); Samiksha Raut (UAB)*

#9 **Connecting ideas across courses: Relating energy, bonds, and how ATP hydrolysis can power a molecular motor** Paper ID 225 Abby Green (Michigan State University)*; Kristin Parent (Michigan State University); Sonia Underwood (Florida International University); Becky Matz (Michigan State University)

#10 **A Comparison of Instructional Design Approaches for Teaching Noncovalent Interactions in Biochemistry** Paper ID 175 Stephanie Halmo (University of Georgia)*; Sasha Stogniy (University of Georgia); Logan Fiorella (University of Georgia); Paula P. Lemons (University of Georgia)

#11 **Collaborative Active Learning Spaces Foster Increased Relatedness and Participation in Introductory Biology Students** Paper ID 220 Kim M Pigford (NC Wesleyan College)*; Miriam Ferzli (NC State University); Margaret Blanchard (NC State University); Michelle Nugent (NC State University)

#12 **How are tours of Botanical Gardens enhancing the student experience in General Bio 2?** Paper ID 17 Melissa R McCartney (Florida International University)*; Simone Oliphant (Florida International University); Ateev Shirajee (Florida International University); Jessica Colon (Florida International University); Jose Alberte (Florida International University)

#13 **Impact of knowledge surveys and student demographics on metacognitive knowledge in an introductory biology course** Paper ID 20 Ginger R Fisher (University of Northern Colorado)*

#14 **Curiosity killed the cat!: Characterizing student-generated questions in a non-majors biology lab** Paper ID 90 Kimberly K Booth (North Dakota State University)*

#15 **Development of an Integrated First-Year Undergraduate Biology and Chemistry Program** Paper ID 159 Stefanie R DeVito (University of Delaware)*; Alyssa Hull (University of Delaware)

#16 **Osmosis and diffusion: Examining the effects of instruction on student engagement and knowledge retention in an introductory biology laboratory course.** Paper ID 171 Aakanksha Angra (Georgia State University)*

#17 **Making Biology a Game Worth Playing** Paper ID 173 William E Falkner (Central Michigan University)*; Debra L Linton (Central Michigan University)

#18 **Modeling Global Citizenship Education in the Tibetan Buddhist monastic science classroom** Paper ID 234 Kelsey Gray (Emory University)*; Jacob Shreckengost (Craig H. Neilsen Foundation); Carol Worthman (Emory University); Arri Eisen (Emory University)

#19 **Digging Deeper into the Cost Component of Expectancy-Value Theory and its Relationship to Gender and Student Performance** Paper ID 180 Melissa L Aikens (University of New Hampshire)*

#20 **Scientific literacy and interdisciplinary thinking via embedded research in a non-majors environmental science course** Paper ID 120 Keith E Gilland (University of Wisconsin-Stout)*; Emily Makina (University of Wisconsin-Stout); Stephen Nold (University of Wisconsin-Stout)

#21 **Investigating relationships among the individual, the team, personal strengths, and peer evaluation in a team-based introductory biology course.** Paper ID 144 David E Steen (University of Minnesota)*; Susan Wick (University of Minnesota)

#22 **Fear of negative evaluation: A novel construct underlying student anxiety in active learning college science courses** Paper ID 46 Katelyn M Cooper (Arizona State University)*; Virginia Downing (Arizona State University); Logan Gin (Arizona State University); Sara E Brownell (Arizona State University)

#23 **Examining the Landscape of Anxiety in Introductory Biology Classrooms** Paper ID 55 Beth Schussler ("University of Tennessee, Knoxville")*; Brianna Reynolds (University of Tennessee, Knoxville)

#24 **Creating inclusive classroom environments through institutional change towards adopting active learning practices** Paper ID 149 Kelly M Schmid (Syracuse University)*; Jason Wiles (Syracuse University)

#25 **Developing a questionnaire measuring university students' sense of belonging and involvement within their home department** Paper ID 189 Melissa R McCartney (Florida International University)*; Eva Knekta (FIU); Kyriaki Chtazikyriakidou (Florida International University)

#26 **Effect of Using Centralized University Testing Centers on Student Test Anxiety, Performance, and Study Time** Paper ID 205 Elizabeth G Bailey (Brigham Young University)*; Josh Payne (Brigham Young University)

#27 **Investigating the personal values and cultural wealth assets of students in an introductory science course** Paper ID 272 Laura Beaster-Jones (University of California-Merced)*

#28 **Does student mindset affect study habits, problem solving strategies and achievement?** Paper ID 282 Malin J Hansen (Red Deer College)*

#29 **The Dreamcatcher Conference: promoting transfer student success in the biological sciences** Paper ID 115 Marina Crowder (University of California, Davis)*

#30-45 Room 312

#30 **Do I Belong Here? Examining If STEM Support Programs Impact Sense of Belonging Among Undergraduates** Paper ID 283 MacKenzie Gray (Portland State University)*; Emma C Goodwin (Portland State University); Suzanne Estes (Portland State University); ERIN E SHORTLIDGE (PORTLAND STATE UNIVERSITY)

#31 **What makes for an inclusive classroom? Student voices and perspectives.** Paper ID 294 Natalia Caporale (UC Davis)*; Alicia Garcia (UC Davis)

#32 **Empowered acceptance or hopeless denial: Can compassion training alter reactions to uncomfortable truths in environmental education?** Paper ID 299 Peter D. Wragg (Metropolitan State University)*

#33 **Figure of the Day: An Enjoyable Classroom Activity that Improves Students' Figure Creation Skills** Paper ID 102 Caitlin Kirby (Michigan State University)*; Peter J.T. White (Michigan State University); Arietta Fleming-Davies (University of San Diego)

#34 **Using a graphic syllabus to support the process of science in an inquiry-based biology course** Paper ID 161 Heidi A Horn (University of Wisconsin-Madison)*; Janet Batzli (University of Wisconsin-Madison)

#35 **Knowledge of learning makes a difference: a comparison of metacognitive regulation in introductory and senior-level biology students** Paper ID 166 Julie Dangremond Stanton (University of Georgia)*; Kathryn Morris Dye (South Georgia State College); Me'Shae Johnson (University of Georiga)

#36 **Interviews of Female Undergraduate Bioinformatics Students Provide Insight into Gender Gaps in Performance and In-Class Participation.** Paper ID 170 Emilee Severe (Brigham Young University); Elizabeth G Bailey (Brigham Young University)*

#37 **Elementary Education Students' Attitudes toward Biology in an Upper-level Biology Course** Paper ID 178 Brittany Smith (Minnesota State University Mankato)*

#38 **A large-scale survey of the study strategies of incoming first-year university students: the relationships of strategy to gender, ethnicity, course type and course grade.** Paper ID 302 Adrienne Williams (UC Irvine)*; Kameryn Denaro (UC Irvine); Michael Dennin (UC Irvine); Brian Sato (UC Irvine)

#39 **The Modulation of Flipped Classroom Design and Student Performance** Paper ID 15 Chaya Gopalan (Southern Illinois University Edwardsville)*

#40 **Preventing Student Procrastination Via Positive Reinforcement** Paper ID 16 Carlos Rojo (San Jose City College)*

#41 **Can video introductions from authors can enhance student understanding of primary scientific literature?** Paper ID 19 Melissa R McCartney (Florida International University)*; Kiana Kasmaii (Florida International University)

#42 **Does Flipped Teaching Improve Student Success In Anatomy at A Community College?** Paper ID 31 Kim-Leiloni Nguyen (Mt San Antonio College)*

#43 **Leaving Research: Factors that impact a student leaving an academic year research experience.** Paper ID 69 Logan E Gin (Arizona State University)*; Katelyn M Cooper (Arizona State University); NSF LEAP Scholars (Arizona State University); Sara E Brownell (Arizona State University)

#44 **Shifting stereotypes? Investigating the impact of an abbreviated intervention for combating students' stereotypes of scientists.** Paper ID 106 Kelsey J Metzger (University of Minnesota Rochester)*

#45 **Exploring URM Students' Preferences for Learning Events Incorporated in Introductory Biology** Paper I30126 Michelle Nugent (NC State University)*; Miriam Ferzli (NC State University)

#46-61 Room 330

#46 **A Network for Three Communities Centered on Visualizations for Biology Education** Paper ID 129 Susan Keen (UC Davis)*; Gael McGill (Harvard Medical School); Jodie Jenkinson (University of Toronto)

#47 **A Qualitative Investigation of Students' Motivation to Engage in the Critical Experiences Required for Persistence in a Biology Career Path** Paper ID 74 Ashley A Rowland (University of Colorado - Boulder)*; Katie Franks (University of Colorado at Boulder); Sarah L Eddy (Florida International University); Lisa A Corwin (University of Colorado Boulder)

#48 **A Longitudinal Study on the Effect of Active Learning on Persistence in Biology** Paper ID 85 Rebecca C Lindow (Eastern Michigan University)*; Gillian A Autterson (Eastern Michigan University); Anne Casper (Eastern Michigan University)

#49 **"Like a Scientist with Training Wheels:" Students describe their science identities** Paper ID 99 Cara Gormally (Gallaudet University)*; Rachel Inghram (Gallaudet University); Megan Majocha (Gallaudet University)

#50 **Assessment norms have disparate impacts on under-represented minority and first-generation undergraduates in introductory STEM classes** Paper ID 7 Shima Salehi (Stanford University), Sehoya Cotner (University of Minnesota), Cissy Ballen (Auburn University)*

#51 **A Framework to Guide Undergraduate Education in Interdisciplinary Science** Paper ID 11 Brie Tripp (Portland State University)*; ERIN E SHORTLIDGE (PORTLAND STATE UNIVERSITY)

#52 **A summary of concept inventories relating to evolution** Paper ID 12 Jeremy Hsu (Chapman University)*; Robert Furrow ("University of California, Davis")

#53 **Lessons learned during the evolution process from lab reports to peer reviewed publication** Paper ID 21 Bhupinder P Vohra (William Jewell College)*

#54 **Effects of Assessment Format on Eliciting Student Reasoning About Natural Selection** Paper ID 30 Caitlin Anderson (North Dakota State University)*; Jonathan Dees (University of Georgia); Jennifer Momsen (North Dakota State University)

#55 **Using annotated research articles in the cell biology classroom: increases in scientific literacy, comprehension, and knowledge of scientific techniques** Paper ID 54 Mary E Washburn (University of North Georgia)*; Melissa R McCartney (Florida International University); Ryan Shanks (University of North Georgia); Miriam Segura-Totten (University of North Georgia)

#56 **Data MAKER Biology Framework: Designing across biology, data modeling, and argumentation learning goals** Paper ID 63 Anna Grinath (Middle Tennessee State University)*; Seth Jones (Middle Tennessee State University); Casey Whitworth (Middle Tennessee State University); Angela Google (Middle Tennessee State University); Harlee Morphis (Middle Tennessee State University)

#57 **Undergraduate Students Communicating Science with the Public** Paper ID 67 Heather E Bergan-Roller (Northern Illinois University)*

#58 **Asynchronous Discussions to Engage Students in Scientific Argumentation** Paper ID 72 Iresha N Jayasinghe (Illinois State University)*; Ranija Turner (Illinois State University); Kristine L Callis-Duehl (East Carolina University); James Wolf (Illinois State University); Rebekka Darner (Illinois State University)

#59 **Testing Religious Cultural Competence in Evolution Education Nationwide** Paper ID 77 Elizabeth Barnes (Arizona State University); Hayley Dunlop (Arizona State University); Sara E Brownell (Arizona State University)*

#60 **Connecting Science to Society in an Undergraduate Evolution Course** Paper ID 94 Erin R Fried (University of Colorado, Boulder)*

#61 **Different Evolution Acceptance Instruments Lead to Different Research Findings** Paper ID 96 Sara Brownell (Arizona State University); Hayley Dunlop (Arizona State University)*

62-77 room 412

#62 **Validating existing assessments of non-cognitive psychological and motivational frameworks for undergraduate STEM populations** Paper ID 105 Meredith A Henry (Emory University)*; Shayla Shorter (Emory University); Louise Charkoudian (Haverford College); Jennifer Heemstra (Emory University); Lisa A Corwin (University of Colorado Boulder)

#63 **The Five Core Concepts in Biology (5CCs) in the classroom: Developing Assessment Tools for Student Understanding of the 5CCs** Paper ID 124 Kyriaki Chatzikyriakidou ()*; Melissa R McCartney (Florida International University)

#64 **Development of an instrument to assess student ability to select and incorporate scientific evidence from the primary literature in their writing** Paper ID 132 Kate Hill (Florida State University)*

#65 **From Fruit Flies to Phalaropes: Textbook Examples of Sexual Selection** Paper ID 133 Linda Fuselier (University of Louisville Biology Department)*; Kasi Jackson (West Virginia University); Perri Eason (University of Louisville)

#66 **Test Driving the Conclusion Assessment Rubric (CAR)** Paper ID 137 Tawnya Cary (Beloit College)*; Michelle A Harris (UW - Madison Biocore Program); Seung Hong (University of Delaware); Yue Yin (University of Illinois at Chicago)

#67 **Consensus Messaging Using Scholarly Literature: Impacts on Students' Conceptions of Global Climate Change** Paper ID 154 Jeremy D Sloane (University of Virginia)*; Jason Wiles (Syracuse University)

#68 **A conceptual framework for case study pedagogy in the undergraduate biology classroom.** Paper ID 176 Ally Hunter (University of California, San Francisco)*

#69 **Student-generated conceptual models as a form of assessment in introductory biology** Paper ID 193 Konnor Brennan (Saint Louis University)*; Elena Bray-Speth (Saint Louis University)

#70 **Assessment of a Curriculum Redesign Highlighting Development of Experimental Design Skills** Paper ID 211 Victoria Fringer (1996)*; Elijah Farley (University of Minnesota Duluth Department of Chemistry); Jacob W Wainman (University of Minnesota Duluth)

#71 **The DNA Illustration Spectrum: The Variety of Ways in which DNA is Represented to Biology Learners** Paper ID 217 Dina Newman (Rochester Institute of Technology)*; Hannah Spector (Rochester Institute of Technology); Julia Steele (Rochester Institute of Technology); Emalee Wrightstone (Rochester Institute of Technology); Kate Wright (Rochester Institute of Technology)

#72 **Got DNA? Teaching Science with Culturally Responsive Pedagogy** Paper ID 236 Kelsie M Bernot (North Carolina A&T State University)*; Sabena Bell (North Carolina A&T State University); Kayla Antione (North Carolina A&T State University); Brittany Council (North Carolina A&T State University); Roy Coomans (North Carolina A&T State University); Joseph Graves (North Carolina A&T State University); Aditi Pai (Spelman College)

#73 **College Student's Consider Diversity and Designer Babies when Reasoning about uses of CRISPR/CAS9** Paper ID 246 Katie Humrick (University of Louisville)*; Linda Fuselier (University of Louisville)

#74 **Workshop Including Science and Religious Educators leads to Positive Attitudes toward Evolution Education** Paper ID 251 John Lindsay (Brigham Young University)*; Jamie L Jensen (Brigham Young University); Danny Ferguson (Brigham Young University)

#75 **Investigation of the Relationship between Intuitive Thinking and Reasoning about Vaccines across Levels of Expertise** Paper ID 253 Melinda T Owens (UC San Diego)*; Erin Nale (San Francisco State University); Jonathon Torres (San Francisco State University); Kristin De Nesnera (Utah Valley University); Kimberly Tanner (San Francisco State University)

#76 **Undergraduate Learning Researchers: A New Role in the Classroom for Promoting Formative Assessment Opportunities** Paper ID 258 Young Ae Kim (University of Arizona)*; Katelyn Southard (University of Arizona); Jonathan Cox (University of Arizona); Lisa Elfring (University of Arizona); Paul Blowers (University of Arizona); Vicente Talanquer (University of Arizona)

#77 **What Are We Measuring? Comparisons between the Biology Concept Inventory and the Biology Card Sorting Task** Paper ID 265 Kamali Sripathi (South Dakota State University)*; Karly Ackerman (South Dakota State University); Dylan Blomme (South Dakota State University); Anne-Marie Hoskinson (South Dakota State University)

Sunday

#78-106 2nd floor Boards

#78 **Test-Enhanced Learning in Biology Education: a Laboratory study** Paper ID 191 Bryn St Clair (Brigham Young University)*; Jamie L Jensen (Brigham Young University); Sam Millar (Brigham Young University); Max Putnam (Brigham Young University); Haley Michelsen (Brigham Young University)

#79 **Developing Conceptual Frameworks in Evolutionary Medicine** Paper ID 235 Daniel Grunspan (Arizona State University)*; Angela Garcia (Arizona State University); Jon Harrison (Arizona State University); Silvie Huijben (Arizona State University); Ana Magdalena Hurtado (Arizona State University); Randolph Nesse (Arizona State University); Benjamin Trumble (Arizona State University); Sara Brownell (Arizona State University)

#80 **Learning Theories Unleash the Power of CUREs (Course-Based Undergraduate Research Experiences) in REIL (Research Experiences in Introductory Lab) Biology Courses and Boost Student Self Efficacy in Scientific Reasoning and Experimental Design** Paper ID 29 Cheryl L Berry (Saint Leo University)*

#81 **Anti-microbial Drug Design, Synthesis, and Testing in an Integrated Sophomore-level CURE enhances academic success and engagement in future research: The BOMM (Biology, Organic Chemistry, and Mathematical Modeling)** Paper ID 32 Linda L Hensel (Mercer University)*

#82 **Can Students Build Data Analysis Skills Using Course-Based Research in Introductory Biology?** Paper ID 35 Marney Pratt (Smith College)*

#83 **Implementation and Refinement of a Full-length Course-Based Undergraduate Research Experience (CURE) in Microbial Ecology and Molecular Evolution** Paper ID 52 Blythe E Janowiak (Saint Louis University)*

#84 **Implementation of a Progressive Scale-up Model for the Development of Research Expansion Modules for a Consortium-based CURE** Paper ID 83 Adam Kleinschmit (Adams State University)*; Jordan Jackson (Adams State University); Wyanet Bresnitz (Adams State University); Austin Baumeister (Adams State University)

#85 **REIL Biology at St. Philip's College** Paper ID 103 Stacie R. Koonhow (St. Philip's College)*

#86 **From rigid syllabi to democratic CELLs (Civically Engaged Lectures and Labs): an attempt to boost science literacy among non-majors** Paper ID 123 Robert D Sieg (Truman State University)*; Jennifer Schroeder (Young Harris College)

#87 **Student perceptions of iteration and collaboration in research during a laboratory course** Paper ID 198 Caroline L Dahlberg (Western Washington University)*; Suzanne Lee (Western Washington University); Benjamin Wiggins (University of Washington); Leah Lily (Western Washington University)

#88 **CUREing exposure to environmental chemicals from personal care products** Paper ID 219 Erika L Doctor (Lynn University)*; Cassandra Korte (Lynn University)

#89 **Developing a sustainable, common thread research experience through multiple 100-level and 200 level science majors biology courses at a two-year community college** Paper ID 276 David A Beamer (Nash Community College)*

#90 **Impact of a Course-Based Undergraduate Research Experience on Students' Science Identity: A Qualitative Approach** Paper ID 22 Alaina J. Buchanan (University of Northern Colorado)*

#91 **Male and Female Perceptions of the Culture of Biological Research following a Course-based Undergraduate Research Experience** Paper ID 182 Jessica Dewey (University of Minnesota)*; Anita Schuchardt (University of Minnesota)

#92 **Pilot Phase Analysis of a CURE Implementation in a Large Enrollment Introductory Biology Laboratory Course** Paper ID 187 Kelly Barry (Southern Illinois University Edwardsville)*; Christine Simmons (Southern Illinois University Edwardsville)

#93 **Can Course-Specific CUREs be Broadly Applicable at Diverse Institutions?** Paper ID 190 Kevin W Floyd (University of Texas at El Paso); Ginger R Fisher (University of Northern Colorado); David Esparza (University of Texas at El Paso); Jeffrey T. Olimpo (The University of Texas at El Paso)*

#94 **Interviews reveal perceptions of students participating in a series of conceptually-linked Course-based Undergraduate Research Experiences** Paper ID 203 Kelly McDonald (California State University, Sacramento)*; Allison Martin (California State University, Sacramento); Salem Bitwoded (California State University, Sacramento); Heather Fletcher (California State University, Sacramento); Navneet Singh (California State University, Sacramento); Thomas Landerholm (California State University, Sacramento)

#95 **Nationally expanding a CURE through new faculty development program: a case study and preliminary investigation of multi-day summer workshop.** Paper ID 213 Ashley Vater (UC Davis)*

#96 **Describing instructor decisions around student ownership and collaboration in CUREs** Paper ID 215 Kelly Hogan (UNC Chapel Hill)*; John Bruno (University of North Carolina, Chapel Hill); Blaire Steinwand (University of North Carolina, Chapel Hill); Sabrina Robertson (UNC Chapel Hill); Bryant Hutson (UNC Chapel Hill)

#97 **The Benefits of Iteration in a Sequence of Course-based Undergraduate Research Experiences** Paper ID 218 Caitlin Light (Binghamton University)*; Megan Fegley (Binghamton University); Nancy Stamp (Binghamton University)

#98 **Investigating Student Outcomes and Evolution of Antibiotic Resistance in an Introductory Biology CURE (Course-based Undergraduate Research Experience) to Broaden Participation in STEM** Paper ID 230 Joya Mukerji (University of Washington)*; Katie J. Dickinson (University of Washington - Seattle); Liz M. Warfield (University of Washington - Seattle); Elli J Theobald (University of Washington); Matt Sievers (University of Washington - Seattle); Mariah Hill (University of Washington); Elisa Tran (University of Washington); Grace E.C. Dy (University of Washington - Seattle); Elizabeth H. Glenski (University of Washington - Seattle); Benjamin Kerr (University of Washington); Scott Freeman (University of Washington)

#99 **An Epistemic Perspective on Student Argumentation in a CURE** Paper ID 245 Dennis M Lee (Clemson University)*; Cazembe Kennedy (Clemson University); Jason Tedstone (Clemson University); Dylan Dittrich-Reed (Clemson University); Lisa Benson (Clemson University)

#100 **The Elephant in the CURE Classroom: What Do We know About CUREs Taught by Graduate Teaching Assistants?** Paper ID 252 Emma C Goodwin (Portland State University)*; Kelly McDonald (California State University, Sacramento); ERIN E SHORTLIDGE (PORTLAND STATE UNIVERSITY)

#101 **The Impact of a Course-based Undergraduate Research Experience (CURE) in a Non-majors Introductory Biology Course at a Community College** Paper ID 255 Katherine A Marsh (Compton College)*

#102 **Mine! Microbe ownership as a gateway for project ownership and positive affect in an introductory biology CURE** Paper ID 264 Pamela Hanson (Birmingham-Southern College)*; Kevin Drace (Birmingham-Southern College)

#103 **Does a CURE Improve Students' Scientific Literacy?** Paper ID 266 Brian P Teague (University of Wisconsin -- Stout)*

#104 **Comparing learning and attitudes between introductory CURE and traditional lab sections over different instructors and semesters by both quantitative and qualitative measures** Paper ID 285 Iglika V Pavlova (UNC Greensboro)*

#105 **Classroom Undergraduate Research Experiences (CUREs) do no harm, and show statistically significant benefits for females.** Paper ID 295 Alaron Lewis (UW Bothell School of STEM)*; Irene Shaver (Rise Institute, Bellevue College); Gita Bangera (Bellevue College); Thelma Madzima (University of Washington, Bothell)

#106 **Seeking methods to measure underlying thinking: validating and using the LIWC software tool for STEM writing** Paper ID 145 Faith Hyun (University of California Santa Barbara); Lidia Swanson (University of Minnesota); Beverly L Smith-Keiling (University of Minnesota)*

#107-122 Room 312

#107 **Using Project EDDIE Curricular Modules to Build Quantitative Reasoning Skills** Paper ID 13 Rebekka Darner (Illinois State University)*; Tanya Josek (Illinois State University)

#108 **Socioscientific Decision-Making in Undergraduate Students: The Role of Epistemic Cognition** Paper ID 49 Jordan D Bader (University of New Hampshire)*; Melissa L Aikens (University of New Hampshire)

#109 **Visualizing crosscutting mathematics concepts in science: Helping students (and faculty) understand rates of change** Paper ID 79 Stanley M Lo (University of California San Diego)*; Adam Burgasser (University of California San Diego); Thomas Bussey (University of California San Diego); John Eggers (University of California San Diego); Jeff Rabin (University of California San Diego); Sherry Seethaler (University of California San Diego); Laura Stevens (University of California San Diego); Haim Weizman (University of California San Diego)

#110 **Weekly e-learning journals as a tool to promote and improve metacognition in undergraduate life science majors** Paper ID 117 Seth W Hunt (University of Delaware)*; Alenka Hlousek-Radojcic (University of Delaware)

#111 **Biofilms as a Context for Understanding Mechanistic Reasoning by Undergraduates** Paper ID 143 Sharleen Flowers (Purdue University)*

#112 **Characterizing instructional approaches to mathematics in the undergraduate biology** Paper ID 158 Fangfang Zhao (University of Minnesota)*; Linh Chau (University of Minnesota); Anita Schuchardt (University of Minnesota)

#113 **Combatting cognitive load with metacognition to improve student performance in introductory genetics** Paper ID 160 Gretchen Wettstein (University of Colorado Boulder)*; Jenny Knight (University of Colorado, Boulder)

#114 **Developing a teaching intervention to promote effective transfer across biological phenomena using general quantitative relationships** Paper ID 167 Mallory Jackson (University of Washington)*; Emily Scott (Univ. Washington); Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington)

#115 **Persistent Insect Misconceptions** Paper ID 293 Emma Wester (East Carolina University)*

#116 **A collaborative digital approach to building primary paper literacy within a framework that fosters critical high-level skills in data analysis and interpretation** Paper ID 298 Revati Masilamani (Tufts University)*

#117 **Students' Mechanistic Explanations Across Undergraduate Chemistry and Biology Courses** Paper ID 210 Melanie Cooper (Michigan State University); Joelyn de Lima (Michigan State University); Jenna Kesh (Michigan State University); tammy m long (Michigan State University); Keenan Noyes (Michigan State University); Christina Schwarz (Michigan State University); Caleb M Trujillo (Michgan State University); Jon Stoltzfus (Michigan State University)*

#118 **Comparison of Analytic and Holistic Coding Approaches and Machine Learning Performances Across A Flux Learning Progression** Paper ID 194 Lauren N Jescovitch (Michigan State University)*; Emily Scott (Univ. Washington); Jack Cerchiara (University of Washington); Mark Urban-Lurain (Michigan

State University); John Merrill (Michigan State University); Jennifer H Doherty (University of Washington); Kevin Haudek (Michigan State University)

#119 **Contribution of Course-Associated Labs to Student Mastery of Lecture Content at a PUI: A Pilot Study** Paper ID 179 Jennifer Bankers-Fulbright (Augsburg University)*; Demey Everett (Augsburg University); Alana Goodson (Augsburg University)

#120 **Exploring the role of motivation on retention of conceptual knowledge and model-based competencies.** Paper ID 135 Bethany J Gettings (Michigan State University)*; tammy m long (Michigan State University)

#121 **The effectiveness of virtual labs in introductory Biology course in promoting basic laboratory techniques.** Paper ID 34 Douglas Ayega (University of North Texas)*

#122 **Characterizing students' graphing practices in pen-and-paper and digital formats** Paper ID 65 Elizabeth Suazo-Flores; Anupriya Karippadath; Stephanie M Gardner (Purdue)*; Joel Abraham (CSU Fullerton); Eli Meir (SimBio); Susan Maruca (SimBio)

#123-138 Room 330

#123 **Exploring Student Self-Efficacy Through Quantitative Biology Group Work** Paper ID 107 Alexander Kulacki (University of New Hampshire)*; Melissa L Aikens (University of New Hampshire)

#124 **Modification of the Experimental Design Ability Test to Assess Learning Gains in Introductory Chemistry Laboratories** Paper ID 206 Elijah Farley (University of Minnesota Duluth Department of Chemistry)*; Victoria Fringer (1996); Zoe Suiter (University of Minnesota Duluth); Jacob W Wainman (University of Minnesota Duluth)

#125 **Where to sit? Student seating preference, motivation, and performance in introductory biology.** Paper ID 242 Chloe Wasendorf (Iowa State University)*; Nancy Boury (Iowa State University)

#126 **How do STEM instructors use the first day of class? Aligning noncontent instructor talk with topics covered on the first day of class** Paper ID 243 A. Kelly Lane (University of Nebraska-Lincoln)*; Claire Meaders (Cornell University); Justin Shuman (University of Nebraska-Lincoln); Michelle Smith (Cornell University); MacKenzie Stetzer (University of Maine); Erin Vinson (University of Maine); Marilyne Stains (University of Nebraska-Lincoln); Brian Couch (University of Nebraska-Lincoln)

#127 **Investigating pre-class activities to support argumentation-to-learn in large-lecture introductory biology** Paper ID 250 Erika Offerdahl (Washington State University)*; Andy Cavagnetto (Washington State University); Jessie Arneson (Washington State University); Jacob Woodbury (Washington State University); Larry Collins (Washington State University)

#128 **Can we influence student success in groupwork? The impact of lab group composition on student outcomes** Paper ID 261 Tanya Tan (Simon Fraser University); Onkar Bains (Simon Fraser University); Erin Barley (Simon Fraser University); Joan C Sharp (SFU); Megan Barker (Simon Fraser University)*

#129 **Agents of Change - Face to Face and Hybrid Introductory Biology course modifications along Vision and Change guidelines.** Paper ID 287 Rachael Hannah (University of Alaska Anchorage)*; Cindy Trussell (University of Alaska Anchorage); Kathyrn Schild (University of Alaska Anchorage)

#130 **Inspiring Evidence-Based Teaching Innovations with the Journal CourseSource** Paper ID 14 Erin Vinson (University of Maine)*; Michelle Smith (Cornell University)

#131 **Democratizing Science Communication Training Access for STEM Graduate Students** Paper ID 18 Melissa R McCartney (Florida International University)*; Tessy Ritchie (USNA); IIdarabasi Akpan (Florida International University); Hannah Opris (Florida International University)

#132 **Biology Graduate Students Perceptions of Research and Teaching: An Ecological Approach** Paper ID 68 Joshua W Reid (Middle Tennessee State University)*; Grant E Gardner (Middle Tennessee State University)

#133 **"Time spent on outreach is time spent away from research": Do STEM graduate students experience conflict between research and outreach activities?** Paper ID 78 Margaurete A Romero (University of Tennessee)*; Beth Schussler ("University of Tennessee, Knoxville")

#134 **The effects of a semester-long pedagogical training on the teaching knowledge and mentoring relationships of graduate and undergraduate teaching assistants** Paper ID 81 Mitra Asgari (Cornell University)*; Frank R. Castelli (Cornell University); Mark A. Sarvary (Cornell University)

#135 **Detecting the Winds of Change: Classroom Observations and Syllabi as independent indicators of instructor transition** Paper ID 138 Rebecca S Reichenbach (North Dakota State University)*; Madison Milbrath (North Dakota State University); Lisa M Montplaisir (North Dakota State University)

#136 **Survey data support international graduate students as biology instructors** Paper ID 141 Lisa L Walsh (University of Michigan)*

#137 **Graduate Teaching Assistants' Cognition Related to Teaching: A Comparison of STEM and Non-STEM Groups** Paper ID 183 Dirhat M Mohammed (MTSU)*; Grant E Gardner (Middle Tennessee State University)

#138 **Analysis of instructional practices used by graduate teaching assistants in response to training that incorporates pedagogical content knowledge** Paper ID 184 Jenna Hicks (University of Minnesota)*; Michael Abebe (University of Minnesota); Jessica Dewey (University of Minnesota); Anita Schuchardt (University of Minnesota)

#139-154 room 412

#139 **Titles used by undergraduate students to refer to their instructors: Effects of instructor gender and age** Paper ID 185 Courtni Horsley (Brigham Young University); Naomi Marshall (Brigham Young University); Elizabeth G Bailey (Brigham Young University)*

#140 **An exploration of the benefits of the undergraduate teaching assistant (UTA) experience across biology courses and other STEM courses at an R1 research-focused university.** Paper ID 200 Frank R. Castelli (Cornell University)*; Mark A. Sarvary (Cornell University)

#141 **Anchoring the Adrift: Developing an instructional training program for our teaching assistants** Paper ID 201 Elizabeth MY Steves (Simon Fraser University)*; Megan Barker (Simon Fraser University)

#142 **Empirical insights into the negative mentoring experiences of doctoral students** Paper ID 208 Trevor T Tuma (University of Georgia)*; Benjamin Hultquist (University of Georgia); Erin Dolan (University of Georgia)

#143 **Examining Graduate Teaching Assistants' Knowledge and Confidence with Inclusive Teaching Practices After Targeted Professional Development** Paper ID 221 Meaghan Stein (University of Minnesota); Seth Thompson (University of Minnesota)*

#144 **Meeting the needs of current and future biology teachers with a hybrid online/in-person approach that teaches biology concepts and pedagogy** Paper ID 232 Elizabeth A Genne-Bacon (Tufts University School of Medicine)*

#145 **Modeling the effect of social interactions on the instructional decisions of biology faculty** Paper ID 237 Melody McConnell (North Dakota State University)*; Lisa M Montplaisir (North Dakota State University); Erika Offerdahl (Washington State University)

#146 **Development of an in-depth training guide for a Scientific Teaching observation tool** Paper ID 240 Emily Bremers (University of Nebraska-Lincoln)*; Jameson DeFreece (University of Nebraska-Lincoln); Mary Durham (University of Nebraska-Lincoln); Brian Couch (University of Nebraska-Lincoln)

#147 **How teaching experience and professional development impacts GTA approaches, self-efficacy, and knowledge of student-centered learning at two universities** Paper ID 244 Heather D. Vance-Chalcraft (East Carolina University)*; Kari Nelson (University of Nebraska Medical Center)

#148 **Professional Development for All: Practices to Broaden Participation in Education Reform** Paper ID 257 Christopher Beck (Emory University)*; Rachelle Spell (Emory University); Lawrence Blumer (Morehouse College); Pamela Hanson (Birmingham-Southern College); Joanna Vondrasek (Piedmont Virginia Community College)

#149 **Are PIs' supervisory responsibilities impacting the power dynamics with their trainees, and trainees' ability to attain their training goals?** Paper ID 275 Laurence Clement (University of California, San Francisco)*; Karen Leung (City College of San Francisco); James Lewis (City College of San Francisco); Naledi Saul (University of California, San Francisco)

#150 **Being a Learning Assistant: A Potential Pathway to Improve Students' Self-efficacy, Science Identity, and Metacognition.** Paper ID 288 Natalia Caporale (UC Davis)*; Jia Tan (UC Davis)

#151 **Self-perception of Research Ability and Performance of Experimental Design Among First-Semester Bioscience Doctoral Students** Paper ID 290 Madhvi J Venkatesh (Harvard Medical School)*

#152 **Increasing retention by involving students in an undergraduate research program during their introductory experience: Results of matched-pairs and mixed methods analyses.** Paper ID 122 Edward A Leone (Oklahoma State University)*; John Stewart (Oklahoma State University); Lucy Bailey (Oklahoma State University); Coral Rewasiewicz (Oklahoma State University); Donald French (Oklahoma State University)

#153 **Expert and novice conceptions of the biotic impacts of climate change** paper ID 26 Emily Holt (University of Northern Colorado)*; Julie Sexton (University of Northern Colorado); Krystal Hinerman (Lamar University); Alicia Romano (University of Northern Colorado)

#154 **Novice and expert: what happens when students interview a scientist about their research?** Paper ID 28 Kyriaki Chtazikyriakidou (Florida International University); Cynthia Cabrera (Florida International University); Melissa R McCartney (Florida International University)*

ROUND TABLE SESSIONS

Saturday

Group 1 Instrument Development--------Room   Bruininks 512a

Diversifying discussions: How do we facilitate talking about biology in our classes?
paper ID **44** Marin Melloy (University of Minnesota - Twin Cities)*; Sagal Mohammed (University of Minnesota); Abdi Warfa (University of Minnesota); Petra Kranzfelder (University of Minnesota); Marcos García-Ojeda (University of California, Merced); Jennifer Bankers-Fulbright (Augsburg University)

Development of Epistasis and Epigenetics Concept Inventories: Phase One
paper ID **249** Nancy Boury (Iowa State University)*; Rebecca Seipelt-Theiman (Middle Tennessee State University)

Group2: Studying CURES--------Room Bruininks 512b

Using Data-Driven inquiry to build a computational course based undergraduate research experience in limnology
paper ID **164** Seth Thompson (University of Minnesota)*; Sehoya Cotner (University of Minnesota); James Cotner (University of Minnesota)

Designing Professional Development Initiatives for Graduate Teaching Assistants Facilitating Course-based Undergraduate Research Experiences (CUREs)
paper ID **151** Amie Kern (University of Texas at El Paso)*; David Esparza (University of Texas at El Paso); Amy Kulesza (Center for Life Sciences Education); Corrie Pieterson (Center for Life Sciences Education); Seema Rivera (Clarkson University); Jeffrey T. Olimpo (The University of Texas at El Paso)

Group 3 Learning in Informal Settings--------Room Bruininks 412

9 Understanding undergraduates' informal learning experiences at a regional zoo
Ashley Heim (University of Northern Colorado)*; Emily Holt (University of Northern Colorado)

39 Middle School Female Interest in STEM and STEM Careers Before and After a Summer-Camp Experience
Kara E Baldwin (Illinois State University)*; Rebekka Darner (Illinois State University)

Group 4 Graduate Student Development--------Room Bruininks 312

A proposed model for evaluating an interdisciplinary graduate training program
paper ID **101** Jyothi Kumar (Michigan State University)*; Shin-Han Shiu (Michigan State University); tammy m long (Michigan State University)

Improving the Laboratory Experience for Undergraduate Students and Graduate Teaching Assistants: A Baseline Study
paper ID **127** Michelle Nugent (NC State University)*; Miriam Ferzli (NC State University)

Group 5 Innovative Pedagogies--------Rm Bruininks 330 table north

Sloganing: A structured activity to help students recall science article content
paper ID **84** Jacob Adler (Brescia University)*

Are Learning Gains from a Recurring "Teach and Question" Homework Assignment Reproducible in a Variety of Classrooms?
paper ID **48** Elizabeth G Bailey (Brigham Young University)*; Madeleine McWhorter (Brigham Young University); Clair Wootan (Brigham Young University)

Group 6 Integrating Active Learning Into Instruction--------Rm Bruininks 330 table south

Integrating research into undergraduate experiences through a community science program
paper ID **292** Ana E Garcia Vedrenne (UC Los Angeles)*

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Helping instructors incorporate active learning into their undergraduate biology classrooms: the Promoting Active Learning and Mentoring (PALM) Network
paper ID **223** Susan Wick (University of Minnesota)*

Sunday

Group 1 Studying CUREs--------Room Bruininks 512a

Let's Get Real: Implementation of Authentic Research Experiences
Paper ID **260** Rachelle Spell (Emory University)*; Christopher Beck (Emory University)

CURE labs and inquiry-based classrooms improve understanding of science practices in different ways
paper ID **296** Bryan D White (University of Washington Bothell)*; Dana Campbell (UW Bothell School of STEM); Thelma Madzima (University of Washington, Bothell); Alaron Lewis (UW Bothell School of STEM)

Stand-Alone CUREs for Classrooms Beyond the Research-Intensive University
paper ID **197** Sarah J Adkins (University of Alabama at Birmingham)*; Jeffrey Morris (University of Alabama at Birmingham)

Group2: Instrument Development--------Room Bruininks 512b

Development of Constructed Response Items to Elicit Student Thinking About Ecology and Use with Automated Assessment
paper ID **186** Michael Fleming (CSU Stanislaus)*; Juli Uhl, Kevin Haudek (Michigan State University)

Development of a Constructed Response Automated Assessment Question to Elicit Student Thinking About Epigenetics
paper ID **163** Juli Uhl (Michigan State University)*

Group 3 Learning in Groups--------Room Bruininks 412

Cooperative Game Play used as a means to Teach and Develop Team-working Skills in the Biological Sciences
paper ID **239** Amanda Salsberg (Bethel University)*; Sara Wyse (Bethel University)

Group Size Has No Effect on Student Performance or Attitudes in a Student-Centered Biology Class
paper ID **71** Deborah Donovan (Western Washington University)*; Georgianne Connell (Western Washington University)

Impact of Group Exams in Non-majors Biology: a Mixed Methods Analysis
paper ID **300** Lindsay Chaney (Snow College)*

Group 4 Instructional Practices--------Room Bruininks 312

You can publish this too! Highlighting and receiving credit for developing innovative instructional activities
paper ID **33** Michelle Smith (Cornell University)*; Erin Vinson (University of Maine)

Team Based- Flipped Classroom in Microbiology: Case Based Learning
paper ID **212** Samantha Giordano-Mooga (UAB)*

Group 5 Core Competencies & Study Strategies-- --Room Bruininks 330 table north

155 Mapping Core Competencies in the Undergraduate Biology Curriculum
paper ID **155** Alexa Clemmons (University of Washington)*; Alison Crowe (University of Washington)

162 Teaching an old dog new tricks: Effects of teaching evidence-based study strategies on student learning
paper ID **162** Tara Slominski (North Dakota State University)*; Sarah Montplaisirn (North Dakota State University); Mary Jo Kenyon (North Dakota State University); Jennifer Momsen (North Dakota State University)

Group 6: Student Skill Development: Graphing, Visualization, & Reasoning------Room Bruininks 330 table south

301 Identifying knowledge bases for graphing in biology: A student theoretical model
paper ID **301** Joel K. Abraham (California State University, Fullerton)*, Elizabeth Suazo-Flores (Pur

297 Teaching and Assessing Qualitative Reasoning Skills in Undergraduate STEM Courses
paper ID **297** Mays Imad (Pima County Community College)*; Kerianne Murphy Wilson (University of California Irvine)

128 A Network for Three Communities Centered on Visualizations for Biology Education
paper ID **128** Susan Keen (UC Davis)*; Gael McGill (Harvard Medical School); Jodie Jenkinson (University of Toronto)

WORKSHOPS

Workshop 1: Professional Development for Scholars-in-Training: What career options do I have in BER?

Lead Facilitator: DBERSiT (Discipline-Based Education Research Scholars-in-Training)
Contact: Brie Tripp (tripp@pdx.edu)
9:30 am – 12:00 pm, graduate students and post-docs only, $0

ABSTRACT
As graduate students and postdoctoral researchers, we are at the beginning of our careers in the ever-growing field of Biology and Biology Education Research. Where do we go from here? How do we navigate the job market? We are often confronted with these questions as the end date to finishing our degree or position approaches. This professional development workshop aims to ease some of the anxiety and provide insight and guidance on future career options: from traditional research careers, teaching track/community college options, and evaluation centers to science communication and policy involvement. We invite participants to join us in a workshop with panelists that can speak to the benefits, challenges, and opportunities of traditional Discipline-Based Education Research routes as well as career opportunities outside of academia.
Panelists will share their experiences in their current position (1-hour time duration): how they got there, what they did right, what they wish they would have done differently, and address questions that participants may have regarding future career choices. This will be followed by break-out sessions/rotations with the five panelists where participants can receive more detailed information and probe panelists for knowledge and feedback (1.5-hour time duration).

PARTICIPANT OUTCOMES
· Gain a better understanding of career options available to those with a graduate degree or other training in BER
· Obtain insight on the “do’s and don’ts” of the BER job market
· Gain ideas about how to obtain a job in their desired field
· Gain a better understanding of how to maintain a healthy work/life balance

PANELISTS: Jeff Schinske, Holly Menninger, Christina Peterson, Brian Sato, and Marjee Chmiel

Jeff Schinske
Jeff Schinske is a biology instructor and the anatomy and physiology course coordinator at Foothill College (San Francisco Bay Area) where he conducts research on equity and inclusion in science classrooms. He leads two federal grant programs: The Scientist Spotlights Initiative, which supports the development and dissemination of inclusive biology curricula, and CC Bio INSITES, which empowers community college biology faculty to conduct and publish education research. Jeff has authored numerous high-profile biology education research articles, is a steering committee member for the Society for the Advancement of Biology Education Research (SABER), and was the 2018 recipient of the national Outstanding Undergraduate Science Teaching Award from the Society for College Science Teachers.

Holly Menninger
Dr. Holly Menninger is the director of public engagement and science learning at the Bell Museum on the St. Paul Campus of the University of Minnesota. Dr. Menninger earned her bachelor’s degree in biology from Denison University and her Ph.D. in ecology from the

University of Maryland. During this time, she appeared on CNN's American Morning talking about cicadas, mosquitoes, and other insects. After her Ph.D. she worked with federal and state policymakers as a senior public affairs associate with the American Institute of Biological Sciences. Prior to her work at the Bell Museum, Dr. Menninger worked in natural resources extension at Cornell University, co-hosted a radio show, led a large citizen science program focused on the biodiversity in our daily lives, and was the inaugural Director of Public Science for the College of Sciences at NC State University.

Christina Petersen
Dr. Christina Petersen is an Education Program Specialist in the Center for Educational Innovation at the University of Minnesota—Twin Cities. Christina works with faculty, departments, and colleges to design courses to promote student learning using evidence-based approaches. Her teaching experience includes courses in undergraduate biology and pedagogical courses. Dr. Petersen's current research focuses on identifying best practices for teaching in active learning classrooms. She has a Ph.D. in Pharmacology from Vanderbilt University and a BS in Zoology from the University of Wisconsin.

Brian Sato
Dr. Brian Sato is an Associate Teaching Professor in the School of Biological Sciences at the University of California, Irvine. He also is the Interim Associate Dean of the Division of Teaching Excellence and Innovation. His research aims to improve STEM education at the undergraduate level. One project explores the impact of instructor exam feedback on students' understanding of the content. Another project examines how teaching faculty can be change agents to improve STEM education across the University of California system. Dr. Sato received his Ph.D. in Cell Biology at the University of California, San Diego.

Marjee Chmiel
Dr. Marjee Chmiel is the Director of Evaluation for Howard Hughes Medical Institute (HHMI) Tangled Bank Studios ad HHMI Biointeractive, where she works on evaluation efforts, organizational learning, and effective philanthropy across a variety of programs and initiatives. She is a social science researcher with expertise in science education, educational media, and research and evaluation methods. Dr. Chmiel's work reflects her passion to reach and educate all individuals through multi-media experiences. Dr. Chmiel has created educational science games for the Jason Project with National Geographic and worked for PBS on an online professional development program for teachers. Dr. Chmiel earned her bachelor's degree in broad field science & chemistry and her Master's in educational policy & leadership from Marquette University. She earned her Ph.D. at George Mason University where she specialized in educational research and evaluation methods. She also serves as an adjunct professor with the University of Maryland's School of Information where she teaches courses in research and evaluation.

Workshop 2: Bringing a Research Lens into Teaching

Lead Facilitator: Katelyn Southard (ksouthard@email.arizona.edu)

8:30 am – 12:30 pm, $35

ABSTRACT

Adopting a research lens in the classroom can be a difficult process for many instructors interested in conducting research in their own classroom settings. Many faculty members who are interested in discipline-based education research (DBER) may be excited to make transformative changes in their classrooms, share interesting approaches to well-known instructional problems, or communicate interesting patterns in student thinking on a particular topic, but might be doing so based on "hunches" or student perspective feedback. The goal of this workshop is to provide insight into DBER methodologies for instructors at the beginning stages of pursuing research questions in their own instructional settings. We will provide some initial training in collecting and analyzing quality evidence of student thinking from within the classroom setting in order to inform a particular research question or learning process. This workshop is geared toward 1) individuals who are interested in starting biology education research but are approaching it for the first time in their own classrooms, or 2) individuals who are currently teaching and would like input on how to use evidence of student thinking patterns from their own classrooms to improve their instructional practices. Workshop activities will center on a case-based approach to 1) defining research goals, 2) evaluating evidence of student learning using a variety of research methods 3) analyzing collected data by focusing on underlying student reasoning patterns, and 4) considering possible actions based on the evidence collected. Participants will spend time dissecting examples and considering how these principles can be applied to their own DBER work. Small- and large-group discussions will provide opportunities for participants to practice evaluating research questions in alignment with target goals for investigation, consider the benefits and limitations of common DBER data collection and analysis methodologies (both quantitative and qualitative), practice implementing a coding scheme and coming to consensus, and make decisions about next steps based on results. Case-based small-group activities and personal reflection activities will stress the importance of focusing on student reasoning patterns rather than evaluation of ideas for "correctness." Additionally, the design of the case-based scenarios and discussions will highlight essential mindsets for transitioning from an instructor-centric classroom approach to using a research-based mindset in which eliciting student ideas, making student thinking visible, collecting evidence of thinking patterns, and making evidence-based instructional decisions are prioritized. These mindset shifts are important whether the participant's goal is to begin a DBER study or to simply improve opportunities for learning in their classrooms by using evidence of student thinking.

PARTICIPATE OUTCOMES

Through participating in the "Bringing a Research Lens into Teaching" workshop, participants will be able to:

1. Identify methods of collecting student thinking that align with research goals.
2. Compare the differences between interpreting student thinking patterns versus evaluating student answers for "correctness."
3. Reflect on the potential benefits of focusing on student thinking in research and teaching.
4. Apply what they have learned to specific cases.

PARTICIPANT ENGAGEMENT
Workshop activities will focus on actively engaging participants in evaluating case-based scenarios of DBER research in classrooms. These scenarios will highlight a variety of evidence-based tools and strategies for collecting and analyzing student reasoning in the classroom. In small groups, participants will work to evaluate scenarios by focusing on 1) defining quality research goals, 2) evaluating evidence of student reasoning patterns, 3) applying evidence-based DBER research tools and methodologies, 4) analyzing data for underlying patterns, and 5) considering possible actions and outcomes based on research results.
Small- and large-group discussions will focus on analyzing patterns in student thinking by noticing key elements of reasoning, creating interpretations of critical features and common patterns in collected evidence, and responsively acting based on results. Specifically, groups will be asked to analyze hypothetical data sets in small groups, while focusing on distinguishing between underlying reasoning patterns vs. potentially distracting variables in the data, and exploring the alignment between the observed results and the research aims. The case-based scenarios will underscore the value of focusing on student reasoning patterns in conducting DBER research and will show differences between teacher-centric evaluative approaches to analysis and learner-centric interpretive approaches to uncovering reasoning patterns in collect student work. Reflection activities will provide participants with the opportunity to voice ideas for their own classroom research and engage in actively providing and receiving specific feedback on these ideas. To assess workshop learning outcomes and to allow participants additional practice, the workshop will close with a small group activity that assesses the participants' ability to transfer the principles used in the workshop to their own unique settings.

Katelyn Southard
Dr. Katelyn Southard received her BER-focused PhD from the University of Arizona in the Department of Molecular and Cellular Biology. Her primary areas of research focus include understanding undergraduate biology students' ideas about molecular mechanisms and improving learning opportunities for students in large-enrollment STEM courses through use of effective instructional teams. Katie served as program coordinator, facilitator, and presenter for the HHMI/NAS Mountain West Regional Summer Institute on Undergraduate Education in Biology (2011-2015). Currently, she is an Assistant Research Scientist at UA for the NSF-IUSE project Developing Instructional Teams for Evidence-Based Instruction in Large Collaborative Learning Environments, where she leads research focusing on evaluating a new model for effective use of instructional teams to increase learning opportunities for students in undergraduate STEM courses.

Jonathan Cox
Dr. Jonathan Cox received his PhD in Epidemiology from Yale University. His interest in teaching and learning was sparked during a Postdoctoral Excellence in Research and Teaching fellowship, part of the NIH's IRACDA program, at the University of Arizona. He transitioned out of basic epidemiology research and moved entirely into undergraduate education after joining the UA's AAU Undergraduate STEM Education Leadership Team. He has extensive experience working with faculty training and evaluation projects across the UA campus. For example, he worked with faculty to establish common learning objectives across an introductory biology curriculum and evaluated the implementation of the Chemical Thinking curriculum serving roughly 2500 students per year. He has taught in-person and online introductory courses including molecular and cellular biology and epidemiology courses. Currently, as a Research Associate for the same NSF-IUSE project, he leads professional development for participating STEM faculty and student teams.

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Workshop 3: Combining forces to use assessment to promote enduring quantitative reasoning curricular reform

Lead Facilitator: Liz Stanhope (stanhope@lclark.edu)

8:30 am – 12:30 pm, $35

ABSTRACT

This workshop will assist participants in contributing to meaningful efforts to foster evidence-based curricular change around improving quantitative reasoning in biology. Vision & Change highlighted the importance of quantitative reasoning for 21st-century biologists. As biology departments work to implement curricular changes there are natural questions that arise about the impact of these changes on student learning. Yet, too often questions of assessment begin and end with individual students. Also, several instruments have been developed to assess students' quantitative skills and reasoning. While each of these tools may provide useful data, they are all slightly different in nature. Departments are left confronted with the challenges of figuring out which assessments are useful for their purposes and how to use assessment data to promote larger-scale, enduring change in departments.

Unlike a traditional workshop, the facilitators see themselves as involved in an ongoing quest to address these issues. While participants will leave with additional skills, we also seek to develop a stronger, more cohesive community of people who will work together to advance our knowledge about assessing quantitative thinking skills in the context of biology and using such assessment data to foster curricular improvement.

The facilitators will discuss the development of an instrument (the BioSQuaRE) to assess quantitative reasoning in the context of biology, and will share their experiences implementing and evaluating curricular change at their institutions. Workshop participants are encouraged to do the same, in the spirit of building a community of practice. While the workshop will not provide participants with a magic bullet to resolve all assessment woes, we hope that at the end of this workshop we will have identified a set of resources and a vision for how we can collaborate to strengthen the use of assessment in effecting lasting improvements in how we prepare biology students for increasingly quantitative careers.

PARTICIPANT OUTCOMES

· Gain familiarity with several assessment instruments that evaluate quantitative reasoning.
· Understand a model of data driven department level curricular assessment.
· Learn from peers about challenges and successes in using assessment to further curricular reform around quantitative skills.

WORKSHOP TIMELINE AND DESCRIPTION OF ACTIVITIES

0:00 - 0:10 (seats arranged in a circle) Facilitators welcome participants and outline the goals and format of the workshop.

0:10 - 0:20 (seats arranged in a circle, moved slightly into pairs) With seats arranged in a circle, facilitators and participants divide into pairs to exchange five-minute introductions. In these introductions, pairs must learn the name, department and home institution of each other, as well as their motivation in attending the workshop.

0:20 - 0:50 (seats arranged in a circle) Each member of a pair gives a one-minute introduction of the other member of the pair, including the information specified in the previous activity.

0:50 - 1:25 (move into small group arrangements) Small group discussions on specific themes, Round 1. One facilitator will be in each group. Topics might require slight adjustment depending on goals revealed during introductions.

(1) Existing assessments (Biosquare, TOSLES, QLRA, Math-Biology Values Instrument, Calc/Bio Concept Inventory)
(2) Department level assessment of curriculum.
(3) Assessment instrument development.
(4) Building and analyzing data sets to assess curricular change

1:30 - 1:55 (still small group arrangements)Small group discussions on specific themes, Round 1. Same themes, new groups.

2:00 - 2:15 Break, snacks, informal conversation

2:15 - 2:50 (seats arranged in a circle) Reflection and synthesis. Dreaming big: Have we succeeded in raising the QR skills of our students since 2010? What are our successes? What are our challenges? What resources and actions would help us as a community of practice move from challenges to successes?

2:50 - 3:00 Conclusion of workshop by facilitators.

PARTICIPANT ENGAGEMENT
As seen in the timeline, our workshop seeks to combine our collective experience into a vision for furthering QR skills in biology majors. The introductory activity will help participants and facilitators network around topics of common interest. Small group discussions will provide a setting to swap techniques and deepen understanding of common challenges. During the synthesis discussion facilitators will try to find themes in the collective knowledge in the room that we can record and build from. Although facilitators expect to share their experience with participants, we view ourselves as peers within the workshop. Participant participation is essential to the success of this workshop, and we hope to maintain connections with participants as we continue our work throughout the academic year.

Erik Larson
Erik Larson is a professor of sociology at Macalester College. Building on his multimethod research, he has more than a decade of experience in working on a variety of assessment activities linked with curricular change at both institutional and multi-institutional levels. His contributions include research design, data analysis, reporting, and developing strategies to implement findings of assessment activities.

Kristine Grayson
Kristine Grayson is an Assistant Professor of Biology at University of Richmond. She has taught at all levels of the Biology curriculum, with particular contributions to the redesign of the third semester of introductory biology (ecology/evolution/physiology) to align with recommendations from Vision and Change. She contributes to the collection and organization of several national assessment instruments in her department. Kristine is an HHMI BioInteractive Ambassador, and Faculty Mentoring Network facilitator with the Quantitative Undergraduate Biology Education and Synthesis project. Her interests include the use and accessibility of data-centric teaching resources for Biology classrooms.

Paul Overvoorde
Paul Overvoorde is the Associate Dean of the Faculty at Macalester College, and also a Professor of Biology there. He is a member of the consortium that developed the Biological Science Quantitative Reasoning exam. He supervises the Assessment Office and various assessment activities at Macalester. He has served as Program Director for an HHMI Undergraduate Science Education Grant. *Liz Stanhope*
Liz Stanhope is an associate professor of Mathematics at Lewis & Clark College. She is a member of the consortium that developed the Biological Science Quantitative Reasoning exam. She is a member of PKAL and has attended the PKAL STEM Leadership Institute. She has served as Program Director for an HHMI Undergraduate Science Education Grant. She also regularly teaches a 100-level hybrid biology/calculus/statistics course that she developed in collaboration with biology faculty members.

Andrew Zieffler
Andrew Zieffler is a Senior Lecturer and researcher in the Quantitative Methods in Education program within the Department of Educational Psychology at the University of Minnesota. He is a member of the consortium that developed the Biological Science Quantitative Reasoning exam. He has authored/co-authored several papers and book chapters related to statistics education, and has been a co-PI on many NSF-funded statistics education research projects. He serves as a member of the Research Advisory Board for the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).