10th Annual SABER National Meeting Conference Materials

Virtual Conference Dates

July 10th, 2020; July 17th, 2020; July 23rd, 2020; July 24th, 2020; and July 31st, 2020

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SABER National Meeting Schedules

Friday, July 10th, 2020

Note: all sessions convened via Zoom; all times PDT

10:00-10:55	Welcome and Introduction of Keynote Speaker by Jenny Knight, 2020 SABER President Instructors as Meaning-Makers: Designing Social-Psychological Interventions to Support Stigmatized Students Elizabeth Canning, Assistant Professor of Psychology, Washington State University Dr. Canning's research focuses on the subtle messages that create and maintain bias and social inequality, both in classrooms and organizational contexts. Her lab also designs and tests psychosocial interventions to try to mitigate these impacts. A few relevant citations are below.			
10:55-11:00	BREAK			
11:00-12:00	Action Group: SABER self-study: How can SABER become generally more inclusive and specifically anti-racist? Facilitated by Kecia Thomas			
12:00-12:20	BREAK			
	Session A: Conceptual Understanding	**Session B: Research & Laboratory Experience**	**Session C: Science & Society and Affect**	**Session D: Conceptual Understanding**
12:20–12:40	**156: A learning progression characterizing how students use mass balance reasoning to understand biology** Emily Scott*, Mary Pat Wenderoth, Jennifer H Doherty (University of Washington)	**101: Investigating Students' Statistics Attitudes and Knowledge in CUREs** Anita Schuchardt (University of Minnesota); Melissa L Aikens* (University of New Hampshire); Jeffrey T. Olimpo (The University of Texas at El Paso); Catherine Kirkpatrick (University of Minnesota)	**106: Talking Science: undergraduates bridging the gap between scientific and non-scientific communities** Josue Simeon, Sarah L Eddy*, Hana Shah (Florida International University)	**237: Observing Growth in Students' Recognition of DNA-Associated Concepts with a Card Sorting Task** Dina L. Newman*, Hannah Spector, Lauren Trumpore, Anna Neuenschwander, L. Kate Wright (Rochester Institute of Technology)

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12:40–1:00	**167: Teaching metabolism as a dynamic system improves student learning in biochemistry** Christine S Booth*, Changsoo Song, Michelle E Howell, Achilles Rasquinha, Aleš Saska, Resa Helikar, Sharmin M Sikich, Brian A Couch, Karin van Dijk, Rebecca L Roston, Tomáš Helikar (University of Nebraska-Lincoln)	**228: Integrated Lab-Lecture Courses Boost Non-Major's Experiences in Introductory Biology** Jessica Merricks*, Dave Gammon, Kathy Gallucci (Elon University)	**200: Students' perspectives on their acceptance of evolution** Ryan Dunk*, Jason Wiles (Syracuse University)	**94: Students' Mechanistic Explanations of Protein Function Cluster around Core Ideas from Chemistry or Biology Courses, but Rarely Both** Caleb M Trujillo (University Of Washington Bothell); Jenna Kesh, Melanie Cooper, Joelyn de Lima, Tammy M Long, Keenan Noyes, Christina Schwarz, Jon Stoltzfus* (Michigan State University)
1:20-1:50	Q/A with presenters from Session A			

Friday, July 17th, 2020

Note: all sessions convened via Zoom; all times PDT

9:30-10:00	**Action Group: Breakout with affinity groups**	
10:00-10:45	**Concurrent Long Talks**	
	8: A scientist like me: demographic analysis of biology textbooks reveals both progress and long-term lags Cissy Ballen (Auburn University)*; Jeremiah Henning (University of South Alabama); Michael Smith (University of Konstanz); Sara Wood (Auburn University); Taylor McKibben (Auburn University); Luoying Chen (Auburn University); Marjorie Weber (Michigan State University); Ash Zemenick (Michigan State University)	**56: Exploration of the transition between high school and college STEM courses: Characterization of students' perspectives and faculty's instructional approaches** Clara Meaders (Cornell University)*; A. Kelly Lane (University of Nebraska-Lincoln); Brian Couch (University of Nebraska-Lincoln); Anya Morozov (University of Nebraska-Lincoln); Justin Shuman (University of Nebraska-Lincoln); Marilyne Stains (University of Virginia); MacKenzie Stetzer (University of Maine); Emma Toth (University of Maine); Erin Vinson (University of Maine); Michelle Smith (Cornell University)
10:45-11:00	BREAK	

	Session A: Professional Development	**Session B: Diversity, Equity, & Inclusion**	**Session C: Assessment & Conceptual Understanding**	**Session D: Science Process Skills**
11:00–11:20	**196: Exploring Laboratory TAs' Ambitious Teaching & Tensions in an Online PD Course** Ryan C Coker*, Miray Tekkumru-Kisa (Florida State University)	**24: "It Comes from Within": Characterizing the Internal Strengths Black Undergraduates Use to Succeed in Science Majors** Chimezie Osondu*, Oluwadamilola Babatola, Morgan Beckham, Brandon Marshall, Darris Means, Birook Mekonnen, Omowunmi Oni, Julie Dangremond Stanton (University of Georgia)	**138: Integrating motivation theories to measure students' motivational profile in a modeling-based introductory biology course** Bethany J Gettings*, Tammy M Long (Michigan State University)	**191: Beyond office hours: what happens when students and professors engage in scientific discourse** Melissa McCartney*, Roxana Alvarez, Yessica Cabrera, Ruben Castellano, Kassandra Concepcion, Mainlyng Duenas, Brittany Jean-Louise, Valery Mardini, Laura Moralejo, Shagayeg Mousavi, Enza Russoniello, Kyriaki Chatzikyriakidou (Florida International University)

11:20–11:40	**38: Content-focused professional development and higher cognitive demand of curricular tasks elevate teaching assistants' teaching practices** Jenna Hicks*, Jessica Dewey, Michael Abebe, Maxwell Kramer, Anita Schuchardt (University of Minnesota)	**25: Students Speaking Up: What supports and hinders self-advocacy for STEM undergraduates with ADHD and/or specific learning disabilities?** Mariel A Pfeifer*, Eve M Reiter, Julio Cordero, McKenna Hendrickson, Julie Dangremond Stanton (University of Georgia)	**211: Mode of Responses Influences Content of Student Responses** Joelyn de Lima*, Tammy M Long (Michigan State University)	**86: A Multi-Institution Curriculum Mapping Project to Investigate Teaching of Core Competencies** Alexa Clemmons* (University of Washington); Deborah Donovan (Western Washington University); Jerry Timbrook (University of Nebraska-Lincoln); Alison Crowe (University of Washington)
11:40–12:00	**168: Supporting Biology International Teaching Assistants' Development of Cultural Competence: A Literature Synthesis** Zhigang Jia*, Grant E Gardner (Middle Tennessee State University)	**147: Beyond the Binary: Factors affecting retention of transgender and gender nonconforming students in STEM** Jeffrey Maloy* (UCLA); Bryce Hughes (Montana State University)	**178: Do Prerequisites Disproportionately Affect Certain Types of Students? Implementation of a Math Prerequisite for Introductory Biology in a Community College Setting** Natalie Wright (Kenyon College); Stacey Kiser* (Lane Community College); Shannon Seidel (Pacific Lutheran University); Christine Andrews (Lane Community College)	**180: Developing Frameworks to Describe Students' Use of Evidence in the Context of Socioscientific Issues** P. Citlally Jimenez*, Ashley Alred, Blaine Meyer, Jenny M Dauer (University of Nebraska-Lincoln)
12:00-12:30	Break/Presenters remain in Zoom rooms for Q/A session			
12:30-2:00	Poster Session			

Thursday, July 23rd, 2020 (DBER Scholars-in-Training)

Note: all sessions convened via Zoom; all times PDT

9:00-12:00	DBER Scholars-in-Training Virtual Career Panel Workshop
12:00-12:15	BREAK
12:15-1:15	Meeting with Dr. Elizabeth Canning (Keynote Speaker from Friday, July 10th)

Friday, July 24th, 2020

Note: all sessions convened via Zoom; all times PDT

9:30-10:00	**Action Group: Summary and recommendations from SABER self-study (Kecia Thomas)**			
	Session A: Active Learning	**Session B: Diversity, Equity, & Inclusion**	**Session C: Instructor Practices**	**Session D: Research, Laboratory Experience**
10:00–10:20	**3: Demystifying the Meaning of Active Learning in Undergraduate Biology Education** Emily P Driessen* (Auburn University); Jenny Knight (University of Colorado, Boulder); Michelle Smith (Cornell University); Cissy Ballen (Auburn University)	**2: Mind the Gap: Narrowing STEM achievement gaps with active learning** Elli J Theobald*, Scott Freeman (University of Washington)	**13: Low-level Learning: Leaving behind most students-- the non-science majors** Austin Heil* (University of Georgia); Cara Gormally (Gallaudet University); Peggy Brickman (University of Georgia)	**117: The Influence of Gender on Students' Perceptions of their Peers' Research Proficiency in Course-based Undergraduate Research Experiences and Traditional Laboratory Courses** David Esparza* (Cornell University); Amy Wagler, Aimee Hernandez, Jeffrey T. Olimpo (The University of Texas at El Paso)

10:20–10:40	**17: How Introductory Biology Students Prepare for Class: Resources and Actions Under Two Conditions** Sabah Sattar, Tina Ballard, Heather E Bergan-Roller* (Northern Illinois University)	**33: Accessible active learning: To what extent is active learning inclusive for science undergraduates with disabilities?** Logan E Gin* (Arizona State University); Frank Guerrero (Arizona State University); Katelyn Cooper (University of Central Florida); Sara E Brownell (Arizona State University)	**153: What types of groups facilitate the best active learning?** Kristine L Callis-Duehl*, Emma Wester, Sandra Arango-Caro (Donald Danforth Plant Science Center); Rebekka Darner (Illinois State University)	**132: Identifying the Impact of the Tigriopus CURE at Multiple Institutions with Diverse Student Populations** Ginger R Fisher*, Kevin Floyd, Jeffrey Olimpo (University of Northern Colorado)
10:40–11:00	**182: Effective application of team-based learning in the online classroom** Lina M Arcila Hernandez*, Kelly Zamudio, Abby Drake, Michelle K Smith (Cornell University)	**201: Christianity as a Concealable Stigmatized Identity (CSI) in graduate biology programs** Elizabeth Barnes*, Taya Misheva, Sara E Brownell (Arizona State University)	**130: Student perceptions of supportive and non-supportive instructors: What characteristics make a difference?** Beth Schussler*, Maryrose Weatherton, Miranda Chen (University of Tennessee, Knoxville); Jennifer Brigati (Maryville College); Benjamin England (Saint Louis University)	**186: Exploring student science identity in a place-based, experiential marine science research program** Christine Ambrosino* (Hawai‘i Institute of Marine Biology); Mackenzie M Manning (Kapiolani Community College); Malia Rivera (Hawai‘i Institute of Marine Biology)
11:00–11:20	**116: Advancing the Guidance Debate: Lessons from Educational Psychology and Implications for Biochemistry Learning** Stephanie Halmo*, Sasha Stogniy, Cheryl Sensibaugh (University of Georgia); Peter Reinhart (Kenyon College); Vanessa Alele, Grace Snuggs, Logan Fiorella, Paula P. Lemons (University of Georgia)	**222: Using Latent Variable Path Modeling to reveal the causal links of evolution acceptance in biology undergraduates** Gena C Sbeglia*, Ross Nehm (Stony Brook University)	**179: Service learning positively impacts classroom climate and empowers students for environmental action** Heather D. Vance-Chalcraft*, Carol Goodwillie (East Carolina University)	**199: Exploring student depression in undergraduate research experiences** Katelyn Cooper* (University of Central Florida); Logan Gin, Sara E Brownell (Arizona State University)

11:20–11:40	**215: Faculty Adoption of Evidence-based Teaching Practices: The Role of Observation Sampling Intensity on Measures of Change** Justin A Goodridge*, Lucy Gordon, Ross Nehm, Gena C Sbeglia (Stony Brook University)	**139: Culturally Responsive Teaching in Undergraduate Science Labs** Hillary Barron* (University of Minnesota); Julie Brown (University of Florida); Sehoya Cotner (University of Minnesota)	**219: Random Call In Class Discussions Facilitates Peer Interaction and Can Reduce Communication Apprehension** Stacy M Alvares* (Edmonds Community College); Elli Theobold (University of Washington); Gwen Shlichta (Edmonds Community College); Jenny McFarland (Edmonds Community College)	**54: Establishing a Framework for the Culture of Scientific Research and Application to Course-based Undergraduate Research** Jessica Dewey*, Anita Schuchardt (University of Minnesota)
11:40–12:00	**6: Using Learning Assistants to Systematically Gather and Analyse Formative Assessment Data in Large STEM Classes** Young Ae Kim*, Katelyn Southard, Jonathan Cox, Lisa Elfring, Paul Blowers, Vicente Talanquer, (University of Arizona)	**225: Religious Students' Perceptions in Biology** Ryan Dunk*, Mia Pepi, Jason Wiles (Syracuse University)	**77: Exploring the Impacts of Graduate Teaching Assistants on Student Experiences in a Course-Based Undergraduate Research Experience** Emma C Goodwin*, Jessica Cary, Erin E Shortlidge (Portland State University)	**18: The Darkside of Development: A systems approach for characterizing the negative mentoring experiences of doctoral students** Trevor T Tuma*, Benjamin Hultquist, John David Adams, Erin Dolan (University of Georgia)
12:00-12:30	BREAK/Presenters stay in room for additional questions and discussion			
12:30-2:00	Poster Session			

Friday, July 31st, 2020

Note: all sessions convened via Zoom; all times PDT

9:30-10:00	**Action Group: Plans for the future**			
	Session A: Active Learning	**Session B: Instrument Development**	**Session C: Affect: Interest/Motivation/etc. & Professional Development**	**Session D: Metacognition, Conceptual Understanding, * Institutional Change**
10:00–10:20	**11: Exploring How Cultural Backgrounds Influence Attitudes Towards Scientific Teaching** Seth Thompson*, Sehoya Cotner (University of Minnesota); Ivar Rønnestad (University of Bergen)	**123: Development of a virtual classroom teaching effectiveness observation rubric** Abha Ahuja* (Minerva Schools at KGI)	**108: Promoting Intrinsic Motivation to Learn Biology through Explicit Attention to Students' Everyday Ideas** Ruth B MacNeille*, Miranda Kuns, Anna Grinath (Idaho State University)	**171: Designing a Questionnaire for Undergraduate Biology Student Epistemologies for Science** Kyriaki Chtazikyriakidou*, Melissa R McCartney (Florida International University)
10:20–10:40	**12: Hidden identities shape student perceptions of active learning environments** Jeremiah Henning* (University of South Alabama); Cissy Ballen (Auburn University); Sehoya Cotner (University of Minnesota)	**136: Validating Science Interest and Identity Items for Use with Diverse Community College Students** Heather Perkins* (Purdue University); Sara Cooper (Foothill College); Jennifer D Kurushima (Evergreen Valley College); Jeffrey N Schinske (Foothill College)	**28: I gave my best effort: Measuring test-taking motivation on the GenBio-MAPS programmatic assessment** Crystal Uminski*, Brian Couch (University of Nebraska-Lincoln)	**102: A survey of study strategies of first-year university students: how strategy choice relates to student demographics and student performance** Adrienne E Williams*, Kameryn Denaro, Michael B Dennin, Brian K Sato (UC Irvine)

10:40–11:00	**185: Comparing the Effects of Repetition, Observation of Active Learning, and Kinesthetic Learning on Non-Major General Biology Students** Kim-Leiloni Nguyen*, Oliver Lopez, Danielle Dervishian, Tyler Flisik, Karyn Kakiba-Russell, Janine Kido, Anthony Lopez, David Moskovitz (Mt San Antonio College)	**154: Defining and Modeling Student Success as a Latent Construct in Learning Assistant Supported Biology Courses** Hannah Huvard*, Robert Talbot, Courtney Donovan (University of Colorado Denver)	**21: Mixed effects of a belongingness intervention on student performance, confidence, and instructor empathy in two introductory STEM courses** Sarah P Hammarlund*, Cheryl Scott, Sadie Hebert, Alyssa Olson, Margaret Sleeth, Sehoya Cotner (University of Minnesota)	**146: Evaluating Representations of Scientific Process and Ethics and Responsible Conduct of Research in Common Introductory Collegiate Biology Textbooks** Thomas McCabe (The University of Texas at El Paso)*; Antonio A Lazos, Isabela D Perez, Kristy J Wilson (Marian University); Jeffrey T. Olimpo (The University of Texas at El Paso)
11:00–11:20	**230: Problem based learning in a computer stimulated collaborative environment can be an effective active learning approach for large medical classrooms** Revati Masilamani*, Tony Gao, Peter Rogers, Berri Jacque (Tufts University)	**83: Scientific civic engagement survey validation** Irfanul Alam*, Lisa A Corwin (University of Colorado Boulder)	**75: The Impact of Group Work on Student Self-Efficacy Towards Quantitative Biology** Alexander Kulacki*, Melissa L Aikens (University of New Hampshire)	**233: Limited diffusion: How, why, and to whom does knowledge of teaching innovations spread?** A. Kelly Lane (University of Minnesota – Twin Cities), Jacob D. McAlpin (University of South Florida), Luanna B. Prevost (University of South Florida), Marilyne Stains (University of Virginia), Brittnee Earl (Boise State University), Stephanie Feola (University of South Florida), Jennifer E. Lewis (University of South Florida), Susan E. Shadle (Boise State University), John Skvoretz (University of South Florida), John P. Ziker (Boise State University), Brian A. Couch (University of Nebraska-Lincoln)

11:20–11:40	**187: Does a personalized and long-term teaching mentoring program actually work?** Michael Moore* (University of Nebraska - Lincoln); Uma Swamy (Florida International University); Carlos Goller (North Carolina State University); Anjali Misra (Allan Hancock College); Anusha Naganathan (University of Rochester); Margaret Shain Stieben (The American Physiological Society); Kathryn Johnson (Trail Build LLC); Susan Wick (University of Minnesota)	**60: Exam Wrappers in Introductory Biology** Joel Ledford*, Geoffrey Benn, Kara Moloney, Young-A Son, Kem Saichaie, Susan Keen (UC Davis)	**55: Improving life science students' attitudes toward mathematics: Insights from implementation of two biocalculus courses** Melissa L Aikens* (University of New Hampshire); Carrie Diaz Eaton (Bates College/QUBES); Hannah Highlander (University of Portland)	**217: The Social Networks of Lecturers with Security of Employment** Daniel Grunspan* (University of Guelph); Brian Sato (UC Irvine); Stanley M Lo (University of California San Diego)
11:40–12:00	**39: CURE as a supplement to the traditional biology lab: How does actively researching cutting edge science topics influence scientific literacy, performance, and identity of science majors?** Joseph LaForge*, Erika C Martin (Emporia State University)	**175: Moving Towards Authentic Assessment in Traditional Classrooms: Identifying How and Where to Make Changes** Justine Hobbins*, Bronte Kerrigan, Kerry Ritchie (University of Guelph)	**194: The work environment and personal characteristics that affect learner-centered teaching practices** Diane Ebert-May*, Jessica Middlemis Maher, Nathan Emery (Michigan State University)	**35: Learning to be a scholar: How professional networks shape biology graduate students' perceptions of the research-teaching nexus** Joshua W Reid*, Grant E Gardner (Middle Tennessee State University)
12:00-12:30	BREAK/Presenters stay in room for additional questions and discussion			
12:30-2:00	Poster Session			

LONG TALK ABSTRACTS

A scientist like me: demographic analysis of biology textbooks reveals both progress and long-term lags

Cissy Ballen (Auburn University)*; Jeremiah Henning (University of South Alabama); Michael Smith (University of Konstanz); Sara Wood (Auburn University); Taylor McKibben (Auburn University); Luoying Chen (Auburn University); Marjorie Weber (Michigan State University); Ash Zemenick (Michigan State University)

Paper ID: 8

RESEARCH QUESTION: Textbooks are one of the primary resources that undergraduate students use to learn science and are often required as part of coursework (Hilton 2016). While providing important reference material and activities of a given discipline, textbooks highlight the historical work of influential scholars who have shaped the field. Whether intentionally or not, textbooks instill readers with ideas about who can contribute to science fields (Good et al. 2010). Therefore, textbooks represent an important opportunity to shape students' existing stereotypes of who scientists are, have been, and can be. According to social impact theory, student perceptions of who can do science are impacted by exposure to role models (Latané & Wolf, 1981). Role models influence student sense of belonging in STEM, and affect their performance and retention (Margolis et al., 2000). Perceptions are shaped by environmental cues within a context, and previous work shows exposure to stereotypical representations of scientists impacts interest in science among women and students of color (Cheryan et al., 2013; Schinske et al., 2016). Exposing students to scientists from a diversity of backgrounds and identities has positive impacts on students' interest and achievement in STEM (Fairlie et al., 2011; McIntyre et al., 2005; Schinske et al., 2015).

The extent to which scientists from diverse backgrounds and identities are included in textbooks remains poorly understood. We sought to characterize the status of demographic representation of biologists across common biology textbooks in the United States, and how representation has changed over the history of biology research. We addressed the following research questions:

(RQ1) Does the demographic representation of scientists in textbooks change over the history of biological discovery?

(RQ2) Are the proportion of women scientists featured in biology textbooks representative of the makeup of active biologists at the time of discovery?

(RQ3) What is the overall demographic (binary gender, race) representation of scientists in biology textbooks, and how does this compare to the makeup of the student population?

RESEARCH DESIGN: We conducted a demographic analysis by extracting >1,100 human names from recent editions of seven common undergraduate biology textbooks using Python Software, and assessing the binary gender and race of featured scientists. To address (RQ1), we used linear mixed effects model using the lme4 package in R version 3.6.0. To address (RQ2), we used Chi-square Goodness of Fit to test for deviations between observed textbook citations and the expected number of citations by men and women scientists, assuming the rate of citations would be proportional to the binary gender ratios of scientists at the time. We used the National Science Board's Science and Engineering Indicators, which measured the approximate number of men and women tenured professors in life sciences over time. To address (RQ3), we used linear mixed effects models. As a final exercise, we extrapolated our results to determine how long it would take for the representation of gender and race in textbooks to reflect the population of students graduating with undergraduate degrees in biological sciences. Then, we forecasted when scientists from demographic groups will be equally represented in textbooks as they are among biology students.

ANALYSIS AND INTERPRETATIONS: (RQ1) When considering representation of scientists over time, we found women and scientists of color were increasingly represented in contemporary scientific discoveries. We did observe a three-way interaction between race, gender, and year of publication ($\chi^2 = 106.0$, $p < 0.0001$) which indicates that the representation of certain groups increased through time (White women and Asian men), while others decreased (White men), and representation of some groups (Asian women, Black women, Hispanic men and women) do not significantly change over time. We observed significant underrepresentation (Asian & Hispanic women) or no representation (Black women) of women scientists of color. (RQ2) We compared the representation of all women scientists within textbooks to the abundance of women who were tenured biologists at the time of discovery, and found that citations of biologists who are women was remarkably proportional to the number of women biologists in the scientific workforce ($P > 0.05$). (RQ3) When considering overall representation of scientists across textbooks, 145 scientists were women (13.1%) and 962 were men (86.9%), representing a 1:7 ratio of women to men ($\chi^2 = 270.1$, $p < 0.0001$). Only 6.67% of the scientists mentioned across textbooks were scientists of color ($\chi^2 = 1385.1$, $p < 0.0001$). These values do not reflect the demographic makeup of textbooks' target audience: the biology student population in the U.S., considering that women and students of color make up 60% and 40% of biology undergraduates, respectively (Snyder et al., 2017).

Finally, we questioned how long until women and scientists of color are represented in biology textbooks at the same proportions as they are represented in the biology student population. Assuming that observed demographic shifts in textbook citations will continue at the same rate, we estimated a best fit line to predict how group representation will change over time. Results showed a grim outlook for some underrepresented scientists. For example, if Black authors continue to be featured in biology textbooks at the same rate, it will take nearly 500 years to reflect the biology student population.

CONTRIBUTION: While demographics in the United States continue to diversify (Landivar, 2013), a demographic mismatch between “who students aspire to be” and “who currently occupies science professions” intensifies. To our knowledge, we are the first work to illustrate the extent of this mismatch over time in biology textbooks, and create forecasts based on historical rates of representation.
To address the call to increase the diversity of scientist role models, classrooms have integrated counter-stereotypical examples of scientists in introductory biology using resources such as Scientist Spotlight (Schinske et al., 2016) and Project Biodiversify (www.projectbiodiversify.org). We do not advocate for an erasure of the history of science, or intend to undermine the enormous contributions of individuals who laid the groundwork for contemporary biology. However, equally important in our efforts to communicate history is to show that science is a diverse discipline and that anyone who is interested in the fundamental principles of life belongs in a science career.

Exploration of the transition between high school and college STEM courses: Characterization of students' perspectives and faculty's instructional approaches

Clara Meaders (Cornell University)*; A. Kelly Lane (University of Nebraska-Lincoln); Brian Couch (University of Nebraska-Lincoln); Anya Morozov (University of Nebraska-Lincoln); Justin Shuman (University of Nebraska-Lincoln); Marilyne Stains (University of Virginia); MacKenzie Stetzer (University of Maine); Emma Toth (University of Maine); Erin Vinson (University of Maine); Michelle Smith (Cornell University)

Paper ID: 56

Research Question: Introductory STEM courses represent entry points into a major, and student experiences in these courses can affect both their persistence and success in the disciplines. Notably, students experience a shift in learning environments between high school and college, with college courses relying more heavily on lecture (Akiha et al., 2018; Stains et al., 2018). This shift may be experienced differently by students based on their backgrounds and is an area that instructors can address with course framing and structure. Here, we present the findings from multiple studies that focus on the student transition between high school and college. The results expand upon previous work that explored disconnects in student expectations of how class time would be used in biology courses (Brown et al., 2017) and how anxiety relates to performance and persistence in biology (England et al., 2017; England et al., 2019). Our research questions include: 1) what predictions and concerns do students have about how-in-class time will be used in their introductory college STEM courses? and 2) how do instructors utilize the first day of class to set up the learning environment in these courses? This work is the first of its kind to broadly characterize the transitions STEM students experience between high school and college and practices instructors use on the first day of class. The findings have practical implications for instructors as they prioritize how to set up learning environments and communicate their expectations.

Research design: Our work utilizes both survey and observational data. We collected survey responses from over 1500 students at three universities in over 20 introductory

STEM course sections, covering ten disciplines, during the first week of classes and mid-way through the semester. Our survey questions aimed to establish students' predictions at the beginning of the semester for how class time would be spent in their STEM courses and determine the information students used to inform their predictions. Another goal of our surveys was to identify common course-based concerns held by students. Students ranked their levels of concern about these items, and we used their responses to create a summary score of concern used to measure their changes in concern between the beginning and middle of the semester. To explore if variation in student predictions or concerns could be explained by differences in student background and/or course variables, we used linear mixed-effects models. Answers to short answer survey questions were analyzed using an inductive coding process. We also observed the learning environments students experienced by characterizing 108 class periods using COPUS (Smith et al., 2013). These analyses allowed us to compare the actual practices experienced by students with their predictions. Finally, to determine how faculty introduce their courses to students, we quantified how much time 23 instructors dedicated to various talking points during the first day of class and adapted the non-content Instructor Talk Framework (Harrison et al., 2019; Seidel et al., 2015) to analyze the ways in which they communicate with students. Our final codebook consisted of 41 positive and negative codes, which we used to categorize the types of talk utilized by instructors at one-minute intervals.

Analysis and Interpretations: Taken together, surveys of students in introductory STEM courses reveal that students predict their classes will consist of about 64% lecture, although there is considerable variation in their predictions. Notably, when compared to the corresponding COPUS results, all students underpredicted the amount of lecture they experienced. The results from our linear mixed-effects models revealed that students enrolled in courses with fewer than 110 students, first-generation students, and first-semester students all predicted significantly less ($p < 0.01$) lecture than their peers. We asked students to identify the factors they used to inform their predictions, and identified a number of considerations including course characteristics and experiences during the first day of class. We also used surveys to identify 13 common student concerns. Examples of common student concerns include knowing what to study and having the necessary skills/background to succeed. We also assessed students' levels of concern during the first-week and mid-semester. While overall levels of student concern decreased ($p < 0.001$), the pattern varied across different demographic groups. In particular, when controlling for initial concern and course grades at mid-semester, female students and lower-performing students held higher levels of concern than their peers ($p < 0.01$). In the open-response survey questions, students mentioned the first day of their introductory STEM class as a pivotal time point, so we also investigated the instructional practices that are used on this day. Our analyses of the first day of class revealed that instructors spend the majority of their time covering policies and basic information (38% SD ± 20%), and course content (18% SD ± 20%). All 23 instructors also utilized positive non-content Instructor Talk during the first day, most commonly building instructor/student relationships (39% SD ± 18%) and establishing classroom culture (30% SD ± 11%). Instances of negatively phrased talk were less common (11 SD ± 12%) and highlight the potential for students to receive mixed messages during the first day, for example encouraging students to come to office hours but mentioning "after you take the first test and get a 40% that's too late." Emergent Instructor Talk codes included topics such as academic integrity and discussing experiences from prior students.

Contribution: Our results add to a growing body of work revealing differences in student predictions and experiences in introductory STEM classes. Students often have misalignments in their predictions about instructional practices and hold concerns about their STEM courses. These results suggest that students may benefit from instructors being more transparent about the structure at the beginning of the course. Our work also shows that introductory students anticipate more active learning than they are receiving, indicating students may be receptive to the addition of student-centered teaching practices. Additionally, we have identified a broad range of course-based concerns that instructors can measure and discuss along with helpful resources associated with the course. The analyses of the first day of class document the range of activities that occur and can be used as a starting point for determining the limitations and affordances of ways to introduce a course. By understanding student predictions and concerns, and how STEM instructors set the tone on the first day, we can better design interventions to help students with the high school to college transition and measure their effect.

SHORT TALK ABSTRACTS
Friday, July 10th

Session A: Conceptual Understanding

Paper ID: 156

A learning progression characterizing how students use mass balance reasoning to understand biology

Emily Scott (Univ. Washington)*; Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington)

Research Question or Problem: When students use fundamental concepts of science to reason, they can make productive connections across diverse biological phenomena that are superficially distinct. For example, the principle of matter conservation can help students develop mass balance reasoning to predict how diverse materials (e.g., Ca2+, blood) accumulate in different compartments (e.g., cell, aorta) in biological systems. However, work in engineering and math education have found that students struggle with mass balance reasoning; biology students may face similar challenges. Therefore, we asked: How do students learn to reason about mass balance phenomena in biology? We leveraged learning progression research from the learning sciences as our theoretical framework, which guided our development of an empirically-derived learning progression describing how students learn to reason about mass balance phenomena in biology.

Research Design: We used a cross-sectional approach to simultaneously collect written and interview data from students at different points in their academic careers (i.e., introductory to advanced biology students, Allied Health majors). This approach provided us with the large number of diverse responses necessary to detect the reasoning patterns described in a learning progression. To collect student reasoning data, we developed 15 short answer plant and animal physiology questions that we administered online at 11 institutions (community college to R1) from fall 2017 to winter 2020. In total, we collected 19,448 responses. We also interviewed a total of 70 biology students at an R1 and a community college about six of the questions.

Analyses and Interpretations: We used a constant comparative method to analyze written and interview data to identify reasoning patterns. One researcher would analyze 100 written responses per question to develop a preliminary rubric describing reasoning patterns for that question. The research team discussed each rubric and iteratively revised all rubrics until they reached consensus. We used interview data to validate the rubrics. Next, two coders tested each rubric by independently scoring 200 additional responses, followed by another round of revision. We considered rubrics as finalized after coders achieved an inter-rater reliability of >0.8 (Cohen's kappa) on ~700 total responses. From these data, we developed a mass balance learning progression that described four increasingly sophisticated levels of student reasoning. L1 (lowest level)–Students focused only on organism/cell features; L2–Students confused accumulation patterns with influx or efflux patterns; L3–Students used only an influx or efflux to predict material accumulation patterns; L4–Students successfully predicted material accumulation patterns using net influxes and effluxes of material to a compartment. From a representative question answered by 658 students, we found that 11% of students reasoned at L1, 21% at L2, 29% at L3, and 39% at L4.

Contribution: Our learning progression provides instructors with a road map for how students develop mass balance reasoning in biology, including conceptual challenges they may face. Instructors can track where their students are on the learning progression–and how their ideas change with instruction–by using our short answer questions as formative assessments. Our work expands the literature on student reasoning about mass balance phenomena, particularly in biology, which is largely unexplored.

Paper ID: 167

Teaching metabolism as a dynamic system improves student learning in biochemistry

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To ensure that students are adequately prepared to meet emerging challenges in STEM, national organizations have called for the re-evaluation of fundamental science education. In biochemistry, students must understand the importance of metabolic networks and conceptualize them as dynamic, interdependent, and regulated processes. Yet, students often struggle to predict the everyday behavior of metabolic pathways during exercise, upon feeding, or when cells are damaged. To conceive metabolic networks appropriately, students must take a systems-thinking perspective where they view and analyze systems as interconnected processes whose functions can be mechanistically explained. This analytical approach allows them to predict how the metabolic networks in an organism would adjust under different biological scenarios. To help students become more explicit systems-thinkers, computer simulations using scaffolding and experiment-like prompting, such as the Predict-Observe-Explain (POE) model of instruction may be useful. Computer simulation-based learning is adaptable and can actively engage students, but its effectiveness in the biochemistry classroom is largely unknown. In this study, we tested if teaching with computational learning modules containing explicit systems-thinking prompts would increase upper-level biochemistry students' mechanistic understanding of metabolic systems.

Using the computational modeling platform, Cell Collective (https://cellcollective.org), we tested two computational learning modules in a two-semester upper-level biochemistry series ("Module" course): (1) Regulation of Cellular Respiration (Biochemistry I, n=64), and (2) Regulation of Purine Biosynthesis (Biochemistry II, n=87). We used the POE model of instruction to guide our scaffolding and designed accompanying assessments. For Biochemistry I, we compared the assessment results from the module to those from a course where students receive typical classroom instruction only ("No module" course, n=64). We also confirmed the results from Biochemistry I trial ("Module" course, n=96; "No module" course, n=75). To better understand the impact of our learning modules, we aligned our learning objectives with (1) learning objectives from the American Society for Biochemistry and Molecular Biology (ASBMB), (2) previously identified student difficulties in systems-thinking and (3) the Systems-Thinking-Hierarchy (STH).

We confirmed that our assessment instruments were reliable and valid. For Cellular Respiration (Biochemistry I), we measured student pre- to post-assessment gain and evaluated statistical significance with two-way paired t-tests. We found that students in the "Module" course showed average pre- to post-assessment learning gains of 8% that were statistically significant, while students in the "No module" course showed no average gain. We compared the "Module" and "No module" groups using ANCOVAs that included pre-assessment scores and demographic variables as predictor variables and found significant differences. For the Regulation of Purine Biosynthesis (Biochemistry II), we tested whether prior exposure to the learning modules impacted student learning gains by taking advantage of the fact that only half of the students had prior exposure to the modules. We found that students who were previously exposed to the learning modules achieved a significant learning gain of 7%, while students who were not previously exposed achieved a non-significant learning gain of 2%. We also investigated performance by gender and found that our modules may have the potential to increase equity in biochemistry education. Finally, students were generally positive about the approach and appreciated its benefits when asked to comment via survey. Overall, our results suggest that the use of this computational learning approach can increase students' understanding of upper-level biochemistry and that repeated exposure may be especially beneficial.

Paper ID: 85

Perceptual Grouping Affects Students' Propensity to Make Inferences Consistent With Their Misconceptions

Laura R Novick (Vanderbilt University)*; Jingyi Liu (Vanderbilt University)

RESEARCH QUESTION: College students have many incorrect beliefs about evolutionary relationships among living things, in part due to the prominence they place on shared habitat as an indicator of such. For example, they think mushrooms are more closely related to plants than to animals because mushrooms and plants both grow in the ground. Consistent with the Gestalt principles of perception, previous research found that how cladogram branches are grouped affects students' interpretations of the relationships depicted. We tested the hypothesis that students would judge misconception-based inferences to be weaker when the perceptual grouping of the branches looks less consistent, as opposed to more consistent, with the misconception.

RESEARCH DESIGN: College students ($n = 83$) with diverse backgrounds and majors received nine cladograms, four experimental and five filler. Two versions of each experimental cladogram differed in whether the perceptual grouping of the taxa was more consistent (mc) versus less consistent (lc) with a misconception. For example, the cladograms for the mushroom misconception were, respectively:

[((fox + badger) + mushroom) + (geranium + grass)] + seaweed

and

[slime mold + ((fox + badger) + mushroom)] + [geranium + grass].

A manipulation check study using trees without taxon labels found that the mushroom branch looks more like it belongs in the same group as the geranium and grass branches in the former than the latter cladogram ($M_{mc} = 2.82$, $M_{lc} = 1.48$, on a 5-point scale; $F(1, 31) = 58.86$, $p < .001$, $\eta\_p^2=0.65$). Students received the more versus less consistent structure for two experimental cladograms each. These cladograms were mixed in with five filler cladograms that did not involve misconceptions.

Students answered an inference question for each cladogram in which they rated on a 4-point scale (1 = very unlikely, 4 = very likely) how likely it was that a character possessed by the target taxon (e.g., "Mushrooms have chitin") was also possessed by a taxon to which it was mistakenly believed to be closely related (e.g., geraniums). We predicted that students who received the more consistent cladogram structures would give higher ratings than students who received the less consistent structures.

ANALYSES AND INTERPRETATIONS: An ANOVA was conducted for each pair of experimental cladograms using consistency with the targeted misconception as the between-subjects factor. We found a significant difference in the mean ratings, in the predicted direction, for three of the four misconception cladogram pairs: (a) Mushrooms are closely related to plants: $F(1, 81) = 10.79$, $p < .01$, $\eta_p^2=0.12$ ($M_{mc} = 2.12$, $M_{lc} = 1.56$); (b) manatees are closely related to whales: $F(1, 81) = 96.55$, $p < .001$, $\eta_p^2=0.54$ ($M_{mc} = 2.59$, $M_{lc} = 1.33$); and (c) cartilaginous and bony fish comprise a valid biological group: $F(1, 81) = 8.11$, $p < .01$, $\eta_p^2=0.09$ ($M_{mc} = 1.95$, $M_{lc} = 1.51$). There was no difference for the birds are not reptiles cladograms: $F(1, 81) = 0.41$, $p > .50$, $\eta_p^2=0.01$ ($M_{mc} = 2.83$, $M_{lc} = 2.93$).

CONTRIBUTION: These results reinforce earlier research demonstrating the critical role principles of perceptual cognition play in students' interpretations of cladograms. Moreover, they suggest that (a) judicious use of perceptual grouping may prove useful in disabusing students of their evolutionary misconceptions and (b) instruction needs to focus students' attention on the (potentially inappropriate) influence of perceptual grouping on tree thinking.

Session B: Research & Laboratory Experience

Paper ID: 101

Investigating Students' Statistics Attitudes and Knowledge in CUREs

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Research Question: Course-based undergraduate research experiences (CUREs) are increasingly being incorporated into postsecondary STEM curricula to augment student access to authentic scientific opportunities. Often, CUREs engage students in conducting statistical analyses as part of the scientific process; yet, limited studies have explored how CUREs may impact students' values for and knowledge of statistics. Expectancy-value theory posits that students' values for statistics – interest in statistics, perceptions of the utility of statistics for future goals, and cost of doing statistics – affect their motivation and, ultimately, achievement on statistics tasks. These values may be influenced in CUREs as a function of project ownership. For example, a student who perceives high project ownership may be more invested in the research project and more likely to actively participate in all parts of the project, including the statistical analyses. We sought to determine to what extent: 1) students' values for statistics changed over the course of a semester-long CURE; 2) students' values predicted their performance on a measure of statistics knowledge in a biological context; and 3) project ownership predicted students' values for statistics.

Research Design: Students (N=209) represented a convenience sample of all individuals enrolled in introductory biology CUREs at a large midwestern university. An adapted version of the Math-Biology Values instrument was implemented in pre-/post-semester format to examine CURE students' interest in and their perceptions of the cost and utility of doing statistics. At these time points, students also took a multiple-choice knowledge assessment (BioVEDA) that evaluated their understanding of variation and statistics in the context of biological experimental design. In a separate post-survey, students were asked about their perceptions of project ownership (PO) using the content scale from the Project Ownership Survey. All attitudinal surveys were on a 6-point Likert scale. Repeated measures analyses were done to detect changes in values for statistics. Multiple linear regressions (forward and backward, stepwise) were performed to test models about the effect of values on statistical knowledge and of project ownership on values for statistics.

Analyses and Interpretation: Students' perception of the utility of statistics showed a significant gain over the course of the semester (Mpre=4.9, Mpost=5.0). However, no change was seen in their interest or their perception of cost. When controlling for pre BioVEDA score (Beta=.6), Utility was the only significant predictor of post BioVEDA score (Beta=.1, p<.001, Rsquare=.3). PO had a significant effect only on post Utility (.6preUtility+.13PO=postUtility; p<.001, Rsquare=.4). These results suggest that including statistics in a CURE project can have an impact on students' statistical knowledge by demonstrating the utility of statistics. Additionally, students who have greater project ownership are more likely to show increased perceptions of the utility of statistics.

Contribution: Few studies have examined how statistics education embedded within CUREs influences students' statistics values and knowledge. Our research is poised to provide new insights into the role and impact of statistics education within CUREs as well as increase the community's awareness of the importance of attending to this aspect of instruction.

Paper ID: 228

Integrated Lab-Lecture Courses Boost Non-Major's Experiences in Introductory Biology

Jessica Merricks (Elon University)*; Dave Gammon (Elon University - Biology Department); Kathy Gallucci (Elon University - Biology Department)

While there are no major differences between the aptitude or ability of stem and non-stem majors, the latter is known to hold more misconceptions, have greater anxiety, and feel less confident in their ability to understand scientific content. These challenges can be mitigated in courses that are thoughtfully designed to create a supportive learning environment. The two most common laboratory course structures are the traditional format, in which content delivery (e.g. lecture) and lab skills practice occur in two distinct settings, and the integrated format, in which students experience the lecture and laboratory activities in a single session. Several studies suggest physics majors, public health majors, and biology majors all benefit from the flexibility and seamlessness of the integrated format (also known as a studio course), but little is known about the impact of this strategy on non-stem majors. The purpose of this research was to compare the perceptions and learning experiences of non-stem majors enrolled in these two course types. Specifically, we addressed two research questions: (1) What are students' perceptions of each course structure (e.g. perceived effectiveness, convenience, enjoyment, etc.)? and (2) Does one course structure facilitate greater gains in terms of students' experience and learning compared to the other? We collected data from a sample of undergraduate participants enrolled in either a traditional or studio version of an introductory biology course for non-majors at a undergraduate-serving liberal arts institution. The two courses share a common set of learning objectives, lab activities, and are taught primarily by overlapping faculty. We administered a survey to gauge students' perceptions prior to the start of the course, including their rationale for selecting the course, their anticipated grade, etc. At the end of the semester, participants completed a second survey to gauge their overall impressions of the course and its effectiveness. Using a mixed methods approach, we analyzed both likert and open-ended response data from these surveys, combined with key enrollment data, to illustrate the general perceptions of these two courses. In order to determine the impact of the lab structure on learning gains, we compared the results from a standardized pre/post content knowledge assessment. Even after controlling for the effect of the instructor, we saw clear patterns in the perceptions and learning experiences of students enrolled in the two courses. While students perceived the studio format to be more difficult initially, in the end students strongly preferred the studio format for several reasons, citing convenient scheduling, strong and positive interactions with their instructor and peers, and the seamlessness of the content delivery. Preliminary data is less clear regarding the impact of these course structures on overall learning gains for this population This presentation will highlight important course components that are relevant to improving the learning experience of non-stem majors in biology courses, as well as initiate a discussion about the role of student perceptions on course effectiveness.

Paper ID: 149

Longitudinal tracking of instructors shows that a short-duration CURE can catalyze expansion to longer CURE experiences.

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Undergraduate research experiences promote many positive learning outcomes and increase persistence in STEM fields, but are not accessible for all students. Course-based undergraduate research experiences (CUREs) have emerged as an effective method of engaging large numbers of students in authentic research experiences, and have been shown to promote many of the same positive outcomes as traditional research. However, CUREs are associated with many barriers to their adoption, and adoption of CUREs by laboratory courses remains low. Short-duration CURE modules have been proposed as a low-barrier entryway into using CUREs, but their effectiveness in promoting expansion to a longer CURE has not been studied. The Prevalence of Antibiotic Resistance in the Environment (PARE) project is a modular CURE designed to be a low barrier gateway into CURE use. PARE consists of a short core module that can be flexibly expanded with a library of add-on modules. Guided by diffusion of innovations (DOI) theory and using the PARE project as a model, we undertook a longitudinal qualitative study to answer the following questions: 1. What factors influence instructors' decisions to adopt the PARE project? 2. Does use of the short-duration PARE module lead to adoption of longer-length CUREs? 3. What factors correlate with transition to an expanded version of PARE?

DOI theory describes 5 stages that an individual goes through when adopting an innovation: knowledge, persuasion, decision, implementation, and confirmation/rejection. We conducted semi-structured interviews with a cohort of 19 PARE-interested instructors from diverse institutions at three time points: pre-implementation, post-implementation, and two years after the initial interview. These roughly correspond to the persuasion/decision, implementation, and confirmation/rejection DOI stages, respectively. Thematic analysis (with two coders) was used to code the transcribed interviews for emergent and DOI-related themes. In the first timepoint, instructors expressed common barriers to the use of CUREs, particularly a lack of personal bandwidth, a lack of time in the semester, and a lack of resources. Instructors were motivated to use PARE because of its perceived scientific impact, its compatibility with their course structure, and its low cost/equipment needs. In the second time point, 16 out of the 19 instructors reported implementing the PARE project, the majority of which used only the core module. At the third time point, the majority of instructors (10/19) had expanded the project beyond the original core module. The most common forms of expansion were use of additional PARE modules or incorporation of additional (non-PARE) CURE experiences. Expanding instructors often expressed that learning from the first attempts with the core module helped them implement longer CURE experiences in later iterations. Conversely, five of the instructors who had implemented PARE at timepoint two had discontinued use by timepoint three, including all of the instructors from two-year colleges. Instructors expressed diverse reasons for discontinuing. Together, these findings provide evidence that a short-duration CURE can lead to longer CURE experiences and catalyze a change in teaching practice. They also underscore the need for continued research into how to make CUREs more sustainable, particularly for instructors at two-year colleges.

Session C: Science & Society and Affect

Paper ID: 106

Talking Science: undergraduates bridging the gap between scientific and non-scientific communities.

Josue Simeon (Florida International University); Sarah L Eddy (Florida International University)*; Hana Shah (Florida International University)

RESEARCH QUESTION: Understanding scientific information is critical for making informed decisions on socio-scientific issues. However, not only is scientific literacy low across the US, but the scientific community has a public trust challenge. At the heart of trust are feelings that an individual/group has your best interest at heart (affective trust) and belief that this individual/group is competent (cognitive trust). Thus, trust is best established through long-term relationships. Unfortunately, the majority of scientists currently come from only a few types of communities, which limits exposure to and trust with many communities in the US. Yet, a diversity of backgrounds is present in academic institutions among the undergraduate population pursuing science degrees. These students are familiar with the language and values of their home communities and are learning the language and values of the scientific community. Thus, these students, especially first-generation students, could be ‘boundary spanners’: connecting the scientific community to the public and spreading scientific information. Our study explores the experiences of first-generation students communicating science through casual conversations with individuals outside of academia (family members, friends, and community members) to understand if they are already taking steps to be boundary spanners.

RESEARCH DESIGN: We recruited 20 upper-division first-generation biology majors into this interview study. Prior to the interview, students completed an online demographic survey. Our semi-structured interviews ranged in length from 15 to 45 minutes and participants were asked a series of questions about their experiences engaging in science-related discussions with people beyond their classmates and their perspective on how their instructors could help them prepare for these conversations.We used open coding to identify themes in the data using both deductive codes, based on the framework of boundary spanning, and inductive codes to identify emergent patterns.

ANALYSIS AND INTERPRETATIONS: The undergraduates interviewed ranged in parent or guardian education level (65% completed high school or less, 25% completed some college, and 10% completed technical or trade school) and ethnicity (55% identified as Hispanic, 25% White, 15% Black, and 0.05% Asian).

Preliminary analyses revealed that although 100% of participants were having socio-scientific conversations with others students, but only 65% discussed socio-scientific topics with individuals outside of academia. If students engaged in these conversations, they were more likely to talk to siblings or friends, than to parents or grandparents. Those who expressed discomfort with these conversations reported that it would be difficult to change an individual's mind and expressed a desire to avoid conflict. When asked whether training in dialogues about socio-scientific topics would be helpful, all students agreed. Participant suggestions for this training centered around incorporating discussion techniques into existing coursework rather than a new course.

CONTRIBUTION: This research suggests that first generation students are attempting the first steps at boundary spanning: initiating conversations. This makes them potential valuable partners in efforts to increase the scientific literacy of the public. Further research on how common these conversations are and how they are received by family and community members is needed.

Paper ID: 200

Students' perspectives on their acceptance of evolution

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

This study is situated within a developing framework for understanding acceptance of evolution articulated by 20 prominent, active researchers on evolution acceptance. This recently published framework provides context about the factors known to be associated with evolution acceptance and helps to chart a direction for further research. The most prominent factors associated with evolution acceptance are (1) knowledge of evolution, (2) knowledge of the nature of science (NOS), and (3) religious affiliation and intensity of religious belief. The authors of the recent overview argue that researchers of evolution acceptance should focus on work geared toward determining the generalizability of known results and investigating evolution acceptance longitudinally in various populations. Here, we take up that challenge by exploring qualitatively how students perceive changes in their acceptance of evolution throughout their higher education experience.

Study Design: Students enrolled in a first year experience at a large, private, research-intensive, northeastern United States university were surveyed online via Qualtrics at the beginning and end of the fall 2017 semester. In spring and fall of 2019 the same students were invited to participate in 30-60 minute long semi-structured interviews which sought to elicit their reasoning and attitudes around acceptance of evolution. All interviews were transcribed, transcripts were read and analyzed by the authors using open coding, and codes were combined for a thematic analysis

Findings and Analysis: Students described a variety of different attitudes and opinions on acceptance of evolution. With regard to the major factors described above, we found that students tended to rely on knowledge of evolution and religious beliefs to describe their attitudes towards acceptance of evolution. Notably, even when presented with the suggestion of their understanding of the aims and processes of science, our student participants were unable to explicate any possible ways that their NOS understandings impacted their acceptance of evolution. Students were more able to articulate how their knowledge of evolution and religious beliefs impacted their acceptance of evolution. For most students, this was described as a possible interference of religious beliefs on their acceptance of evolution. Most of the students we interviewed were not strongly religious, and they discussed how their relative lack of strong religious convictions were likely helpful in their acceptance of evolution. Others, however, described a feeling of tolerance of evolution acceptance from their religious beliefs.

Contribution and General Interest: This work will allow future research to explore the similarities and differences between individuals in acceptance of evolution. Hearing students' conceptualizations of their acceptance of evolution can aid in development and refinement of further quantitative work by providing context to students' reasoning patterns. Also, we simply think it is important to center students' lived experience and interpretation of their understanding, and this qualitative work allows us to hear specific experiences over quantitative averages. We are hopeful that the results presented here will be useful for all members of the SABER community, especially those interested in evolution education and/or the use of qualitative inquiry for exploring science teaching problems.

Paper ID: 10

Context matters: variation in psychosocial factors across three institution types

Sara Berk (Auburn University)*; Shima Salehi (Stanford University); Catherine Creech (Mt Hood Community College); Sheritta Fagbodun (Tuskegee University); Michele Shuster (New Mexico State University); Rebecca Brunelli (California State University, Chico); Abby Drake (Cornell University); Carrie Hall (University of New Hampshire); Sadie Hebert (University of Minnesota); Justin St. Juliana (Cornell University); Daniel Stovall (Winthrop University); Min Zhong (Auburn University); Sehoya Cotner (University of Minnesota); Cissy Ballen (Auburn University)

RESEARCH QUESTION: To enhance equity and diversity in biology classrooms, research in biology education focuses on best practices that increase learning outcomes and reduce barriers for all students. However, the impact of individual educational institutions on creating and/or mitigating barriers is less understood. If we pursue research questions in multiple contexts, we can better develop pedagogical context knowledge that is responsive to unique situational factors (Barnett & Hodson 2000). To foster contextual knowledge in biology education research, we conducted an exploratory analysis by harnessing a large research coordination network to test the following questions across three institution types: community colleges (CCs), minority serving institutions (MSIs), and research-based (R1) universities: 1) To what extent do we observe demographic gaps in academic performance based on race/ethnicity in introductory biology? 2) To what extent do we observe differences in social psychological factors in introductory biology? And 3) How do psychosocial factors such as test anxiety and stereotype threat mediate demographic performance gaps?

We focused on test anxiety and stereotype threat as our two psychosocial factors because they have both been shown to impact student performance, and are likely influenced by institution type. We suggest that due to the malleable nature of both test anxiety and stereotype threat, results from one institution type may be difficult to generalize to others.

RESEARCH DESIGN: We quantified test anxiety (Pintrich et al. 1991), stereotype threat (hereafter ethnicity stigma consciousness, or ESC - Picho and Brown, 2011), and exam performance of 3594 college students at 2 CCs, 3 MSIs, and 3 R1 institutions. We then used mixed effects models to test whether these factors varied for underrepresented minority students (African Americans, Hispanic/Latinx, Native Americans, and Pacific Islanders; hereafter URM) at different institution types. We also used structural equation models to test for the mediating effects of test anxiety and ESC on exam performance for students based on URM status across institution types.

ANALYSES AND INTERPRETATION: We found that performance gaps based on race/ethnicity were evident at MSIs and R1 universities, but not at CCs (β_{CC}= -0.23, p=0.74; β_{MSI}= -0.311, p<0.001; βR1= -0.42, p<0.001). URM students had higher levels of ESC relative to non-URM students at R1 universities and MSIs, but not at CCs (βCC= 0.11, p=0.91; βMSI= 0.28, p<0.01; βR1= 0.35, p<0.001), and URM students only had higher test anxiety at MSIs (βCC= 0.16, p=0.79, βMSI= 0.32, p<0.001, βR1= 0.18, p=0.65). Finally, we found that test anxiety mediated exam performance for URM students at MSIs, but not at CC or R1 universities. We found no evidence for mediation of exam performance through ESC at any of our institutions, but the reasons for incomplete mediation varied by institution type.

CONTRIBUTION: Our findings demonstrate that institutional context plays important roles in the mechanisms underlying achievement gaps. This is especially important given that psychosocial interventions vary in effectiveness across different student populations (Schwartz et al. 2016). We emphasize the need for collaborative research to increase our understanding of student experiences in biology.

Session D: Conceptual Understanding

Paper ID: 237

Observing Growth in Students' Recognition of DNA-Associated Concepts with a Card Sorting Task

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DNA is not just a complex molecule; it is a complex concept. As a molecule, it is both too small to see and too large to visualize (potentially millions of base pairs, which is far beyond human capability). As a concept, we need to consider the implications of everything from subtle chemical interactions at the individual base level to larger effects of 3-D chromatin structure to more abstract implications of informational content. Because of our minds' inability to focus on the large and small, the concrete and abstract, all at once, biologists use a variety of different representations when discussing different aspects. All of these representations are very different from each other in appearance (consider the stylized double helix compared to a string of DNA sequence or a box-and-line diagram of an operon). Learners are not as adept at moving from one representation to another and transferring their knowledge from one setting to another. We hypothesize that students may fail to recognize the commonality of concepts when presented in different visual formats. To test this hypothesis, we developed a set of 20 cards that represented 4 different DNA concepts (replication, gene expression, mutation/evolution, and DNA repair), each represented with 5 different types of drawing (chemical structure, DNA sequence, double helix, box-and-line, chromosome). On day one of the semester, students in an honors-level, highly reformed, introductory biology course were placed in nine groups of four, given the cards, asked to sort them however they pleased, and told to assign names to their groups. Approximately 12 weeks later, they were placed back in the same groups and asked to do the same activity. Pre and post course sorts and groups names were compared. Interestingly, most groups were able to identify at least some cards as representing mutation, replication and gene expression both pre and post, and the number of concepts identified increased significantly over time (at least 8 of 9 groups identified each conceptual category on the post assessment). Overall, "deep" sorts (correlating with conceptual categories) increased, while "surface" sorts (correlating with diagrammatic features) decreased. Considering every pair of cards that was sorted together, "deep" pairings increased from 41% to 54% and "surface" pairings decreased from 21% to 15%. Certain pairs were recognized by nearly all groups, while others were recognized by no one. The former may have additional clues in the drawings that suggest similarity, or they may represent more foundational concepts. Interviews will be used to gain insight into the student thinking behind particular pairs. Additional work is investigating how students at all levels compare with experts. We believe that this card sorting activity may be a useful tool for evaluating representational competence and how students learn important concepts across the curriculum.

Paper ID: 94

Students' Mechanistic Explanations of Protein Function Cluster around Core Ideas from Chemistry or Biology Courses, but Rarely Both.

Caleb M Trujillo (University Of Washington Bothell); Jenna Kesh (Michigan State University); Melanie Cooper (Michigan State University); Joelyn de Lima (Michigan State University); tammy m long (Michigan State University); Keenan Noyes (Michigan State University); Christina Schwarz (Michigan State University); Jon Stoltzfus (Michigan State University)*

Prerequisites or corequisites link many college and university courses implying that students should be transferring and applying ideas between these courses. Taking advantage of these linkages as introductory STEM courses are reformed and redesigned to focus on science practices, core disciplinary ideas, and crosscutting concepts requires understanding if and how students are using science practices and core ideas across linked courses. In this study, we focus on the science practice of mechanistic explanation related to the core idea of structure and function in two linked introductory courses, chemistry (Chem1) and cell and molecular biology (Bio1). Mechanistic explanation involves identifying underlying factors, determining the properties of those factors or what those factors do, and systematically linking these factors into causal chains that explain how and why the phenomena occurs. Our central hypothesis is that developing mechanistic explanations of phenomena in one discipline is enhanced by a mechanistic understanding of related core ideas from other disciplines. Our main objectives for this research are to: (1) document patterns found in students' mechanistic explanations; (2) determine if and how students use ideas related to intermolecular forces from Chem1 to explain protein structure and function in Bio1; and (3) explore how the context of a prompt influences what ideas students use to explain the same underlying phenomenon. To characterize students' mechanistic explanations, we are using diagrammatic, model-based explanations in which we describe a phenomenon and ask students to construct a representation and write an associated explanation of how and why the phenomenon occurs. Here we analyze explanations of why two proteins have different functions using three prompts with different contexts: (1) students are asked to choose two proteins and explain why they have different functions; (2) students are asked to explain why one protein specifically transports sucrose and another specifically transports lactose; or (3) students are asked to explain why a hormone binds to one receptor and not another. We developed these prompts and a coding scheme using an iterative process of assigning prompts as part of the regular coursework, analyzing the resulting student explanations for themes using a combination of a grounded approach and coding schemes developed during previous work, and revision of prompts. Students who had just completed an introductory cell and molecular biology course were randomly divided into three groups and given one of three final prompt versions. Three coders analyzed 138 student explanations, obtaining 81% interrater agreement (Cohen's Kappa = 0.69). Hierarchical cluster analysis revealed that students frequently link factors related to chemical properties or biological information into meaningful causal chains that explain why different proteins have different functions. Occasionally students combine ideas related to both chemical properties and biological information as part of the same explanation, but this is rare. An independence test of the clusters and the prompt version suggested the student ideas elicited depended on which

prompts were given (chi -squared = 77.564, df = 10, p-value = 1.505e-12). In addition, there was a statistically significant difference between the number of causal connections elicited by the different prompts (Kruskal-Wallis test (chi-squared = 21.069, df = 2, p-value = 2.66e-05). Our results indicate that students in a cell and molecular biology course can use ideas from chemistry to develop mechanistic explanations of protein function and can meaningfully combine this with ideas related to biological information, but careful scaffolding of instruction and prompts is required for this to happen. We will discuss implications of our research for instruction and prompt design that encourages students to make these connections.

Paper ID: 148

A student who understands evolution, accepts evolution: evidence from a systems view of evolution acceptance

Rachel L Salter (North Dakota State University)*; Kurt R Williams (North Dakota State University); Jennifer Momsen (North Dakota State University)

Research Question: For decades, biology education researchers have tried to determine why evolution acceptance in the U.S. lags behind peer nations and how biology teachers can make strides towards increasing national levels of evolution acceptance. Whether there is a causal relationship between students' understanding of evolution and evolution acceptance remains controversial. Resolving this debate is critical for designing effective classroom interventions to increase student acceptance of evolution. We present results from path analyses comparing two causal models of evolution acceptance: (1) understanding does not cause acceptance, or (2) understanding does have a causal effect on acceptance.

Research Design: We synthesized models from literature to test the causal effects of evolution understanding on acceptance among university students. We included five factors related to evolution acceptance: religiosity, understanding of the nature of science, openness to experience, number of science classes taken, and knowledge of evolution. We surveyed 312 HA&P students at a public Midwestern university using a battery of published surveys and a demographic questionnaire. We analyzed students' survey responses using path analysis, a framework for modeling causal effects among a set of variables. Path analysis tests hypothesized causal relationships holistically, defining the effects that covariates have on each other as well as the outcome of interest. This method is especially suited to testing competing hypotheses, such as whether increasing students' understanding of evolution results in greater acceptance.

Analyses and Interpretations: Model 1 tests the hypothesis that understanding of evolution would not be causally related to acceptance. This model failed three of four global fit tests ($\chi 2(9)=51.57$, $p<0.001$; SRMR=0.078; CFI=0.849; RMSEA=0.126). The relationship between knowledge and acceptance could not be explained by this model, as indicated by the covariance residuals and modification indices. Model 2 adds a causal effect from knowledge to acceptance. This model demonstrated excellent model fit ($\chi 2(9)=8.631$, $p>0.05$; SRMR=0.025; CFI=0.994; RMSEA=0.028). We estimated the standardized total causal effects of the five factors on acceptance: (1) religiosity (–0.48), (2) knowledge of the nature of science (0.26), (3) understanding of evolution (0.19), (4) number of science classes taken (0.12), and (5) openness to experience (0.12) (all $p<0.05$). When considering these factors as a system, we reject the hypothesis that conceptual understanding of evolution is not causally related to acceptance. Rather, the observed data are consistent with the existence of this relationship.

Contribution: Research investigating the relationship between evolution knowledge and acceptance has yielded opposing conclusions. We sought to clarify the causal role of evolution knowledge on acceptance by applying a causal modeling framework that situates knowledge within a system of factors shown to impact acceptance. Data from our sample support the hypothesis that understanding evolution plays a significant role alongside other personal and cultural factors in supporting students' acceptance of evolution. Our findings imply that effective instruction about evolution and the nature of science are productive avenues for increasing evolution acceptance.

Friday, July 17th

Session A: Professional Development

Paper ID: 196

Exploring Laboratory TAs' Ambitious Teaching & Tensions in an Online PD Course

Ryan C Coker (Florida State University)*; Miray Tekkumru-Kisa (Florida State University)

Research Question: This study focuses on an online ambitious teaching professional development course (ATPD) designed to support teaching assistants' (TAs) learning to elicit, assess, and use students' thinking. Rather than using students' ideas as resources to foster meaningful learning that builds on those ideas as the raw material of learning, novice teachers often attempt to identify and eradicate students' misconceptions, approaching students' elicited ideas as obstacles to learning. Thus, pedagogical tensions may arise for TAs as they attempt more ambitious instruction. In the context of this ATPD, we ask:

1. What are TAs' orientations to student ideas and their role in teaching?

2. What pedagogical tensions arise when TAs attempt to use ambitious teaching practices?

Research Design: Seven TAs of a general biology lab course enrolled in the ATPD and completed a set of assignments designed to support TAs' learning about key ideas underpinning ambitious instruction from intentionally selected readings. We analyzed each TAs' discussion board posts and teaching reflections, coding TAs' statements concerning student thinking as viewing student thinking as (1) evidence of content coverage, (2) obstacles to understanding, (3) tools to prime student thinking, interest, and activity, (4) elements of a positive classroom environment, and (5) as the raw materials of learning. We also identified statements where TAs expressed tensions about eliciting, assessing, and using students thinking as the raw material of instruction. This study employed a cross case comparison to highlight themes across TAs' orientations to student thinking and the tensions they experienced or expressed.

Analyses & Interpretation: Preliminary analyses reveal consistencies between orientations to student thinking and the tensions TAs bring up when discussing their teaching practice. Audrey, for example, orients to student thinking as the raw material of learning, and also as evidence of content coverage throughout his ATPD work. Most prominently, Audrey sets an ambitious goal of orchestrating ambitious science discussions, but expresses a tension between asking open-ended, probing questions to elicit and work on students' ideas, and asking fact-based questions that verify or correct students' understanding, writing, "I have a problem with starting conversations with open-ended questions, then trying to steer student thinking with [initiate-respond-evaluate] pattern questions. I definitely start panicking toward the end of conversations because I immediately think that the students will take too long trying to get to the main idea that we'll run out of time". Despite a goal aligned with ambitious teaching, Audrey navigates this tension in practice by diverting to more traditional forms of teaching.

Contribution: In this proposal, we presented a single case of the seven TAs that participated in the ATPD. These findings show that despite exhibiting an orientation to student thinking aligned with ambitious instruction, and describing the advantages of more ambitious forms of teaching, some TAs experience tensions that result in the selection of more traditional teaching practices.

Our findings indicate that a PD targeted at building TAs' capacity for ambitious instruction must attend to the tensions they identify to support TAs' appropriation of ambitious teaching practices that productively engage undergraduate students in the discourse and practices of science.

Paper ID: 38

Content-focused professional development and higher cognitive demand of curricular tasks elevate teaching assistants' teaching practices

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

BACKGROUND: Science education is changing to prioritize cognitively demanding curricula delivered using student-centered pedagogy (AAAS, 2011). These curricular changes require elevated teaching practices. Professional development (PD) is often required to support instructors implementing reformed curriculum that is student-centered and cognitively demanding. PD is particularly important for graduate teaching assistants (TAs), as they receive little pedagogical training yet are primary instructors for undergraduate courses. It is critical to examine the combined effect of curriculum and PD on TAs' teaching practices, as effectiveness of PD can depend on the curriculum TAs teach (Addy & Blanchard, 2010). Few studies separately examine the impact of PD and curriculum on TAs' teaching practices in higher education. RESEARCH QUESTIONS: "How does reformed curriculum interact with curriculum-aligned PD that incorporates modeled teaching practices and opportunities for reflection to affect TA performative and planned teaching practices?" and "How does cognitive demand of curricular tasks affect TA teaching practices?" RESEARCH DESIGN: The conceptual framework guiding this study draws on work on professional development (Reeves et al. 2016), teacher professional knowledge (Gess-Newsome et al. 2019), and cognitive demand (Stein et al. 1996). This study describes the effects of a curriculum and PD intervention on two aspects of TAs' teaching practices: performative aspects (spontaneous in response to classroom events) and planned aspects (likely to be structured before class). Intervention curriculum featured structured opportunities for reform-oriented teaching practices, and Intervention PD was situated in the context of these specific curriculum activities and modeled the teaching practices TAs were intended to use. Both the intervention curriculum and PD were implemented in a quasi-experimental design in an introductory biology laboratory course ($N_{Traditional} = 21$, $N_{Intervention} = 21$). ANALYSES AND INTERPRETATIONS: TAs were recorded while teaching, and recordings were analyzed using the Reformed Teaching Observation Protocol (RTOP). Cognitive demand of the recorded tasks varied across curriculum type, and was determined using the Task Analysis Guide in Science (TAGS). Intervention curriculum and PD had an additive effect on TAs' teaching practices (measured by RTOP; $M_{TradTrad}= 32$, $M_{IntTrad}= 49$, $M_{IntInt}= 62$, $F(2,69)=46.1$, Cohen's $f=1.2$, $p<0.0001$). Linear models of TAs' performative and planned teaching practices that incorporated curricular task type (Traditional or Intervention), PD type (Traditional or Intervention), and the cognitive demand of the observed task indicate that PD has a larger effect on performative practices (p.eta.sq= 0.15, ß= 0.3) than on planned practices (p.eta.sq= 0.05, ß= 0.16). Cognitive demand of curricular tasks has the largest effect on both performative (p.eta.sq= 0.22, ß= 0.4,) and planned practices (p.eta.sq= 0.41, ß= 0.6). CONTRIBUTIONS: This study suggests that curricular tasks that are planned to be cognitively demanding provide more structured opportunities for instructors to implement advanced teaching practices. These results suggest while content-focused PD or cognitively demanding tasks individually have an effect, implementing both provides maximum impact on TAs' teaching

practices. findings suggest strategies to prioritize resource allocation when designing PD for TAs.

Paper ID: 168

Supporting Biology International Teaching Assistants' Development of Cultural Competence: A Literature Synthesis.

Zhigang Jia (Midddle Tennessee State University)*; Grant E Gardner (Middle Tennessee State University)

Problem Statement: According to Institute of International Education, a total of 377,943 international graduate students enrolled in U.S universities in 2019. Many of them teach gateway science courses as international teaching assistants (ITAs) and can greatly impact student learning and retention. American students have prevalent negative perceptions and resistance against ITAs, which can affect this instructional impact. Most ITA research focus on only one of ITAs' major challenges: language, culture, and pedagogy. Research show ITAs' cultural competence can impact ITAs' linguistic and pedagogical skills. Therefore, one way to assist ITAs in overcoming instructional challenges as a whole is by utilizing the lens of cultural competence to examine their instruction, incorporating language and pedagogy as cultural skills. Cultural competence is the ongoing process to obtain the ability to teach students with different cultural backgrounds. This literature synthesis' goal is to synthesize what efforts have been made in ITAs' teaching professional development (TPD) to improve ITAs' cultural competence and summarize the outcomes of those efforts.

Research Design: This study adopted a cultural competence model as analytical framework, with five components: cultural awareness (self-reflection on cultural background), cultural knowledge (educational foundations about diverse cultural groups), cultural skill (the ability to interpret cultural data), cultural desire (motivation to become culturally competent), and cultural encounter (cross-cultural interactions). The authors used the search terms "International teaching assistant + professional development" and "international teaching assistant + culture" in ERIC and identified n = 106 manuscripts after excluding those focusing on non-educational perspectives, such as policy and law. After filtering, n =29 empirical and peer-reviewed manuscripts (dated from 2000-present) were identified in which some efforts have been made to improve at least one of the five components in ITA TPD program.

Analyses and Interpretations: The author kept extensive analytic memos and annotated bibliographies, and an outside researcher reviewed the coding to ensure reliability and validity. For cultural awareness, n =12 manuscripts highlight ITAs' self-reflections on stereotypes and biases against American students. For cultural knowledge, n =15 manuscripts indicate that ITAs should have foundational knowledge of U.S educational system, especially K-12 science curriculum, to understand the variation in student prior-knowledge. Two critical cultural skills were identified from n =13 manuscripts: appropriate rapport management and facilitating classroom discussions. Manuscripts (n =7) note that ITAs' can improve cultural desire by matching personal goals with departmental requirements. For cultural encounters (n= 10), ITAs were encouraged to interact with students, faculty, and peers in diverse contexts and integrate culture into teaching. ITA TPD were found to yield inconsistent results to improve ITAs' cultural competence, but more positive outcomes were found in studies where cultural encounter was a critical component of the TPD program. Future research should explore how to design ITA TPD programs using cultural encounter as a core strategy.

Contribution: This literature synthesis has important implications for biology ITA TPD to support ITAs to make their instruction more inclusive to American students.

Session B: Diversity, Equity, & Inclusion

Paper ID: 24

“It Comes from Within”: Characterizing the Internal Strengths Black Undergraduates Use to Succeed in Science Majors

Julie Dangremond Stanton (University of Georgia)*

Black scientists have achieved excellence in their fields because they persisted in earning science degrees despite many barriers. While the barriers Black students face have been described, the strengths they use to succeed in undergraduate science majors have not been well studied. To support Black students in earning undergraduate science degrees, we must understand their mechanisms of success. An anti-deficit achievement approach can be used to explore the experiences of high-achieving students from underrepresented minority groups. This involves reversing deficit-oriented questions such as ""Why do so many Black students leave science majors?"" and reframing them as achievement-oriented questions such as ""How do Black students persist in science majors despite all the known barriers?"" Following this approach, we used the community cultural wealth framework to understand the strengths that Black undergraduates bring to their science majors. Community cultural wealth consists of six forms of capital or “knowledge, skills, abilities, and contacts” that students of color possess and can use for educational success (Yosso, 2005, p.77). We asked the research question: “What internal strengths do Black students use to persist in their science majors?”

To answer this question, we used participatory action research (PAR). PAR involves a partnership between researchers and individuals who are part of marginalized groups, with the goal of addressing social issues. These individuals, known as co-researchers, bring critical expertise as members of the marginalized group being studied. Our PAR team included six co-researchers who are Black science majors and two faculty members. Together we studied academically-successful Black science majors in the final year of their undergraduate degree program at a doctoral university (n=33). Data were collected using a demographic survey and two semi-structured interviews. During the second interview, a card elicitation activity was used to encourage participants to describe their community cultural wealth. Qualitative data were examined using content analysis. Each transcript was coded to consensus by two or more members of our team. Pattern coding was used to identify potential themes in the coded data. The themes that resonated with co-researchers were explored with additional thematic analysis.

We found that participants used a variety of internal strengths to persist in their science majors. For example, participants described their ability to “just get it done”, which involves focusing to complete a difficult task without complaining or procrastinating. Participants expressed that “failure is not an option” when explaining why they created their own path instead of quitting when they encountered barriers on the standard path towards a career goal. Participants pointed to their willingness to ask for help, even when instructors or peers did not seem to like it, as a key to their success. Some participants also described their ability to codeswitch or adapt their communication style to the situation, as an asset that allowed their ideas to be appreciated. The field of science can benefit from the inclusion of scientists with these unique internal strengths. We are using these results to inform a workshop designed for faculty to address implicit bias in the classroom. By helping instructors to recognize the internal strengths Black students bring to science, we can support Black students to earn science degrees.

Paper ID: 25

Students Speaking Up: What supports and hinders self-advocacy for STEM undergraduates with ADHD and/or specific learning disabilities?

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

Many students with disabilities (SWD) initially pursue majors in science, technology, engineering, and mathematics (STEM), yet relatively few students will graduate with a STEM degree. SWD in STEM are less likely than their counterparts in non-STEM majors to use academic accommodations. The reasons for this phenomenon are largely unknown. One factor that affects SWD in all majors is the shift in legislation that guides the accommodation process between high school and college. In high school, accommodations are the responsibility of school personnel. In college, students become responsible for their own accommodations. Thus, many SWD are learning to manage their accommodations on their own for the first time in college. Managing accommodations requires self-advocacy. Self-advocacy is defined as communicating individual wants, needs, and rights in order to determine and pursue needed supports and accommodations. While self-advocacy has been identified as a critical skill linked to academic success for SWD in college, little is known about how SWD in STEM practice self-advocacy. Two of the most common disabilities on college campuses are attention-deficit hyperactivity disorder (ADHD) and specific learning disabilities (SLD). We previously modified and refined a conceptual model of self-advocacy for undergraduate STEM students with ADHD and/or SLD, defining what components encompass self-advocacy for students with ADHD and/or SLD in undergraduate STEM courses. The research question guiding our current study is: What supports and hinders self-advocacy for students with ADHD and/or SLD within undergraduate STEM courses?

Semi-structured interviews (n=25) were conducted at a university with highest research activity. All participants were STEM majors who received accommodations for ADHD and/or SLD. Data were analyzed using content analysis and thematic analysis by a diverse research team, including at least one or more undergraduate STEM students with ADHD and/or SLD. All transcripts were coded to consensus by at least two members of our research team. We identified how STEM instructors, peers, families, and other professionals support self-advocacy for our participants. For example, participants explained that they tend to feel more comfortable engaging in self-advocacy with STEM instructors that use group work and class discussion because they perceive their instructors as more approachable. We found that peers can support self-advocacy by normalizing disability and accommodation use, and by helping our participants navigate academic life. For example, peers supported students with ADHD and/or SLD by helping them identify who they should talk to when an accommodation issue arises. Many of the barriers to self-advocacy are tied to the culture of STEM courses and participant perception of what it means to be successful in a STEM course. For example, many participants shared that they feel reluctant to talk about their disability with their instructors or peers in a STEM course because they are uncertain of how others will respond when they learn the participant uses accommodations. Some participants described opting out of testing accommodations because they do not want their peers to notice their absence from the classroom on exam days. Our participants also explained that they may chose not to use accommodations in a STEM course because their peers may be their coworkers or supervisors in the future. Our study contributes to existing research by being one of the first studies to examine self-advocacy within undergraduate STEM courses, and by defining supports and barriers to self-advocacy in STEM courses for students with ADHD and/or SLD. Defining supports and barriers to self-advocacy in STEM courses is important because all STEM instructors will interact with students with ADHD and/or SLD in their courses. We offer implications for STEM instructors to support self-advocacy for students with ADHD and/or SLD in their courses.

Paper ID: 147

Beyond the Binary: Factors affecting retention of transgender and gender nonconforming students in STEM

Jeffrey Maloy (UCLA)*; Bryce Hughes (Montana State University)

Trans and gender nonconforming (TGNC) students on college campuses face barriers not encountered by their cisgender peers, including chilly campus climates, increased experiences of harassment and bullying, systemic microaggressions, and difficulty finding peer support groups. In particular, given the traditionally gendered academic environments experienced by students in STEM majors, TGNC students in STEM majors may be presented with unique challenges that lead to inequitable outcomes. However, to date no analysis has specifically investigated retention of TGNC undergraduate students in STEM majors. This deficit in knowledge about the TGNC student experience is likely due in part to the lack of high quality longitudinal student major data that is inclusive of TGNC identities.

Using pooled, longitudinal data for five cohorts of undergraduate students surveyed in their first and fourth years of college (n=47,110), we studied whether TGNC students who aspired to STEM majors (n=114) persisted in STEM by their fourth year of college at a different rate than their cisgender peers. TGNC students indeed are less likely to persist in STEM than their cisgender peers; where 73% of cisgender peers were still enrolled in a STEM major after four years, only 63% of TGNC students were. Within STEM majors, we found a realignment of TGNC students into different categories of STEM majors. Whereas a plurality of TGNC students in STEM majors listed their major within the life sciences category in their first year, this was the least common STEM major category for TGNC students by their senior year. In contrast, cisgender STEM students were most likely to report a life sciences major in their first year of college, and this category was still the second most prevalent category of STEM majors by their senior year.

Using multilevel logistic regression modeling, we identified factors that differentially predict TGNC student persistence in STEM majors from their cisgender peers. Involvement in a faculty member's research and studying with peers both increase cisgender students' likelihood of persisting in STEM, but these experiences did not significantly predict persistence for TGNC students. Additionally, we found a significant interaction between TGNC identities and the seeking of personal counseling, an indicator of mental health; cisgender students who seek personal counseling are less likely to persist in STEM majors, but this effect is even more pronounced for TGNC students who seek personal counseling.

These results represent an important step forward in understanding the experiences of TGNC students in STEM majors and identifying inequities that exist between TGNC and cisgender students in STEM fields. The identification of factors that differentially impact TGNC and cisgender students in STEM fields will significantly contribute to further inquiry into the TGNC student experience and to develping interventions that may increase persistence of these students in STEM majors.

Session C: Assessment and Conceptual Understanding

Paper ID: 138

Integrating motivation theories to measure students' motivational profile in a modeling-based introductory biology course.

Bethany J Gettings (Michigan State University)*; tammy m long (Michigan State University)

RESEARCH PROBLEM: The National Academies of Sciences, Engineering, and Medicine has highlighted the need for research on the critical role of motivation in college STEM. Motivation is known to be a predictor of STEM persistence and achievement and has been explored in web-based instruction, flipped instruction, and project-based learning environments. However, little is known about the role of motivation in large, introductory STEM courses which often pose barriers to STEM persistence, nor on the influence of science practice-based pedagogical approaches, such as model-based instruction (MBI).

RESEARCH DESIGN: I am conducting a study that integrates two theoretical frameworks to measure multiple motivational variables: (1) Expectancy-Value Theory measures science academic perceived competence (PC) and task value (TV), which includes three TV types: intrinsic value (IV), utility value (UV), and attainment value (AV). (2) Achievement Goal Theory uses a trichotomous model to measure mastery (M), performance approach (P-AP), and performance avoidance (P-AV) goal orientations. Students from an MBI biology course for majors were surveyed to assess motivational constructs at the beginning (T1; N=173) and end (T2; N=145) of the semester. Items were measured on a 5-point Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Cronbach's alphas ranged from 0.83-0.97, indicating that there is strong internal consistency for the test items measuring each of the motivational constructs. The proportion of missing data for each of the variables used in this study ranged from 0.15% at T1 to 0.006% at T2. Little's test verified missing data was completely at random (MCAR; X2(424)=430.30, p=0.41); thus, I performed listwise deletions within each motivation construct to remove incomplete surveys.

ANALYSES AND INTERPRETATION: Students were binned into high-, middle-, and low-achievement tritiles using incoming GPA to examine the differences between achievement groups at T1 and T2. ANOVAS on each variable indicated no significant differences between achievement groups for any of the constructs at either time point measured separately. All three tritiles had their largest positive shift for the construct of AV, but pairwise comparisons indicated these shifts were statistically insignificant. It is noteworthy, however, that although statistically insignificant, the low-achieving tritile experienced a positive shift between T1 and T2 in every motivational variable measured.

CONTRIBUTION: This study provides an integrative, theory-based framework for measuring students' motivation, and adds to literature about evidence-based pedagogies in STEM. In particular, our findings suggest there may be marginal benefits of strategies such as MBI in improving motivation, particularly for lower-achieving students who may be underprepared for college science courses. Mechanisms underlying trends reported here will be further examined through related studies, including cognitive behavioral interviews.

Paper ID: 211

Mode of Responses Influences Content of Student Responses

Joelyn de Lima (Michigan State University)*; Tammy M Long (Michigan State University)

Context plays a vital role in both shaping students' learning and in eliciting their knowledge. Understanding how context can help or hinder learning and assessment is therefore important for improving science learning outcomes. While context has been defined in multiple ways (e.g., disciplinary perspective, specific words in a prompt), we restrict our use of 'context' here to refer to the mode by which students respond to a prompt.

Narrative responses are commonly used for assessing students' reasoning, but models are increasingly represented in college biology classrooms. Features of student-constructed models can provide insights into thinking and reasoning that are not captured in multiple choice or narrative responses. However, little is known about whether the two modes of response are equivalent in terms of eliciting students' ideas. In this study we explored the influence of response mode on the content of students' explanations about evolution by natural selection.

We asked students in two sections of a large-enrollment introductory biology course to respond to prompts about evolution by natural selection by constructing both a model and written narrative. We used qualitative content analysis to develop a rubric for analyzing the content of student responses. Responses were binned into levels that reflect inclusion of key concepts, naïve ideas, and threshold concepts that have been reported in research on evolution learning. We then analyzed levels using mixed ordinal logistic regressions and mixed logistic regressions.

We found that mode influenced the content of responses in various ways. Students' narratives were more likely to include the key concepts of differential survival and reproduction ($p<0.001$) and limited resources ($p<0.001$), but were also more likely to contain teleology ($p<0.001$), a naïve idea. Students' models, however, were more likely to include the threshold concept of probability ($p<0.001$) and the key concept of variation ($p=0.07$). Other key concepts, such as heritability, were elicited no more frequently in narratives or models.

Our findings suggest that mode of response can bias interpretation of students' understanding of evolution by natural selection. Incorporating multiple modes of assessment has potential to generate a more holistic view of students' understanding and may promote greater transfer by requiring students to think and reason across contexts.

Paper ID: 178

Do Prerequisites Disproportionately Affect Certain Types of Students? Implementation of a Math Prerequisite for Introductory Biology in a Community College Setting.

Matthew R Fisher (Oregon Coast Community College)*

Research Question/Problem: We addressed three educational problems: 1) nationally low rates of student success in introductory biology courses (especially for underserved populations), 2) incomplete understanding of the efficacy of the prerequisite model, & 3) a lack of educational research at the community college level. In response, we asked the following research question: In what ways does a math prerequisite affect student success in an introductory biology course at a community college, and does this disproportionately affect certain demographic groups of students?

The prerequisite model is based on the premise that prerequisites are required for success in follow-up courses. While there is intuitive appeal to this model, it has not been thoroughly tested. The research on this is conflicting, with some evidence painting prerequisites as useful, while others indicate they have no effect on future academic success. Prerequisites that do not promote student success may be detrimental to students because unnecessary courses cost money & work against financial aid limits.

The rationale for our study is twofold: 1) to elucidate the efficacy of a math prerequisite in biology & 2) to consider issues of equity by examining the effects of prerequisites on underserved populations of students.

Research Design: The prerequisite model is widespread in academia but there is no consensus in the literature that they have the intended effect of promoting student success in subsequent courses. Instead, the limited amount of research provides contradictory results.

Our research utilized a retrospective, quantitative research design. We obtained grades & demographic data from 1416 students at a community college in the United States. Our analysis used five years of data prior to implementation of a math prerequisite for a biology course & six years after it. Alignment between our analysis & research questions was achieved by comparing student success (measured by course grade) before & after implementation, & by disaggregating data based on demographic variables.

Analysis & Interpretations: In the five years before implementation of the math prerequisite, students that previously completed math were more likely to pass introductory biology than those who had not completed math (73.8% vs. 56.2%; chi-squared=23.93, $p<0.0001$, n=722). The math prerequisite appeared effective in improving student success by significantly increasing pass rates from 65.7% before implementation of the prerequisite to 77.1% after its implementation (chi-squared=22.05, $p<0.0001$, n=1416). Although no achievement gap was identified for underrepresented minorities, female, or veteran students; Pell grant recipients were less likely to pass BI 211 than non-Pell grant recipients (67.5% vs. 74.1%, respectively; chi-squared=7.1, $p=0.008$, n=1414) & had lower mean grades (2.03 vs. 2.30 grade points, respectively; Wilcoxon rank sum test, $p=0.0002$, n=1414).

Contributions: Our results refine the literature on the efficacy of prerequisites by providing multiple indications that prior completion of a math course significantly improved student success in an introductory biology course. The implication is that math courses may be adept at promoting success in introductory biology classes for all demographic groups except one. Our results are of broad interest to educators for its practical use in designing evidence-based curriculum pathways that promote student success & retention.

Session D: Science Process Skills

Paper ID: 191

Beyond office hours: what happens when students and professors engage in scientific discourse

Melissa McCartney (FIU)*

Numerous calls for reform in undergraduate biology education highlight the need for students to engage in the practices used by professional scientists. However, development of scientific practices is often a secondary component of undergraduate curriculum. One way to encourage more scientific practice development in undergraduates is by implementing Lave and Wenger's communities of practice, where students are able to become a core participant in science through engagement in authentic activities of the scientific community.

Oral discourse around research is a critical part of scientific research, spanning everything from laboratory meetings to thesis defenses to networking to conference presentations, making this a crucial scientific practice for undergraduates to master. Academic scientists likely engage in oral discourse around research on a daily basis, making them 1) ideal partners for students just beginning to learn scientific discourse and 2) members of a community of practice likely to welcome students into the conversation. However, data from our laboratory suggests that while an overwhelming large percentage of students (88%) have met with their professors outside of class to discuss coursework, a much smaller percentage of students (23%) has met with a professor to discuss research, suggesting that students are rarely participating in this scientific practice. How can we encourage more research discourse between students and professors?

We developed a novel method for engaging undergraduates in scientific discourse. Working in small groups, students select a published research paper from a faculty member in their department that connects to a biological concept being taught in their course. Students then spend 5 weeks working together to annotate the research paper and develop an understanding of the research taking place. Next, students meet with the authors of the research paper to engage in discourse about the research and to gain a more comprehensive understanding of both the research taking place in their department as well as the faculty members who make up their department.

We recorded 17 separate student-professor interviews. Using thematic analysis (inductive coding), we analyzed interview transcripts and identified 10 separate themes used in student-professor discourse on research, including experimental design, critical thinking, and real-world connections. Additionally, we isolated questions asked by students and used Bloom's taxonomy as a framework for categorizing the complexity, or lack thereof, of these student-led questions. The majority of these questions were categorized as a 1 (remember) or a 2 (understand), with a few questions reaching a 3 (apply). We continue to analyze this data set further using an experimental design framework. Finally, we see a positive shift in student's sense of belonging to their department before and after engaging in scientific discourse with a professor in their department, suggesting additional benefits beyond simply learning a scientific practice.

Taken together, our data set begins to provide insight into how students and professors can better engage to discuss research findings, both as a way to increase student's sense of belonging within their department, as well as to provide a way for students to participate in a scientific community of practice. We will discuss best practices we have found, both for students and professors, to help encourage research dialogue.

Paper ID: 86

A Multi-Institution Curriculum Mapping Project to Investigate Teaching of Core Competencies

Alexa Clemmons (University of Washington)*; Deborah Donovan (Western Washington University); Jerry Timbrook (University of Nebraska-Lincoln); Alison Crowe (University of Washington)

Through resources elaborating the Vision and Change core concepts and competencies (e.g., BioCore Guide, Conceptual Elements Framework, BioSkills Guide), we now have nationally agreed upon learning goals for undergraduate biology programs. To continue the effort of curricular transformation, we must next investigate alignment of existing instruction and assessment with these goals. To explore this process, we have mapped current course offerings onto competency learning outcomes in five undergraduate biology degree programs.

Specifically, we applied the planned-enacted-experienced model of curriculum review (Gehrke, Knapp, and Sirotnik, 1992) to compare BioSkills Guide learning outcomes (planned curriculum), instructor-reported teaching (enacted curriculum), and class materials and student-reported teaching (experienced curriculum).

We developed and piloted a novel curriculum mapping survey to systematically gather instructors' perceptions of their competency teaching. Instructors self-reported how frequently they taught and assessed 20 program-level, competency learning outcomes in one or more of their courses. Our study included 107 instructors providing data on 117 undergraduate biology courses (in total, 175 observations of instructor and course) across five institutions: two community colleges, two regional comprehensive universities, and one research university. We gathered evidence of validity based on response processes through think-aloud interviews and survey-embedded probing questions. We then more deeply investigated the experienced curriculum in a subset of these courses by collecting (1) student responses on a similar survey and (2) syllabi and exams.

By comparing the planned and enacted curricula, we uncovered a number of shared trends in instructor-reported competency teaching, including learning outcomes that were commonly taught (e.g., Scientific Thinking and Data Interpretation and Evaluation were reported to be taught in >1 class session in 89% and 88% of courses, respectively) and others that were less commonly taught (e.g., Collegial Review and Doing Research were reported to be taught in >1 class session in 39% and 46% of courses, respectively). Furthermore, we found that certain learning outcomes were commonly taught but less commonly assessed (e.g., Collaboration was reported to be taught in >1 class session in 84% of courses but assessed in only 48% of those courses). We present these and other trends, along with indications for national biology education reform efforts including development of assessments and faculty learning opportunities. Preliminarily analyses (n=3 courses) comparing the enacted and experienced curricula found that student and instructor perspectives were generally aligned. Mean student survey responses were within one level (on a six-level frequency scale) of instructor's response for 13-15 out of 20 learning outcomes. However, certain learning outcomes (e.g., Doing Research, Modeling) were more often misaligned. These results have implications for understanding not only how competencies are taught, but how instructors message core competency teaching to students via class materials and other means. We additionally hope this talk will spark future work developing curriculum mapping as a common practice for evaluating and monitoring curricular transformation.

Paper ID: 180

Developing Frameworks to Describe Students' Use of Evidence in the Context of Socioscientific Issues

P. Citlally Jimenez (University of Nebraska - Lincoln)*; Jenny M Dauer (University of Nebraska-Lincoln)

Rationale: Student interpretation and application of scientific information to explain complex problems in a societal context has remained a goal of science education as conveyed in 'Vision & Change' competencies. Enactment of this practice in science classrooms remains a challenge for students and educators alike. Students struggle to apply relevant information when synthesizing evidence to explain interdisciplinary phenomena, along with reflecting how the evidence supports or contests their own ideas, without explicit instruction. Likewise, educators may not be equipped with tools to assess students' understanding and application of scientific information, and constantly struggle in curating curriculum that aids students' construction of scientific explanations beyond simple definitions. Thus, there is a need to characterize students' practice of applying scientific evidence to support their reasoning when constructing explanations to create useful tools for science educators.

Research Question: We addressed this educational need by asking "what are levels of proficiency that describe how students use evidence to support their reasoning when explaining complex phenomena in a real-world context?" Our research output is the development of theoretical coding frameworks that can be used to analyze and assess student responses. Secondly, we asked "after course revisions based on our findings, do students perform better in subsequent semesters?"

Design: Our research focused on characterizing students' use of evidence as they applied a structured decision-making tool to solve socioscientific issues in a multidisciplinary science literacy course. Through multiple-iterative constant coding of a subset of student responses, we developed frameworks that describe students' level of proficiency in 1: providing reasoning to address assumptions via evidence (RAAvE), and 2: linking evidence to reasoning (LEtR), when determining the effects of alternative solutions to a complex issue. We engaged in design-based research, collecting and coding responses in 2016 and a revised course in 2018.

Analyses & Interpretations: In our RAAvE framework, a response at a proficiency level of two indicates no attempt to go beyond assumptions, while at level four, students explain how or by how much the evidence supported assumptions in their reasoning. In our LEtR framework, a student response at a level one indicates no evidence was used while a level three means the evidence was clear and connected. We found that 73% of students in 2016 achieved a level two in the RAAvE framework, and 83% achieved a level one in the LEtR framework. We subsequently revised the course in 2018, focusing on how students use evidence in their reasoning. We found that most students had higher level reasoning (38% at level three, 36% at level four) in the RAAvE framework, and few (only 12%) were at level one in the LEtR framework.

Contribution: Our coding frameworks have been converted to rubrics for student assessment across multiple settings dealing with the interpretation and application of scientific information, as well as supported various teaching tools that aid students in applying scientific evidence to support their explanations. These tools may aid researchers and educators in exploring how students interpret and integrate scientific information, make meaningful connections with the information, and bolster their ability to make quality decisions about complex issues outside the classroom.

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Friday, July 24th

Session A: Active Learning

Paper ID: 3

Demystifying the Meaning of Active Learning in Undergraduate Biology Education

Emily P Driessen (Auburn University)*; Jenny Knight (University of Colorado, Boulder); Michelle Smith (Cornell University); Cissy Ballen (Auburn University)

Research Questions: The broad principle of active learning is based on the constructivist theory that learners need to construct their own understanding in order for it to be meaningful (Piaget & Inhelder, 1967). Undergraduate biology instructors have increasingly embraced the use of active learning instructional practices over the past decade (Aragón et al. 2018). Previous results show that such practices increase performance and decrease failure rates (Freeman et al. 2014) and disproportionately benefit underrepresented students in science (Ballen et al. 2017). However, the actual definition of active learning and how instructors apply active learning strategies in the context of undergraduate biology are less clear. Given this, we investigated the following two questions in the context of undergraduate biology courses: (1) How do instructors define active learning?; and (2) What active learning strategies do instructors use in their courses?

Research Design: We extracted information from articles in three peer-reviewed biology education journals (Life Sciences Education, Journal of Microbiology & Biology Education, and CourseSource) using the preferred reporting items for systematic reviews and meta-analyses (PRISMA, 2015). We included any article that contained the term ‘active learning’ in the title, abstract, or text. In addition to exploring the literature, we surveyed SABER members via the society’s listserv to collect information concerning the active learning techniques they use in and their definition of active learning in the context of undergraduate biology classrooms.

Analyses/Interpretations: We extracted and categorized active learning definitions and strategies from 148 articles, from 2016-2018, and 105 survey responses. More than 80% of the collected published articles did not provide a definition of active learning. Of the less than 20% of articles that did define active learning, they most frequently used terms such as interaction/engagement or not lecturing/listening. The survey responses also used these terms most frequently. With regard to specific active learning strategies, both the articles and survey responses mentioned discussion most frequently (25% and 34%, respectively), followed by group work (19% and 29%), and metacognition (19% and 45%). Summarizing the data from both the surveys and literature, the biology education community defined active learning as an interactive and engaging process frequently implemented using strategies such as metacognitive reflection, peer discussion, group work, formative assessment, practicing core competencies, live-action visuals, worksheets, and/or games.

Contributions: The term active learning can be used to generate awareness and collaboration among those interested in improving their teaching. However, because the term is rarely defined and can have many different meanings, those who use active learning should include their definition and strategies when they report their practices. These additional details will allow the community to address more nuanced questions (e.g. do specific active learning instructional strategies promote student learning in multiple environments?). These questions can be more effectively answered when the approach and context of the learning environment has been precisely defined.

Paper ID: 17

How Introductory Biology Students Prepare for Class: Resources and Actions Under Two Conditions

Sabah Sattar (Northern Illinois University); Tina Ballard (Northern Illinois University); Heather E Bergan-Roller (Northern Illinois University)*

RESEARCH QUESTION: When students prepare for class, they are better able to engage during class and learn. Having students prepared for class is particularly important in classrooms that use student-centered strategies, which are difficult to implement when students are not familiar with the material. However, many students do not effectively prepare for class due to time constraints, uncertainty of instructor expectations, or lack of value. Additionally, many instructors are unsure of how to motivate and guide students to prepare for their class. Although resource guides are available for instructors to help their students prepare for class, many instructors do not use these guides potentially due to lack of their own time or awareness. Further, little has been done to compare the effects between different guides. We investigated how two different guides affected if and how students prepared for introductory biology classes, specifically the resources students used and the actions they took.

RESEARCH DESIGN: This research was conducted at a four-year university in a student-centered introductory biology course. Students over two semesters were assigned to prepare for class with either the freedom to prepare for class using and doing what they choose (Choice Treatment) or specific reading passages from the assigned textbook (Text Treatment). Both treatments were to report how they prepared in a survey before each class for participation points that counted towards their course grade.

ANALYSES & INTERPRETATIONS: Entries were analyzed quantitatively for the number of entries compared to what was expected and the number of actions and resources reported. Students reported preparing for class at similar frequency, with no significant effect for treatment, $F(1, 150) = 1.83$, $p = .178$, on the number of entries submitted per student. A slightly higher percentage of entries were submitted from students in the Choice Treatment (84%) out of the expected entries compared to the Text Treatment (77%). Students reported using one resource per entry regardless of treatment, $F(1, 150) = 0.09$, $p = .76$. However, students commonly reported doing more than one action to prepare for a class with students in the Text Treatment ($M = 1.7.$, $SD = 0.6$) reporting doing more actions per entry than students in the Choice Treatment ($M = 1.4$, $SD = 0.4$), $F(1, 150) = 9.38$, $p = .0026$.

Entries were analyzed qualitatively for what students did (actions) and what students used (resources) using emergent thematic analysis. Codes were analyzed for their frequency and combinations. Students most commonly reported reading regardless of treatment. However, Choice Treatment students tended to read online material whereas Text Treatment students read the assigned textbook passages. In addition to reading, Choice Treatment students watched videos and read slides more whereas the Text Treatment more often took notes while reading.

Together, this suggests that when students are tasked with finding their own resources, they engage less with the resources they find. More work is needed on how these conditions may affect engagement in class and achievement of learning outcomes.

CONTRIBUTION: This work closely examines mechanisms of what students do to prepare for class and what may influence preparation. This work may help inform instructors on how to guide their students to prepare for class and potentially influence the effectiveness of active engagement during class.

Paper ID: 182

Effective application of team-based learning in the online classroom

Lina M Arcila_Hernandez (Cornell University)*

Research Question: Online learning has become established in higher education, with more institutions offering online undergraduate courses every year (Allen and Seaman, 2015). While online offerings have several positive attributes such as scheduling flexibility and accessibility, major challenges are the high frequency of student attrition and isolation (Knapp, 2018). Furthermore, since online courses require different content delivery tools than face-to-face (F2F) offerings, it is unclear if learning outcomes are comparable between these course types (Knapp, 2018). To address these challenges, we developed an online evolution and biodiversity course that mirrored a team-based F2F course. Team-based learning (TBL) is a pedagogical approach where students work on individual and team assignments in a sequential pattern: pre-lecture work, individual quiz, team quiz, lecture, team work (Michaelsen and Sweet, 2008). Previous work on TBL showed positive outcomes for student's accountability and performance (Clark, Nguyen, Bray, & Levine, 2008). Specifically, we wanted to answer: (1) Is TBL in STEM courses transferable to online offerings while maintaining student's performance? And, (2) does the implementation of TBL reduce attrition rates in online courses?

Research Design: To understand the effects of TBL in an online STEM course, we developed an online course using the same curriculum, learning goals, and TBL pedagogy as a F2F course. Students from both courses took the same exams at the same time. We used a pair-design comparison exploring course performance and retention between the established F2F course (241 students) and the newly developed online course (35 students). We also asked the students to take a pre- and post-knowledge test on the first and last week of the course.

Analyses and Interpretation: Students on both courses had positive course performances with similar final grade distributions. The F2F offering had a slightly higher final grade (median + se: 93.2% + 0.44) than the online offering (92% + 1.35; p-value=0.05). Furthermore, students in both courses had positive learning outcomes as observed when comparing the pre- and post-knowledge tests (p-value<0.05; Hedges' g=1.8 F2F; Hedges' g=1.2 online). A similar number of students dropped both courses (F2F: 6 students; online: 5 students). When accounting for the total number of students, attrition rates for F2F were lower than expected (2.5% attrition; X2=215.7; p-value<0.05) and rates for the online course were not different from expected (14% attrition, X2=16.46; p-value=0.14). The attrition rate in the online course was low compared to reported attrition rates of 40%-80% for online courses (Smith 2010).

Contribution: This study shows that TBL has positive effects on two of the main challenges in online learning: it was a factor helping to increase student retention in a STEM online course and helped support students' performances when learning goals and curriculum were the same as the F2F offerings. In response to the COVID-19 pandemic, many institutions are transitioning courses to online offerings, our study supports the use of TBL strategies when delivering online courses.

Paper ID: 116

Advancing the Guidance Debate: Lessons from Educational Psychology and Implications for Biochemistry Learning

Stephanie Halmo (University of Georgia)*; Sasha Stogniy (University of Georgia); Cheryl Sensibaugh (University of Georgia); Peter Reinhart (Kenyon College); Vanessa Alele (University of Georgia); Grace Snuggs (University of Georgia); Logan Fiorella (University of Georgia); Paula P. Lemons (University of Georgia)

Science education research supports a shift from traditional lecturing to evidence-based instruction, yet it is unknown if particular evidence-based pedagogies are more effective than others for learning outcomes like problem solving. Research supports three distinct pedagogies: worked examples plus practice, productive failure, and guided inquiry. These approaches vary in the nature and timing of guidance, but all engage the learner in problem solving. In worked examples plus practice, stemming from cognitive load theory, students receive explicit step-by-step explanations on how to solve a problem and then practice implementing these solutions independently. In productive failure, stemming from theory on desirable difficulties, students explore problems and generate possible solutions on their own prior to receiving explicit guidance. In guided inquiry, stemming from social constructivism theory, students actively engage in solving problems and are guided throughout the process by instructional supports that fade away as knowledge is built. Experts debate the relative effectiveness of these approaches, but they have not been directly compared. Therefore, we aimed to address the following research question: what are the comparative impacts on student learning for methods of instruction that vary in the nature and timing of guidance?

We investigated the impact of worked examples plus practice, productive failure, and two forms of guided inquiry - unscaffolded and scaffolded guidance - on student learning of a foundational concept in biochemistry. We recruited students from two prerequisite courses for introductory biochemistry (introductory biology and organic chemistry). Students who agreed to participate and completed a basic knowledge pretest (N=189) were randomly assigned to one of the conditions. Each condition involved a 35-45-minute lesson on the physical basis of noncovalent interactions, a persistently troublesome foundational concept in biochemistry. After instruction, participants completed an assessment of basic knowledge and two types of transfer problems. Near transfer problems resembled the problems used during instruction, while far transfer problems drew upon the same knowledge learned in the lesson but were presented in a different context. Participants' written responses to the problems were analytically coded and scored alongside the basic knowledge test items.

We compared all four pedagogies for basic knowledge performance and near-transfer problem solving. Due to logistical constraints, we compared productive failure and scaffolded guidance for far-transfer problem solving. All learning outcomes were analyzed using ANCOVA with semester as the block effect, basic knowledge pretest performance as a covariate, and instructional condition as the independent variable. Our comparison showed that 1) the four pedagogies did not differentially impact basic knowledge performance, 2) worked examples plus practice, productive failure, and scaffolded guidance led to greater near-transfer problem-solving performance compared to unscaffolded guidance, and 3) productive failure and scaffolded guidance did not differentially impact far-transfer problem-solving performance. Our data advances the guidance debate by suggesting that some variability in the nature and timing of guidance may be fine for student learning, while cautioning active-learning instructors against the unintentional use of unscaffolded guidance.

Paper ID: 215

Faculty Adoption of Evidence-based Teaching Practices: The Role of Observation Sampling Intensity on Measures of Change

Justin A Goodridge (Stony Brook University)*; Lucy Gordon (Stony Brook University); Ross Nehm (Stony Brook University); Gena C Sbeglia (Stony Brook University)

Research Problem: Recent work by Stains et al. (2018) has focused on measuring progress in faculty adoption of student-centered instruction at the national level using classroom observation instruments (i.e., the COPUS: Classroom Observation Protocol for Undergraduate STEM). Specifically, Stains et al. (2018) utilized the COPUS to measure classroom behaviors in >2,000 classes (n=1 to~4/instructor) in order to draw inferences about faculty practices nationwide. These authors reported that a COPUS sampling intensity (SI) of at least 4 classes per instructor was required for valid measurement. Our work uses more intensive SIs and simulation methods to empirically test the impact of COPUS SI on claims about classroom learning environments. We ask: How does the number of classes sampled using the COPUS impact: (RQ1) the measurement of classroom learning environments and (RQ2) the measurement of faculty change through time? Both questions are of central importance to measuring nationwide progress in faculty adoption of student-centered instruction.

Research Design: Using the COPUS, trained raters (IRR Kappa>0.80) conducted extensive observations (n=128) of faculty (n=3) teaching large undergraduate biology courses (n = 4 semesters;~11 classes/instructor/semester). A purposive sampling design was used to select faculty along a continuum of evidence-based behaviors (i.e., absent to common). Each individual class was classified as didactic, interactive lecture, or student-centered using the online COPUS analyzer (Stains et al. 2018). Each course was classified as traditional (all classes didactic), transitioning (some interactive lecture or student-centered), or active learning (nearly all student-centered). We simulated varying COPUS SIs by randomly sampling an increasing number of classes (e.g., 1 class, 1000x; 2 classes, 1000x, etc., up to 11) for each instructor for each semester. By comparing the proportion of each instructional style at each SI with the actual proportion represented by the largest SI (~11 classes), we established at which SI accurate inferences could be drawn about classroom environment (and faculty change over time). SIs for which the proportion of each instructional strategy was +/- 15% of the actual proportions were considered valid.

Analysis & Interpretation: Simulation studies of the dataset indicated that courses with high variability in instructional styles required more COPUS observations (~8-9) to attain an accurate estimate of classroom environment within semesters and through time. The minimum SI (n = 4) recommended by Stains et al. was accurate only for homogenous (e.g., didactic only) behaviors/instructors. The SI used by Stains et al. was found to generate false inferences for faculty transitioning from didactic to student-centered learning.

Contribution: Our findings call into question the instructional sampling intensity (SI) utilized by Stains et al. to make claims about the current state of STEM instruction in the United States. Instructors transitioning from didactic to evidence-based instruction--which is likely to be common--required double the number of COPUS observations as suggested by Stains et al. to accurately characterize teaching strategies. Sampling intensity emerges as a crucial but poorly studied variable central to measuring progress towards the recommendations advanced by Vision and Change.

Paper ID: 6

Using Learning Assistants to Systematically Gather and Analyse Formative Assessment Data in Large STEM Classes.

Young Ae Kim (University of Arizona)*

RESEARCH PROBLEM & STUDY CONTEXT: Calls for high-quality learning experiences in undergraduate STEM education has been promoted (NRC, 2015). Classroom assessments create opportunities to explore and foster student thinking, as well as to analyze and transform teaching practices to better support student learning (Black & Wiliam, 1998). Formative assessment enables instructors to elicit student thinking, make inferences about student understanding, and take actions that foster student learning (Cowie & Bell, 1999). In large enrollment classrooms, instructors face challenges to facilitate and assess students' understanding when they are engaged in evidence-based teaching practices. Our project designed a specialized role, Learning Researcher (LR) to support continuous classroom-based formative assessment. The LR is an undergraduate student whose main tasks are to collect and analyze student thinking data during classroom activities, then generate daily reports that provide feedback to instructors for subsequent planning and instructional decisions. We have worked with 27 different LRs embedded in 23 classrooms across a variety of STEM disciplines for over three years at our institution.

STUDY DESIGN: This qualitative study sought to investigate how LRs approached formative assessment and to characterize their formative assessment skills and practices. Data collection included written daily reports, pre-post interviews, focus groups, observations and audio recordings of LR training. LRs' daily written reports (n=493) were analyzed using a constant comparative method, paying attention to what the LRs noticed, the types of descriptions they included in their reports, the nature of their inferences and interpretations, and the characteristics of their suggestions for instructors. During analyses, independent coding assignments and patterns and themes emerging from the data were discussed until consensus was reached among the researchers.

RESULTS: Our analyses indicate that the quality of the LRs' written reports varied, but in general, most LRs demonstrated ability to notice and report on important aspects of student thinking. They provided detailed descriptions of what students could or could not do, including evidence in the form of students' questions and responses during class activities. LRs were also able to make general suggestions for fostering student understanding. Our analyses revealed that LRs' initial approach to the assessment of student thinking tended to be more descriptive than interpretive. When they built inferences, claims about student learning were presented without much supporting evidence and explicit rationale. LRs often commented on the correctness of task products, adopting an evaluative stance rather than trying to make sense of student reasoning in the assessment of students' ideas. LRs struggled to generate specific suggestions for task design and instruction based on student thinking. They more commonly suggested actions that focused on improving managerial and engagement issues. In general, undergraduate LRs demonstrated ability for systematically gathering formative assessment data in large STEM classrooms but struggled to analyze these data in responsive ways.

Session B: Diversity, Equity, & Inclusion

Paper ID: 2

Mind the Gap: Narrowing STEM achievement gaps with active learning

Elli J Theobald (University of Washington)*; Scott Freeman (University of Washington)

Despite widespread efforts to increase access to and inclusion in STEM, women and minoritized students remain under-represented in both STEM majors and STEM professions. Achievement gaps—differential performance between historically under- and over-represented students—in college contribute to this problem because lower-performing students are less likely to major in STEM, and also more likely to drop out of college altogether. How can instructional practices in university classes be modified to remedy this issue? Active-learning techniques have been shown to improve student performance on average and we asked whether active-learning could also narrow achievement gaps.

Using two sources of evidence, we tested the hypothesis that active learning can close achievement gaps for historically under-represented students: First, we systematically reviewed the literature to identify studies that compare active learning to traditional lecturing and meta-analyzed the 133 studies that met our criteria. Second, we contacted authors of contributing studies to solicit individual participant data disaggregated by student characteristics. We received data from 15 studies (9,238 total students) that collected student exam scores, and data from 26 studies (44,606 total students) that collected failure rates. To these data, we fit hierarchical Bayesian regression models to ask if active learning has disproportionate benefits for minoritized students.

We found that active learning is effective across contexts, including across STEM disciplines, class sizes, and course levels, and that different types of active learning had little impact on student improvement – all types of active learning are effective. However, when active learning is used infrequently (<30% of total class time), learning gains are equivalent to those from lecturing. Critically, statistics and data science active learning is woefully understudied–our meta-analysis contained no such studies.

Second, by pooling data across studies, we found that on average, active learning nearly halves achievement gaps for minoritized students in STEM. However, when active learning is implemented for the majority of class time (more than 66% of the time) differences in failure rates between historically underrepresented students and historically overrepresented students were reduced by 75%.

In all, this work has two tangible conclusions: first, historical achievement gaps in STEM can be reduced or eliminated with evidence-based instruction. Second, instructors teaching statistics and data science courses, in biology contexts or not, should consider experimentally innovating their teaching methods, and publishing student outcomes.

Paper ID: 33

Accessible active learning: To what extent is active learning inclusive for science undergraduates with disabilities?

Logan E Gin (Arizona State University)*; Frank Guerrero (Arizona State University); Katelyn Cooper (University of Central Florida); Sara E Brownell (Arizona State University)

While active learning teaching methods have been shown to improve student achievement, the altered teaching format could present unique challenges for students with disabilities who request academic accommodations from Disability Resource Centers (DRCs). DRCs are offices on university campuses that provide academic services for students with disabilities. Academic accommodations for traditional lecture courses often include note-taking services, preferential seating, extended time for exams, closed captioning of videos, and interpreters. The typical model for receiving accommodations in traditional lecture science courses involves a student self-disclosing their disability to the DRC and providing documentation, meeting with a coordinator to discuss potential needs and challenges, and then selecting a standard set of accommodations. However, it is unclear whether this traditional model is effective in providing services for students with disabilities in active learning science courses. To our knowledge, there is not literature that has addressed whether DRC accommodations have been adapted to serve students with disabilities in active learning science courses. Our research questions for this study were: What active learning-related challenges have DRC directors identified for students with disabilities in college science courses? What approaches have DRCs taken to alleviate challenges for students with disabilities in active learning science courses?

In this in-depth interview study, we conducted semi-structured interviews with directors of DRCs from 37 universities with large undergraduate student populations and large enrollment science courses. We interviewed DRC directors about how they are accommodating students with disabilities in active learning classrooms and the barriers associated with active learning environments. Two researchers analyzed the interviews using inductive coding methods to determine the challenges associated with active learning and the ways in which DRC directors have mitigated such challenges in college science courses. They developed a coding rubric to analyze the data with an inter-rater reliability score of $\kappa = 0.89$. We used a theoretical framework of Universal Design for Learning, an approach that guides how to improve learning environments to enhance the learning for all individuals, in order to explore how active learning could be made more inclusive for students with disabilities. We identified that 100% of directors were aware of active learning. However, only 16% of DRCs were able to highlight an example when their DRC provided students with a specific accommodation for active learning before the course started. Most accommodations for active learning are determined retroactively or on a case-by-case basis, which requires students to be responsible for identifying aspects of active learning courses that they struggle with and report these challenges in order to receive appropriate accommodations. We identified a set of common challenges that DRC directors reported regarding specific active learning practices such as small group work, clicker questions, cold call, and online activities. We also identified common solutions that are being used by DRCs across the U.S. to accommodate students with disabilities who experience challenges with small group work, clicker questions, cold call, and online activities. However, despite their previous knowledge of active learning and experiences with student challenges, there were no DRCs that provided standardized accommodations specific to active learning. With this study, we hope to provoke a conversation about creating more inclusive active learning classrooms for students with disabilities.

Paper ID: 201

Christianity as a Concealable Stigmatized Identity (CSI) in graduate biology programs

Elizabeth Barnes (Arizona State University)*; Taya Misheva (Arizona State University); Sara E Brownell (Arizona State University)

Research in social psychology has illustrated the negative outcomes of those with Concealable Stigmatized Identities (CSI) and how this research could be useful for studying the experiences of underrepresented groups in biology. A Concealable Stigmatized Identity (CSI) is an identity that is socially devalued in a particular context that can be hidden from others such as LGBTQ+, socioeconomic status, and religious identity – all of which are underrepresented identities in academic biology. We used the CSI framework to study one identity that is both concealable and potentially stigmatized in biology – Christian religious beliefs of biology graduate students. Although Christianity is the cultural norm in the American public, Christians in academic biology are in the minority and have been stereotyped as less competent than other groups in science, which may lead them to conceal their Christianity in biology. Further, prior research with undergraduates and professors indicates that Christians may hide their identity because they are afraid of being stigmatized within the biology community. In this study, we conducted semi-structured interviews with 33 Christian graduate students at 16 research institutions nationwide using questions derived from the CSI framework to (1) study the experiences of a potentially stigmatized group in biology and (2) explore the utility of the CSI framework in studying the experiences of underrepresented graduate students in biology. To these ends, we asked the Christian graduate students to describe how Christians are perceived within the biology community and their experiences revealing and/or concealing their Christian identity in the biology community. We analyzed the interviews using both deductive and inductive coding to explore the presence of experiences that reflect the CSI framework in our interviews. Our interviews indicate that Christianity operates as a Concealable Stigmatized Identity (CSI) in the context of biology graduate programs. Students perceived that Christians are negatively stereotyped as unintelligent and unaccepting of science in the biology community. Students also reported that Christians are stereotyped as extremists and fundamentalists. Christian students were afraid that those in the biology community would stereotype them as bigoted or intolerant if they were to reveal that they are Christian. Most students reported that Christians are made fun of in the biology community or that people in biology community responded negatively when the student revealed their Christianity. Many students described having to reveal their identity to correct negative stereotypes about Christians in the biology community. Students indicated that they feel more comfortable revealing their identity around other Christians or around those who seem genuinely interested and respectful of their identity. Students often said they were not overt about their Christianity, but did not actively hide it, while other students described being actively covert about their identity, particularly around anti-religious individuals or individuals higher on the social hierarchy such as senior graduate students or professors. These interviews indicate that using the CSI framework may be a useful tool for studying the experiences of underrepresented groups in STEM with concealable identities.

Paper ID: 222

Using Latent Variable Path Modeling to reveal the causal links of evolution acceptance in biology undergraduates

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

Research Question or Problem: Evolution acceptance is lowest in groups poorly represented in the evolutionary sciences (e.g., women, underrepresented minorities; Mead et al. 2015) raising questions about its role in degree persistence and career choice. Although a large body of work has used correlation and regression to explore associations among religiosity, conflict perception, evolution knowledge, acceptance, race, and gender, these methods are poorly suited for analyzing indirect effects, collinear variables, and latent constructs. Our work employs latent variable path modeling to shed new light on the causal mechanisms driving evolution acceptance, with a particular focus on the role of conflict. The perception of conflict between one’s personal beliefs and evolution is hypothesized to impact acceptance, but empirical work remains limited. We ask: 1) Does conflict perception impact evolution acceptance? 2) Does conflict perception mediate the causal link between (a) evolution knowledge and acceptance, and (b) religiosity and acceptance? And 3) Does race contribute to acceptance when controlling for all other variables? Research Design: We used latent modeling to investigate interrelationships among key variables hypothesized to drive patterns of evolution acceptance in biology undergraduates (n=1276). Latent constructs were estimated using validated measures of acceptance (I-SEA-3 scales: micro, macro, human evolution), knowledge (CANS), perception of conflict (SECM-3 scales: perceptions of community, family, and individual), and religiosity (2 scales: identity, participation). We used Rasch analysis to evaluate productive measurement of constructs. A literature review was used to integrate constructs into latent variable path models in R (Lavaan). We modeled direct and indirect links between latent constructs. Covariates included race, gender, ELL status, reading/writing ability, and major. Analyses & Interpretations: All instruments functioned well and the path model had acceptable fit (Robust CFI=0.95, Robust RMSEA=0.03, SRMR=0.04). Individual (but not family or community) conflict had a direct causal relationship with all scales of acceptance (β=-0.65 to -0.56, $p<0.01$). Evolution knowledge had both a direct (β=0.14 to 0.19, $p< 0.01$) and indirect relationship mediated by individual conflict perception (β=0.07 to 0.13, $p< 0.01$) with all acceptance scales. The total impact of knowledge on acceptance was similar across evolution scales (β=0.22 to 0.30, $p< 0.01$), and ~half of this impact was mediated through individual conflict perception. Religious identity did not directly impact evolution acceptance, but participation did impact microevolution acceptance (β =-0.11, $p<0.05$). Both religiosity scales had indirect relationships with acceptance mediated by individual conflict perception (β =-0.22 to -0.10, $p<0.01$). The total impact of the religiosity scales on acceptance (β =0.09 to 0.36, $p<0.05$) was similar to the impact of knowledge. Finally, race contributed to macro and human evolution acceptance even when controlling for religiosity and conflict perception (β =0.05, $p<0.05$). Overall, individual conflict perception was an important mechanism driving acceptance. Contribution: This study highlights the strengths of methodological approaches for building causal models that explain educational patterns, and reveals new relationships among core constructs central to understanding evolution acceptance in biology undergraduates.

Paper ID: 139

Culturally Responsive Teaching in Undergraduate Science Labs

Hillary Barron (University of Minnesota)*; Julie Brown (University of Florida); Sehoya Cotner (University of Minnesota)

Undergraduate science classrooms have potential to perpetuate the exclusion of certain groups of people. They can also, however, be a catalyst for equitable participation in science. Utilizing pedagogies of empowerment, such as culturally responsive science teaching (CRST), in undergraduate classrooms can mitigate the gatekeeping phenomenon seen in science. In this study, we advance the conversations of equity in undergraduate science education by examining CRST that is informed by the views and experiences of teaching assistants (TAs).

This study is grounded in the theoretical framework of culturally relevant pedagogy, which refers to teaching practices that link school and culture to improve academic successes, foster critical consciousness, and support cultural competence in the classroom. Stemming from culturally responsive pedagogy, CRST has been a pathway through which multiple students' backgrounds can be validated and even privileged in the classroom.

This study applied a grounded theory methodology to address the following research question: in what ways do biology teaching assistants enact culturally responsive science teaching? Grounded theory is an approach to qualitative analysis that aims to develop an abstract or theoretical understanding of an experience or set of experiences. Mitch, Katie, Chad, and Greg (pseudonyms) participated in a semester-long fellowship during which they received targeted, base-level supports surrounding concepts of CRST. They were each observed weekly in their labs where they were teaching and the data sources obtained were TA reflections, observation field notes, post-observation interviews, and focus groups.

Grounded theory employs a three-pronged approach to qualitative analysis: open coding, line-by-line coding, and axial coding. During open coding, data were broken down into discrete parts in order to examine, compare, and find salient indicators of CRST. Next, we engaged in line-by-line coding to assign codes to words and phrases, and then organized codes that seemed similar into potential categories. Lastly, we completed axial coding by using constant comparison methods to explore more deeply the dimensions of each potential category. As we engaged in the constant-comparison process, we looked across elements of the categories, such as similarities, differences, and outliers in codes. We then intensively examined the properties and dimensions of code to identify how they relate to their respective category. This lends itself to the development of interpretive themes. The resulting themes were Funds of Knowledge Connections, Differentiating Instruction, Intentional Scaffolding, and Reducing Student Anxiety.

The purpose of this study was to better understand the ways undergraduate biology teaching assistants (TAs) enacted CRST, a pedagogical framework that has yet to be formally explored in postsecondary science spaces. This study demonstrated that, with targeted supports, biology TAs can enact CRST in undergraduate science learning spaces in distinct ways. The implications of this work are important both in science education research and in discipline-based education research where accessible and inclusive undergraduate science education is still developing. We contend that these findings provide new insights into the ways undergraduate science education might be reimagined to create equitable science learning opportunities for all students.

Paper ID: 225

Religious Students' Perceptions in Biology

Ryan Dunk (Syracuse University)*; Mia Pepi (Syracuse University); Jason Wiles (Syracuse University)

Diverse representation in science, technology, engineering, and mathematics (STEM) has been a problem since the inception of modern western science. In this study we focus on an often overlooked group that faces underrepresentation in many STEM fields – students of particular religious backgrounds. A recent study shows that non-Christian members of the general public perceive Christians as less competent than the average person in science. The potential for this bias is even more impactful in biology, as many individuals from particular sectarian traditions perceive a conflict between their religious beliefs and scientific explanations for the diversity of life on earth. Here, our goal is to extend these findings by directly analyzing the persistence of religious students in biology using a framework of perceived bias, sense of belonging, and grit.

Theoretical Background and Framework: Overall, perceived bias is defined as an individual's belief that they are the subject of discriminatory behavior due to some aspect of their personality or being. A recent study found that if stereotype threat is activated in Christian students before given a task, results tended toward underperformance and misidentification with science, a hallmark that students are aware of existing biases. Despite these biases, however, there are many Christian students who do intend to major in STEM fields. This could be due either to having a strong sense of belonging in science or to resilience for achieving long-term goals, part of grit. Both of these traits have been shown to affect persistence and retention of undergraduate students in STEM. Hence, our model proposes that Christian students who remain in STEM majors despite perceived bias do so by relying on their grit and/or their sense of belonging in STEM.

Study Design: To investigate these influences, we conducted a series of semi-structured interviews with third-year undergraduate students in biology-related majors at a private, research-intensive university in the northeastern US who self-identified as being religious. Interviews were transcribed and codes were developed using a constant comparative method and revised throughout the process. These codes were then combined into overarching themes, both de novo and those in the framework.

Findings and Analysis: Across interviews, our preliminary coding found support for each link in our theoretical model. These students tended to have strong determination in their goals. For many students this alone was sufficient to overcome perceptions of bias they expressed. However, despite the fact that students tended to perceive some general negative bias towards religious students, they did not often articulate this bias specifically. This may be due to the absence of directly anti-religious statements; students often mentioned a more general perception of disagreement between religion and science. We also found that students tended to identify more strongly with their religious identity than their science identity.

Contribution and General Interest: This work complements and adds to recent work on studying religious populations in biology by testing a theoretical framework through qualitative interviews with religious students. We are hopeful that the results presented here will be useful for all members of the SABER community, especially those interested in representation of religious students and/or the use of qualitative inquiry for exploring science teaching problems.

Session C: Instructor Practices

Paper ID: 13

Low-level Learning: Leaving behind most students-- the non-science majors

Cara Gormally (Gallaudet University)*; Peggy Brickman (University of Georgia); Austin Heil (University of Georgia)

Science education and policy often focuses on STEM majors. Yet, more than 8 out of every 10 college students are not STEM majors. We asked: what are the stated learning expectations for non-science majors? Our study goal was to characterize the stated expectations for student learning in non-science majors courses. To do this, we used survey results provided by Howard Hughes Medical Institute (HHMI) BioInteractive. The HHMI survey asked about demographic data and faculty were asked to contribute at least 10 learning objectives that they had used the last time they taught an introductory biology course. HHMI specifically requested fine-grained learning objectives (i.e., the knowledge and skills faculty wish students to gain after completing a class day, learning module or activity, and/or that are used to guide specific formative and summative assessment questions.)

We analyzed instructor and institutional demographics from 39 instructors teaching non-science majors who completed the survey. 72% of respondents reported working full time in their position, and 43% had tenure-track appointments. Learning objectives (LOs) were coded for Bloom's level, content as described by core units in biology via a review of commonly used textbooks, and Vision & Change competencies. As a comparison, we obtained and coded LOs from two best-selling textbooks for non-majors and state mandated course learning goals from Texas and Washington.

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Findings from this survey of LOs (N=1194) reveal that instructors at research universities submitted a higher proportion of learning objectives that tested high level thinking skills as measured by Bloom's Taxonomy. Most instructors report creating LOs themselves, and most instructors share the LOs with students. Overall, 66% of all learning objectives at all institutions focus on low-level thinking skills. Few LOs focused on science process skills that students might use in everyday life to make science-informed decisions.

These findings indicate a need to revisit the goals of instruction for non-science majors - the vast majority of our citizens.

Paper ID: 153

What types of groups facilitate the best active learning?

Kristine L Callis-Duehl (Donald Danforth Plant Science Center)*; Emma Wester (Danforth Plant Science Center); Sandra Arango-Caro (D); Rebekka Darner (Illinois State University)

Students who engage in scientific argumentation show a greater understanding of scientific concepts, practices and culture (Asterhan and Schwarz 2007). Engaging students in authentic scientific discourse is a primary goal of science education, but there are many challenges to accomplishing this in the classroom. For example, gender dynamics may influence how productive scientific arguments are in student groups (Callis-Duehl et al. 2018).

Research Question: How does group-gender-makeup impact scientific argumentation behaviors?

Methods: Students in four chemistry and eight biology classes at two large research institutions were randomly assigned semester-long groups ("group type") based on self-reported gender: all-female groups, all-male groups, and mixed-gender groups, with 4-5 students per group. Students stayed in their same groups all semester, and participated in group discussion activities at least once a week.

Survey Data: Students completed three online surveys: content inventory (pre-post), group discussion satisfaction survey (post), and a self-efficacy survey (pre-post with reflective pre). These surveys were analyzed using a one-way ANOVA and Tukey's means comparison test.

Video Data: The last discussion activity of the semester was video recorded for analysis. Videos were analyzed using the validated Assessment of Scientific Argumentation in the Classroom (ASAC; Sampson et al 2012) protocol. The ASAC protocol includes 19 codes, broken into three themes – cognitive (how a group develops understanding around a scientific concept), epistemic (how consistent the discussion is with the norms of argumentation) and social (e.g. respect and leadership) aspects of scientific argumentation. Each code was rated on a 3-point scale of "never," "sometimes," or "always." Two researchers coded each video and resolved inter-rater reliability. We compared each theme's score by group type using a one-way ANOVA analysis.

We recorded data for 487 students: 31 all-female, 22 all-male, and 38 mixed gender groups. Due to a lack of data on gender non-conforming students, our analysis will focus on "male" and "female" students.

Survey data: We found no significant difference in the percent-change in content inventory scores or the self-efficacy scores based on student gender or group type. We found a significant difference in the satisfaction scores based on group type ($p=0.0221$), but not based on gender.

A comparing between group types indicates a significantly lower satisfaction mean score for all-male groups (p=0.045) compared to mixed-gender and all-female groups. In other words, students in all-male groups reported much lower satisfaction with their group discussions than students in the other group types. Within mixed-gender groups, both male and female students reported similar, non-significant, levels of satisfaction with their group discussions, leading us to conclude that the group dynamic of all-male groups contributed to lower satisfaction scores.

Video Data: We found no significant difference in cognitive or social scores between group types. However, we did find significantly lower cumulative epistemic scores (p=0.0286) for all-male groups compared to other group types. The lower epistemic scores indicate that all-male groups may be engaging in less productive scientific arguments in terms of supporting statements with evidence, challenging unscientific statements and placing their conclusions in the context of scientific theories, despite students in these active-learning classes having been trained in and practicing productive argumentation throughout the semester.

These results indicate that to foster productive arguments, active-learning instructors should make mixed-gender groups and avoid all-male groups. In the future, we will use network analysis to determine if there is a difference in the argument contributions by gender in the different group types.

Paper ID: 130

Student perceptions of supportive and non-supportive instructors: What characteristics make a difference?

Beth Schussler ("University of Tennessee, Knoxville")*; Maryrose Weatherton (University of Tennessee, Knoxville); Miranda Chen (University of Tennessee, Knoxville); Jennifer Brigati (Maryville College); Benjamin England (Saint Louis University)

Factors that influence the persistence of undergraduate STEM students have been the focus of many reform efforts. Students with higher anxiety in introductory Biology are less likely to persist in the Biology major. Average class anxiety levels are negatively correlated with student perception of instructor autonomy-supportive practices. Autonomy-supportive practices maintain students' motivation via listening to students, providing explanations, using non-controlling language, allowing self-paced learning, and acknowledging student feedback. But how do students perceive these supports? The purpose of this study was to identify student-perceived characteristics of supportive instructors in Introductory Biology classes at an R1 institution. Our research questions were: What are characteristics of high instructor support, and what distinguishes student-rated high- and low-support instructors? In Fall 2019, we surveyed students in 6 220-student introductory Biology classes (3 organismal and 3 cellular). We asked them to rate their perception of the level of support their instructor provided (1-10, low to high) and why they rated their instructor that way. We chose 2 instructors with the lowest average support ratings and 2 instructors with the highest average support ratings to analyze (N=635). Each set of instructors included one organismal and one cellular biology instructor. All authors read and discussed the student open-ended responses to develop a consensus codebook of instructor supportiveness categories. Responses were then independently coded by the authors. One author coded all student responses (primary coder), and the four co-authors provided a second set of codes (secondary coders). Initial code agreement was 76%; the primary and two secondary coders then reconciled all disagreements. Codes were sorted and tallied by support rating and by instructor. Five categories of support codes were identified: 1) relational (e.g. approachability, perception of caring / not caring), 2) instrumental (e.g. office hours, review sessions), 3) pedagogical (e.g. good / poor teaching), 4) personality (e.g. nice or mean), and 5) ambiguous (e.g. no personal contact / don't know). Relational, pedagogical, and personality codes could be positive or negative; no students indicated negative instrumental support. As student support ratings increased, the percent of negative relational and pedagogical codes declined and positive relational, instrumental, pedagogical, and personality codes increased. Comparing instructors with high- and low-support ratings, high-support instructors had more positive relational codes. Positive pedagogical codes were more frequent for high-support instructors, but the main difference was a lack of negative pedagogical codes for high-support instructors. Instrumental, personality, and ambiguous codes were less useful in defining differences. These results suggest that relational and pedagogical support drove these students' perceptions of instructional support. These results align with research on autonomy-supportive practices, indicating a useful framework for future studies. In the future, classroom practices leading to these ratings need to be explored via classroom observations, course document analysis, and student interviews. This may support suggestions for instructor practices that increase perceptions of support, decrease average class anxiety levels, and improve persistence in Biology.

Paper ID: 179

Service learning positively impacts classroom climate and empowers students for environmental action

Heather D. Vance-Chalcraft (East Carolina University)*; Carol Goodwillie (East Carolina University)

Research Question: Service learning (SL) integrates service opportunities into course curricula in partnership with a community organization. We asked whether students who participate in service learning in a plant biology course demonstrate greater content knowledge, classroom connectedness, and self-efficacy for environmental action than students who do not participate in service learning. Experiential learning theory suggests that real-world participation in service may be associated with deep learning while social learning theory adds that working together on community service may better engage and motivate participants. Therefore, we hypothesized that participation in SL would improve student content knowledge, enhance positive perceptions of course climate, and increase student empowerment to environmental action. Research Design: We tested this hypothesis in an SL course in plant biology. The SL section was initiated in 2014, in association with our city Parks Department, to involve undergraduates in removal of an invasive species along a local greenway. SL field trips complement traditional lecture sessions on basic plant biology. We compared student outcomes in two course sections (one with, one without, SL) with the same instructor during fall 2019. Data on student content knowledge, perceptions of classroom climate, and views of one's ability to positively impact the environment were collected through surveys given at the beginning and end of the semester. Content questions were instructor-generated and focused on basic topics in plant biology; two published, validated surveys, the Connected Classroom Climate Inventory (CCCI) and Self-Efficacy for Environmental Action (SEEA) scale, were also used. Analyses and Interpretations: Using one-factor ANOVA, the content pre-test, post-test, and learning gain scores did not differ (all $p>0.05$) between SL and non-SL sections even though some class time was used for SL instead of content in the SL section. Paired t-tests on scores from the CCCI showed significant increases in the SL section's students' perception of their peers' respect for one another ($t_{26}=2.73$, $p=0.0113$), opinion that students smiled ($t_{26}=2.51$, $p=0.0187$) and laughed ($t_{25}=6.02$, $p<0.0001$) together, and view that students in the class cooperated with one another ($t_{26}=4.56$, $p=0.0001$). In contrast, classroom connectedness scores in the non-SL section did not change over the semester. Finally, paired t-tests on SEEA scores showed significant increases in the

SL students' confidence in their ability to help protect the planet (t_{26}=2.13, p=0.0431) and their feelings that they could positively impact the environment (t_{26}=2.80, p=0.0095), while students in the non-SL section exhibited no significant changes in self-efficacy for environmental action over the semester. Therefore, our hypothesis that participation in SL would enhance positive perceptions of the classroom climate and increase student feelings of empowerment to environmental action compared to students who did not participate in SL was supported. Class time devoted to service learning did not detract from learning gains on other course content. Contribution: This study provides evidence for the benefits of SL in biology courses, outside of the ecological benefit of invasive species control. In agreement with social learning theory, the collaborative SL experience created a more positive course environment that appeared to engage and empower the students.

Paper ID: 219

Random Call In Class Discussions Facilitates Peer Interaction and Can Reduce Communication Apprehension.

Stacy M Alvares (Edmonds Community College)*; Elli Theobold (University of Washington); Gwen Shlichta (Edmonds Community College); Jenny McFarland (Edmonds Community College)

Research Question or Problem: Classroom discussions are an important part of active learning and the practice of calling on students from a randomized list after a question has been proposed to be a way to help promote inclusivity and equity in those discussions. However, data suggests that anticipating being called on may trigger anxiety-induced behaviors (including skipping class; Cooper et al. 2008), and may affect minoritized groups more than their majority peers. Thus it is important to determine whether practices suggested to promote equity and inclusivity are doing so through multiple measures. Our study examines community college biology students' perceptions of random call within the construct of communication apprehension, which is the fear and anxiety associated with anticipating communication with another person (McCroskey 1977).

Research Design: We surveyed community college students taking in-seat biology courses at the end of the quarter over five quarters. Using Likert-scale questions, our survey assessed how much the type of call used in the course contributed to students' agreement that they communicated with their peers as well as how much they felt comfortable communicating with their instructors. We also explored actions students reported considering if they anticipated being called on through a non-ordered categorical question. Finally, we collected open-ended responses on students' perceptions of the benefits and drawbacks to random call in order to capture communication anxiety that might be missing from the Likert and non-ordered categorical questions. Hypotheses about the effects of random call versus other methods were tested in both a model selection framework and in a classical p-value testing framework, and the results were identical.

Analyses and Interpretations: Our results, based on 460 student responses with 349 unique responses, covered the same six biology courses taught by six instructors over five quarters. We found, in classes implementing random call, students were more likely to agree they interacted with peers, but less likely to agree they felt comfortable asking the instructor questions. Odds are 2.01 times higher and 1.87 times lower, respectively, for students in random call classes to answer one category higher than students in non-random call classes. We also found a smaller difference between URM students' and non-URM students' self-reported motivation in random call classes. Finally in regards to potential communication apprehension, our data suggests that students who experience random call are less likely to report they will skip class if they anticipate being called on.

Contribution: Our data show that random call may increase student participation during class discussions and potentially decrease behaviors associated with communication apprehension (i.e. skipping class). Our data expands upon, and is in contrast to other studies that show students will skip class to avoid being called on (Cooper et al. 2018). We suggest that how instructors implement random call in a classroom can increase equity and may influence the effect of random call on communication apprehension. These data generate new insight into the impact of random call. In particular, this work will be of interest to instructors as they attempt to increase inclusion and equity in the classroom through the practice of random call during class discussions.

Paper ID: 77

Exploring the Impacts of Graduate Teaching Assistants on Student Experiences in a Course-Based Undergraduate Research Experience

Emma C Goodwin (Portland State University)*; Jessica Cary (Portland State University); Erin E Shortlidge (Portland State University)

Research Question: Positive outcomes from course-based undergraduate research experiences (CUREs) have catalyzed increased CURE implementation in introductory biology labs. Graduate teaching assistants (TAs) often are instructors of these labs, and inevitably may be expected to serve as CURE mentors while students collaborate on research within a structured course. We hypothesize that graduate students, who are often novice researchers and teachers, will vary both in ability and motivation to teach in this capacity, which will impact their students' experiences. We use Expectancy-Value Theory (EVT; Eccles and Wigfield, 2002) and the established CURE framework (Auchincloss et al., 2014) as theoretical guides for our study design to explore the impact of individual CURE TAs on their students' experiences.

Research Design: This study was conducted at a large research institution where introductory biology students participate in the SEA-PHAGEs CURE curriculum (Jordan et al., 2014). To learn how TAs differentially impact their students, we conducted 20 modified in-class focus groups with students taught by 9 TAs. Here students (n=383): 1) discussed three questions asking how their TA impacted their experiences, and 2) individually completed a worksheet where they selected what they thought were the most and least important learning objectives to their TA. The questions and list of objectives were designed to align with aspects of the CURE framework, the EVT, and preliminary study data.

Analyses and Interpretations: Two researchers reviewed videos of the focus groups, and used inductive and deductive coding methods to develop a comprehensive codebook. Both researchers then coded each focus group to consensus. We observed patterns in the total frequency of each code reported by each TA's students, and trends emerged that differentiated student perceptions of the environment their TAs fostered. For example, students of four TAs repeatedly discussed experiencing a comfortable classroom environment. In contrast, students of five different TAs rarely discussed feeling comfortable, occasionally even describing times when their TA created a stressful environment.

To assess student perceptions of learning objectives, we calculated the percentage of each TA's students who perceived a given learning objective to be important or unimportant to their TA. Regardless of TA, students identified that the two most important objectives were that they develop basic lab skills and understand the host system. Students nearly ubiquitously felt that experiencing discovery, becoming excited about research, and gaining career clarification were unimportant to their TAs. However, there was wide variation in perceptions of a few objectives between different TA's students'—for example, only 9% of one TA's students felt that facilitating collaborative experiences was important to their TA, while 46% of another TA's students felt their TA prioritized collaboration. A similar pattern emerged in students' perceptions of their TA's priority for facilitating iteration.

Contribution: The impact that TAs have on their CURE students are largely unexplored. This study finds that individual TAs can impact their students' comfort in class and perceptions of experiences critical to the CURE framework, like iteration and collaboration. These data will be of interest to faculty who train CURE TAs and coordinate CURE programs, and ultimately could inform professional development efforts for CURE TAs.

Session D: Research, Laboratory Experience

Paper ID: 117

The Influence of Gender on Students' Perceptions of their Peers' Research Proficiency in Course-based Undergraduate Research Experiences and Traditional Laboratory Courses

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Research Question: Women are often regarded as an underrepresented population across STEM fields. Within laboratory courses, there is evidence for gendered task division, wherein men spend more time conducting experiments and women are relegated to data scribing. Course-based undergraduate research experiences (CUREs) have been posed as an inclusive means to offer UREs; however, limited research has been done on how students' demographic features impact their interactions in such spaces. We investigated the following questions of gender identity as it manifests in CURE and non-CURE courses: 1) Who do students perceive as most proficient at the course research?; 2) How do students' cognitive and affective outcomes predict their chances of being nominated as proficient?; and 3) For what reasons do students find their peers to be proficient? We adapted Carlone & Johnson's science identity framework to describe how cognitive and affective development mediates social performance, science competence, and perceived recognition based on students' gender identity.

Design: We conducted a quasi-experimental, mixed-methods study to investigate the gender dynamics of four CURE and four non-CURE biology courses. To capture social performance, we asked students (N=135) to complete social network surveys, which asked them to nominate a peer enrolled in their course as most proficient and justify this choice via an open-ended prompt. Further, we requested that students complete validated cognitive (e.g., E-EDAT), affective (e.g., Science Identity Survey), and demographic measures in pre-/post-semester fashion to identify how these constructs related to students being perceived as proficient, as determined by linear mixed models. Thematic analysis was used to code students' justifications of their nominations.

Analyses & Interpretation: There is strong evidence of a difference in the distributions of network density for CURE and non-CURE sections. A Kolmogorov-Smirnov test for density shift and t-test both indicate an increase in network density for non-CURE sections ($p < 0.0001$ for all comparisons) with no effect of gender on density ($p > 0.05$). Therefore, non-CURE students were more likely to nominate a variety of their peers as proficient across the semester as compared to CURE students, regardless of gender. Network homophily, however, was affected by gender ($p < 0.001$), suggesting that women and men were likely to nominate peers of the same gender, except for women in non-CURE courses. Predictors of receiving a nomination include students' levels of project ownership ($p < 0.003$) and, possibly, science identity ($p = 0.05$), both of which induce network homophily among students. These results imply nomination ties are more likely for students with similar levels of affective attributes. Students' justifications aligned with these results, with statements such as "She seems dedicated to the material" indicative of the perception of project ownership and "He is a biology major and understands things when I don't" indicative of the science competence aspect of science identity. However, student justifications predominantly focused on cognitive factors in peers who they perceived as proficient in both CURE (73%) and non-CURE (68%) courses, regardless of the gender of the nominator or nominee.

Contribution: Collectively, the results of this study can inform best practices to promote equitable instruction and treatment of all students enrolled in CUREs.

Paper ID: 132

Identifying the Impact of the Tigriopus CURE at Multiple Institutions with Diverse Student Populations

Ginger R Fisher (University of Northern Colorado)*

RESEARCH QUESTION: Institutions nationwide are increasingly implementing course-based undergraduate research experiences (CUREs) as part of the biology curriculum. While CUREs have been shown to have many positive benefits for students, few studies have examined whether similar outcomes are achieved when a course-specific CURE is scaled to diverse institutions with diverse student populations. Furthermore, it is unclear if CUREs benefit all students in the same way, especially those students from minoritized populations. Our work therefore focused on the following question: to what extent is the Tigriopus CURE scalable to diverse institutions, and how comparable are student outcomes across implementation sites? Based on the Opportunity to Learn framework, we hypothesized that student outcomes would be similar at all institutions and for students from all backgrounds, namely because the Tigriopus CURE affords all students the same opportunity to conduct authentic research.

RESEARCH DESIGN: To address our research question, we measured student outcomes before and after implementation of the Tigriopus CURE at five institutions: a women's college, two liberal arts colleges, a community college, and a Hispanic-Serving Institution (HSI). Specifically, students ($N = 341$) completed the Biology Motivation Questionnaire (BMQ), the Expanded Experimental Design Ability Tool (E-EDAT), and Estrada et al.'s (2011) Science Identity Scale. We also provided professional development for instructors from four of the institutions ($N = 8$) to aid them in administering the CURE, thereby increasing the likelihood that the CURE would be implemented with high fidelity.

ANALYSES AND INTERPRETATION: Survey data from four institutions were modeled using a linear mixed-effects model, with post-score as the response, pre-score as the control, and a normal random effect for the classroom to account for auto-correlation within classes. Data from the community college were removed due to small sample size. Overall, students at different institutions had similar trends of increasing intrinsic motivation, career motivation, self-determination, and self-efficacy after enrolling in the Tigriopus CURE. However, these increases were only significant in a few instances. For example, only students from the HSI and one of the smaller liberal arts college had significant increases in intrinsic motivation ($p<0.05$). Students at the HSI and a liberal arts school exhibited significant increases in career motivation ($p<0.05$) and self-efficacy ($p<0.05$) after participation in the CURE. When students from all institutions were analyzed together based on demographic characteristics, there were no differences in their intrinsic motivation, career motivation, and self-determination. However, first-generation students exhibited lower self-efficacy ($p=0.04$) and grade motivation ($p<0.01$) than their counterparts. In addition, minoritized students showed lower E-EDAT scores ($p<0.01$) while those for who English is not a first language exhibited higher science identity ($p=0.01$). Thus, while many psychosocial measures were similar across demographic characteristics, there remain some differences that require further investigation.

CONTRIBUTION: These results provide insight into the differential impact of CUREs on students from diverse backgrounds and indicate that, in many respects, CUREs may have similar benefits for all students. This information is critical for CURE developers and facilitators.

Paper ID: 186

Exploring student science identity in a place-based, experiential marine science research program

Christine Ambrosino (Hawaiʻi Institute of Marine Biology)*; Mackenzie M Manning (Kapiolani Community College); Malia Rivera (Hawaiʻi Institute of Marine Biology)

Research Problem: While underrepresented minority (URM) students may experience conflicts between the culture of the science classroom and their personal identity, pedagogies developed within a critical, place-based framework can simultaneously nurture students' science and cultural identities by allowing them to engage with scientific concepts through their own knowledge systems. This project explored the growth of science identity in recently graduated high school and early undergraduate URM students during participation in a place-based, experiential marine science research program grounded within a Hawaiian cultural context.

Research Design: To thoroughly examine science identity, a personal and multidimensional construct, we utilized a mixed-methods research design that incorporated online surveys, interviews, and artifacts from participants (recently graduated high school and early undergraduate URM students) in a 5-week, place-based, marine science research program. The anonymous, pre-post Likert-scale and open-ended survey included questions about course content understanding, confidence in conducting research, interest in science and an academic pathway, and descriptions of science terminology. Student artifacts included pictoral representations of scientists, written research reports, and conference-like oral presentations that were digitally recorded. Focus group interviews were conducted to enrich the survey data and allow students to present their own interpretations of their course artifacts.

Analyses and Interpretations: Pre-post t-test analysis of survey responses, affective image analysis, and ethographical and coded analysis of oral presentations were utilized to measure student perceptions. Student-participants were also invited to inform the analysis through interviews and image-elucidation with program artifacts (e.g., students describing their own reaction to viewing drawings and written reports from peers). After participation in the program, student engagement increased and student attitudes towards science became more positive. Student descriptions of "science" and "scientist" utilized fewer stereotypes and became more diverse and inclusive, and when asked to draw a scientist, 30% of the participants drew themselves. Two major themes also emerged from review of the focus group transcripts and open-ended survey responses: 1) sense of community and collaboration among scientists; and 2) interdependence among diverse roles within the scientific and local communities.

Contribution: These results support previous studies that have shown students who feel connected with scientific content perform better in the classroom and have more positive attitudes toward science in general. The project is also an effective example of integrating of rigorous scientific methodology and inclusive place-based pedagogies within a unique cultural framework. Most of our students transition to local community colleges after high school. Our goal is to facilitate successful transitions to these campuses by empowering their self-confidence and sense of identity in STEM. Success for Hawaiʻi's students at the college and ultimately professional levels in the marine and ocean science, conservation and management fields is critical to the ongoing protection and sustainability of valuable Hawaiian and Pacific cultural and natural resources.

Paper ID: 199

Exploring student depression in undergraduate research experiences

Sara E Brownell (Arizona State University)*; Katelyn Cooper (University of Central Florida); Logan Gin (Arizona State University)

Depression is a top mental health concern among undergraduates and has been shown to disproportionately affect individuals who are underserved in science. As we aim to create a more inclusive scientific community, we argue that we need to examine the relationship between depression and undergraduate research experiences. While studies have identified aspects of research that affect graduate student depression, in response to the dubbed "graduate student mental health crisis," we know of no studies that have explored the relationship between depression and undergraduate research. We used a theoretical lens of concealable stigmatized identities (CSI) to explore depression in the context of undergraduate research. Because depression is a covert identity, individuals often have the choice to reveal this identity and given the stigma associated with this identity, individuals may be reluctant to reveal even if sharing this identity could be beneficial. In this study, our specific research questions were: (1) how do undergraduates' symptoms of depression affect their research experience? (2) how do undergraduate research experiences affects students' feelings of depression? and (3) What recommendations, based on undergraduates' reported experiences, can promote a positive research experience for students with depression in undergraduate research? Using a national sampling approach, we recruited 35 undergraduate researchers majoring in the life sciences from 12 research-intensive public universities across the United States who self-identified with having depression; we did not require students to be formally diagnosed with depression since mental healthcare is disproportionately available to privileged individuals in the U.S. We conducted hour-long semi-structured interviews with students about their experience with depression in an undergraduate research experience. Interviews were transcribed and two independent raters used inductive and deductive coding to identify prominent themes throughout the interviews and achiever inter-rater reliability ($\kappa = 0.88$). We found that students' depression affected undergraduate researchers' motivation and productivity, creativity and risk-taking, engagement and concentration, and self-perception and socializing in undergraduate research experiences. We also found that students' social connections, failing in science, getting help, receiving feedback, and the demands of research affected students' depression. Notably, we demonstrated that students who felt comfortable revealing their depression identity perceived more positive experiences. However, students could name few faculty members in science who had depression and did not know if one could be successful in research and have depression. This highlights the stigma associated with this identity and the need for students to have role models. Based on this work, we articulate an initial set of evidence-based recommendations for research mentors to consider in promoting an inclusive research experience for students with depression.

Paper ID: 54

Establishing a Framework for the Culture of Scientific Research and Application to Course-based Undergraduate Research

Jessica Dewey (University of Minnesota)*; Anita Schuchardt (University of Minnesota)

When undergraduates first take laboratory courses or participate in direct mentorship research opportunities, they are asked to move into the world of scientific research and interact with its culture. This process, called border crossing, can be challenging for students (Aikenhead, 1996). One avenue for helping students successfully border cross into the culture of scientific research is identifying the specific cultural aspects that may support (i.e. entry points) or challenge (i.e. barriers) border crossing. Before the cultural aspects involved in border crossing can be identified, a framework that specifies the cultural aspects of scientific research must first be established. Research Questions: Our research questions were 1) what aspects make up the culture of scientific research? And 2) what aspects of the culture of scientific research do students perceive after participation in a CURE? Research Design Q1: A systematic literature review was performed to synthesize cultural aspects of scientific research from the literature. Culture was defined as the practices, norms/expectations, and values/beliefs of a group (Phelan et al., 1991). Practices are the day-to-day activities of a group, Norms/Expectations are the standards that influence how a group and its members behave, and Values/Beliefs are broad ideas that help define a group. The databases of Google Scholar and ERIC were searched to identify peer reviewed articles that included in their titles keywords such as "culture AND science", "practices of scientific research", "norms of scientific research", and "values of scientific research". These articles were screened through full-text review. The snowball approach was used to find additional articles that either referenced the initial set of articles or were referenced by theses articles. Sixty-eight articles were included in the final review. Analyses and Interpretations Q1: The cultural aspects identified in these articles were sorted into the three culture categories based on their fit with the definition of each category. Then, the aspects within each category were thematically grouped. In the end, the Culture of Scientific Research (CSR) Framework comprised nine Practices, nine Norms/Expectations, and eight Values/Beliefs. Research Design Q2: Informal interviews were conducted with students (N=190) at a large Midwestern university during poster sessions held at the end of a second semester introductory laboratory course designed as a CURE. Students presented their research projects and were asked three broad questions about what they liked, found challenging, and took away from their experiences in this course. These interviews were audio recorded and transcribed. Analyses and Interpretations Q2: Five hundred and eighty-two student responses were coded based on the CSR Framework. Students mentioned 21/26 aspects in the framework. Values/Beliefs were mentioned less frequently (5% of responses) than Practices (37%) and Norms/Expectations (58%) as challenging or valued aspects. Additionally, we found differences in students' perceptions based on their gender and project topic. Contribution: Our work establishes a new analytical framework for understanding the culture of scientific research. With this framework, more research can be done to identify cultural barriers and entry points that students may experience when border crossing into scientific research.

Paper ID: 18

The Darkside of Development: A systems approach for characterizing the negative mentoring experiences of doctoral students

Trevor T Tuma (University of Georgia)*; Benjamin Hultquist (University of Georgia); John David Adams (University of Georgia); Erin Dolan (University of Georgia)

Research Problem: Effective mentoring has been linked to several positive outcomes for graduate students in STEM fields, including greater scholarly productivity, academic performance, career advancement, and well-being. Yet, mentoring, like any other interpersonal relationship, can also have negative elements. Empirical studies on the problematic or dysfunctional mentoring experiences of graduate students are virtually non-existent, despite the potential detrimental effects and growing body of research suggesting that negative mentoring experiences occur in the workplace and undergraduate research settings. This is particularly concerning given the alarmingly high rates of attrition from STEM graduate programs and increasing concerns over the mental and physical well-being of graduate students. The dearth of knowledge on this subject warrants attention given graduate students' dependence on their advisor for support and because prior research suggests that a graduate student's relationship with their advisor is the most influential factor in their graduate school experience and outcomes.

Research Design: To address this knowledge gap, we conducted a qualitative study to define and characterize negative mentoring experiences in life science graduate research. We conducted semi-structured interviews with a sample of life science doctoral students in the US (n=40) who represented diverse institutions, socio-demographics, and program timepoints, and who indicated that they had negative experiences with their research mentor.

Analyses & Interpretations: We analyzed the interview data using standard inductive and deductive content analysis procedures, keeping in mind findings from research on negative mentoring experiences in other settings while remaining open to new forms of negative mentoring unique to graduate life science research. Then, we interpreted our findings using an ecological systems framework to characterize how their negative mentoring experiences were shaped at various levels of the science research ecosystem. Doctoral students in our study attributed their negative mentoring experiences to multiple levels of this ecosystem: (1) problematic mentor behaviors and characteristics, (2) poor relationship quality or functions, (3) issues with lab, departmental or institutional culture, and (4) issues related to the culture of science. Collectively, graduate students reported that these experiences had detrimental effects on their personal and professional development, including their self-efficacy, career goals, and physical and mental well-being.

Contribution: Our results indicate that graduate students experience negative mentoring similar to those reported in the workplace and undergraduate research studies. Our results also reveal that graduate students experience negative mentoring that is unique to academic research and their stage of development. This study provides the first systematic identification and characterization of the negative mentoring experiences in graduate education and provides a starting point for responding to recent calls from the National Academies to improve STEM graduate education and mentorship practices. Our results can also serve as a foundation for developing a quantitative measure that can be used to study the prevalence and impacts of negative mentoring in graduate education and for testing interventions aimed at preventing these experiences and mitigating their experiences.

Friday, July 31st

Session A: Active Learning

Paper ID: 11

Exploring How Cultural Backgrounds Influence Attitudes Towards Scientific Teaching

Seth Thompson (University of Minnesota)*; Sehoya Cotner (University of Minnesota); Ivar Rønnestad (University of Bergen)

Research over the last decade has indicated that active learning and student-centered instruction lead to better learning outcomes in undergraduate biology courses than traditionally common methods, such as lecturing. This shift in pedagogical approach has been applied to both high-enrollment lecture-based courses as well as smaller enrollment laboratory courses. However, much of the research on evidence based teaching practice has come from a North American perspective, with very little research addressing how faculty members from different parts of the world feel about these new teaching strategies or how international students experience student-centered teaching. Understanding how students and faculty from different cultures use and/or experience evidence-based teaching strategies is imperative for maximizing the learning opportunities for all students.

We present on a small-scale study conducted in the summer of 2017 that examined the attitudes towards scientific teaching practices among faculty members and students from North America, Norway, and Japan. We measured instructional strategies and student engagement using the Classroom Observation Protocol for Undergraduate STEM (COPUS) and performed focus groups with faculty and students to better understand their experience with different instructional techniques. Overall participation, in the form of student generated questions during lecture, was largely dominated by a group of about 5-6 students (~33% of the class). North American and Norwegian students asked far more questions during lecture than Japanese students. Incoming confidence in doing science related tasks was highest in North American students, intermediate in Norwegian students, and lowest in Japanese students, although these differences were not statistically significant. Additionally, it is unclear if lower confidence scores reported by Japanese students were driven by a true confidence deficit or were related to the language barrier experienced by these students. Overall, opportunities for students to interact with peers during lecture were limited. All lectures did contain several opportunities to interact with the professor; however, only the lectures by Norwegian faculty contained defined opportunities for students to interact with their peers. More defined opportunities for peer interactions may help increase the participation of students that tend not to contribute at the whole-class level. All lectures observed had opportunities where peer interactions could have occurred, so facilitating peer interaction would not require a major pedagogical shift. In summation, there are important cultural factors that shape how student and faculty members engage with student-centered instructional techniques and this should be considered when designing courses that incorporate international instructors and students.

Paper ID: 12

Hidden identities shape student perceptions of active learning environments.

Jeremiah Henning (University of South Alabama)*; Cissy Ballen (Auburn University); Sehoya Cotner (University of Minnesota)

RESEARCH QUESTION: Active learning pedagogies (ALPs) represent one suite of tools commonly used to promote greater classroom inclusivity. However, the social aspects of ALPs, may differentially impact students who possess one or more identities that have been historically marginalized in science, such as sexual orientation, political affiliation, religion, race/ethnicity, or first-generation status. Across three universities (University of Minnesota, Auburn University, and University of South Alabama), we measured a broad-suite of social identities salient in STEM classrooms to understand: (Q1) how do student identities shape in-class student-student dynamics, student-faculty dynamics, perceptions of group work, and overall comfort within STEM classrooms?, (Q2) how do identities shape institutional sense of belonging and perceptions of institutional inclusivity? And (Q3) How do multiple identities shape disciplinary sense of belonging, confidence in conducting science (science self-efficacy)? RESEARCH DESIGN: We used a post-course survey from three universities to ascertain which aspects of a student's identity are most salient in their experiences in active-learning environments, especially with respect to group work across universities that differ in student identity representation, university culture, and geographic location (midwestern versus southeastern United States). To understand how multiple aspects of student identity shaped perceptions of in-class dynamics (Q1), institutional sense of belonging (Q2), and disciplinary sense of belonging (Q3), we first grouped student responses to questionnaire items using a exploratory factor analysis, which created composite response variables for each question. Next, we performed multi-model inference multiple regression to parameterize a multi-level path model that included all student identities to understand how each identity facet shaped in-class dynamics (Q1), institutional (Q2) and disciplinary (Q3) sense of belonging. ANALYSIS AND INTERPRETATIONS: Overall, we found that nearly all students identify with at least one minority social identity, often several. Student that commute to campus report lower science-self efficacy and institutional sense of belonging at all universities.

We show that students at a large midwestern university who are politically conservative and/or religious perceive lower inclusion in active-learning environments, while students who identify as queer report negative experiences in groups. However, conservative and religious students did not report the same feeling of lower inclusion from universities in the southeastern United States. Additionally, students that held multiple marginalized identities had lower retention rates in STEM disciplines and lower graduation rates relative to students that held only one of the identities. CONTRIBUTIONS: These and other findings lead us to conclude that targeted efforts to improve classroom climate, such as equitable teaching strategies, will benefit students who might feel marginalized in peer-learning environments. Additionally, this work highlights the prevalence of marginalized identities within our student body, beyond gender and race/ethnicity. Our work also highlights the strong tie of institutional and societal norms and culture on shaping marginalized identities across our institutions.

Paper ID: 185

Comparing the Effects of Repetition, Observation of Active Learning, and Kinesthetic Learning on Non-Major General Biology Students

Kim-Leiloni Nguyen (Mt San Antonio College)*

Research Question: Neuroscience research has shown that repetition strengthens synapses and reinforces neural circuits, resulting in retention and learning. There is enormous amount of evidence that indicates active learning is superior to traditional lecture for student learning. However, active learning often takes more time and physical space than repeating key points by lecturing. With limited amount of time and space in classroom, which is most effective for learning: repeating key concepts, passively observing peers participating in a kinesthetic activity, or actively engaging in a kinesthetic activity?

Research Design: Our study uses a quantitative method to answer the above question in nine sections of non-major, General Biology course, involving 216 students in Spring 2020. Three sections, taught by 3 faculty members, n=66 students, listened to 10 minutes of lecture on the cardiovascular system with an additional 10 minutes of repetition in lab of blood flow through the heart and body (Group 1). Six sections, taught by 3 additional professors, participated in a 10-minute kinesthetic active learning activity in lab on blood flow instead of repetition of lecture. The same faculty taught the kinesthetic activity to the six sections. Because of the size of the classroom, only students in half the room (right or left, not front or back of the room), n=77, passively watched (Group 2) their peers doing the activity while the other half, n=73, actively participated in the kinesthetic activity (Group 3). Pre-activity quiz with 4 questions and post-activity quiz, repeating the same 4 questions in the pre-activity quiz, were administered to all three groups to measure content knowledge. One faculty, not the professor for any of the sections, graded all the quizzes using the same rubric. Results of pre- and post-activity quizzes were analyzed to determine the learning gains in each group and to compare the differences between the three groups.

Analyses and Interpretations: Maximun points on the quiz was 4. For the repetition of lecture group, Group 1, the average on the pre-lecture quiz = 1.63 and average on post-lecture quiz = 2.62, difference = 0.99. For Group 2, the passive group observing their peers in the kinesthetic activity, the average on the pre-activity quiz = 1.31 and average on post-activity quiz = 2.83, difference = 1.52. For the active group doing the kinesthetic activity, Group 3, the average on the pre-activity quiz = 1.28 and post-activity quiz = 3.13, difference = 1.85. The biggest gain was in the actively participating group, followed by the group that was observing the activity. The lecture group started with the highest pre-activity quiz but had the smallest gain in learning through repetition. Preliminary ANOVA one way test comparing the differences in each score on the pre- and post-activity quizzes for all three groups returned $F = 9.4$, F crit = 3.0, and $p = 0.0001$. The learning gains between these three groups were significantly different. Data will be further analyzed to determine where is the biggest learning gains, controlling for incoming knowledge.

Contribution: Our results confirm 1) repetition does help but not as much as kinesthetic active learning and 2) engaging students is superior to passively watching. This information will be helpful for faculty to decide either to reiterate key concepts or implement a kinesthetic activity and if so, with how many students?

Paper ID: 230

Problem based learning in a computer stimulated collaborative environment can be an effective active learning approach for large medical classrooms.

Revati Masilamani (Tufts University)*

Research Question or Problem: Medical schools are attempting to restructure education to provide more opportunities for active learning to promote scientific and medical skill building. This undertaking will require pedagogical and technological innovations that support the needs of busy medical school faculty as they learn potentially unfamiliar approaches to teaching and assessment. Problem Based Learning (PBL) provides a pedagogical framework that in addition to increasing student understanding of complex scientific concepts, fosters critical thinking skills, metacognition, persistence, motivation and transfer of learning to new situations. Computer supported collaborative learning (CSCL) technologies can enhance the outcomes of PBL by fostering work-life skills such as collaborative problem solving, with peer teaching and shared decision-making. It also allows instructors to provide feedback in real time by giving them instant access to discussion artifacts.

Research Design: We designed a CSCL scenario to include the following crucial elements of the PBL theoretical framework: a real-world context, solution flexibility, promotion of collaborative learning, and creation of artifacts demonstrating mastery of concepts and skills. The goal was to evaluate whether this approach could be used effectively with a large first year medical school class (60+) and two instructors. We created patient case studies in immunology, invoking challenging content that the students had learnt. They were expected to apply their conceptual understanding of the topic towards diagnoses and treatment. The material was housed on a collaborative digital learning platform. Tools allowed for polling, discussion and posting. Student posts were archived on the results page and allowed groups to access each other's responses. Students were provided with an anonymous unique ID code. We pursued a mixed methods approach in this study. Conceptual gains were measured by a pre-post content test with 5 multiple-choice items. Student artifacts were coded for accurate and inaccurate conceptions. Self-efficacy and engagement were measured by retrospective pre-post surveys with 10 Likert style items on a 6 point scale; and quality of student discussions were scored on a multi-parameter rubric by a trained observer. The pre-post measures were analyzed by paired t test with Cohen's d for effect sizes.

Analyses and Interpretations: 58 out of the 62 students completed the pre-post assessments. There was a 30% increase in the pre-to-post content means, while the retrospective self-efficacy survey showed a 15% increase in the pre to post means. Both these differences were statistically significant. Group dynamic observations showed that the collaborative discussion had multiple patterns, the most typical being a back-and-forth interaction between multiple members of the group suggesting a truly democratic discussion. Groups that arrived at comprehensive solutions to the questions, typically engaged in discussions that had a higher frequency of accurate conceptions. Misconceptions in such groups were usually challenged early on in the discussion and accurate consensus was arrived at. Polling results indicate that 83% of students preferred the CSCL case-based approach to content learning, compared to the 70% who preferred lecture style teaching. 70% of students said they wanted more CSCL style case-based learning exposure.These findings suggest that a PBL intervention situated in a CSCL environment can effectively facilitate transfer of higher order conceptual learning into problem solving skills for physicians-in-training. Engaging in this form of case based learning provides medical students with improved self- efficacy and team-based practice.

Contribution: This intervention provides proof of principle that CSCL can make PBL an effective approach for large medical classrooms with a minimum number of highly trained instructors facilitating these sessions.

Paper ID: 187

Does a personalized and long-term teaching mentoring program actually work?

Susan Wick (University of Minnesota)*; Michael Moore (University of Nebraska - Lincoln); Uma Swamy (Florida International University); Carlos Goller (North Carolina State University); Anjali Misra (Allan Hancock College); Anusha Naganathan (University of Rochester); Margaret Shain Stieben (The American Physiological Society); Kathryn Johnson (Trail Build LLC)

Research questions: The impact of evidence-based practices on student outcomes is well established, but we know less about effective mechanisms to support instructors' efforts to utilize good teaching practices. The Promoting Active Learning and Mentoring (PALM) Research Coordination Network in Undergraduate Biology Education was created to support professional development for postdocs and faculty who want to incorporate evidence-based active learning into their classrooms. For at least six months, PALM Fellows receive mentoring from an experienced mentor on a project matched to each Fellow's specific goals. The PALM community interacts in person and virtually in bi-annual Gatherings, monthly journal clubs, and mentor orientation, creating a nation-wide community of practice. To assess network effectiveness, we evaluated four questions:

1. Do PALM Fellows successfully use active learning in their classrooms?

2. Do Fellows gain confidence in their ability to persist in using active learning strategies effectively?

3. What helps to make a Fellow-mentor partnership work?

4. What helps participants feel part of a supportive network?

Research design: Using a mixed-methods approach, we used interviews, surveys, and artifact assessment. We did COPUS analysis of pre- and post-mentoring teaching videos to determine if Fellows successfully adopted evidence-based teaching practices. Through surveys that Fellows completed upon acceptance and after one year of participation, we examined changes in self-reported attitudes and confidence in using backward design and active learning.

We conducted semi-structured in-person interviews with Fellows and mentors (n=8, from 7 Fellow-mentor pairs) who had been in the PALM Network for at least 6 months, recruited Fellows and mentors to send us perspectives on their experiences in PALM, and solicited suggestions for improving the network at every Gathering.

Analyses and interpretations: Analysis of artifacts, including surveys, interviews, and presentations on classroom innovations, indicates PALM Fellows successfully implement active learning in their classrooms. All Fellows surveyed reported completion of their classroom innovation, as corroborated by semi-formal interviews. COPUS analysis of Fellows' teaching videos before and after their mentorship indicated positive changes in teaching practices, aligned with the areas Fellows had aimed to improve. Survey and interview data demonstrate clear and significant changes in Fellows' self-reported confidence in planning, implementing, and assessing backward design and active learning strategies in the classroom. Additional survey and interview data support the COPUS analysis of changed classroom practices. Fellow and mentor reflections and the informal discussions at Gatherings offer a diverse perspective on Fellow-mentor relationships and provide context to the many partnerships supported by PALM. PALM participants, no matter their prior level of experience with active learning or type of institution, report that individual mentorship and the interaction with the broader community has been beneficial for their professional growth. By providing their contextualized perspectives we hope to reduce barriers to further adoption of active learning.

Contribution: This research provides a framework for researchers and practitioners on how to build and assess effective mentoring networks to aid in the sustained adoption of evidence-based teaching practices.

Paper ID: 39

CURE as a supplement to the traditional biology lab: How does actively researching cutting

Erika C Martin (Emporia State University)*; Joseph LaForge (Emporia State University)edge science topics influence scientific literacy, performance, and identity of science majors?

Research Question or Problem: In recent decades, research has shown that student engagement in authentic research has significant positive impacts on students such as development of science literacy and reasoning skills. Course-based Undergraduate Research Experiences (CUREs) have been shown to cause a deeper appreciation for scientific research, increase student confidence in their ability to do science, and increase student confidence in research skills. In addition, students who participate in CUREs have a stronger sense of ownership of their science projects, and higher levels of persistence in the sciences than those who participate in traditional laboratory courses. We had three questions we aimed to answer with our research which were addressed with three different assessment instruments (in parentheses, after the listed question). Our questions were:

1. Do students in CURE classrooms enjoy science and view themselves more favorable as individuals able to do competent science more than students in non-CURE classrooms? (PITS, post-course online survey)

2. Are students in CURE classrooms more scientifically literate compared to students in non-CURE classrooms? (TSOLS, post-course online survey)

3. Do students in CURE classrooms feel like their research has real-world implications compared to students in non-CURE classrooms? (PITS, post-course online survey)

Research Design: We assessed three different sections of introductory undergraduate biology laboratory courses for biology majors. CURE (n = 18) and Non-CURE (n = 50) participants were freshman students enrolled at Emporia State University (ESU). ESU is a masters granting institution in rural central Kansas with ~3,500 undergraduates enrolled and a total enrollment of ~5,700 students. Three laboratory classes with class sizes of 18, 21, and 29, were represented in this study. The courses were taught in Fall of 2019. Mid- and post-course assessments were given as hard copies during their regular laboratory period. CURE students participated in an entire-class group project with guidance by the teacher on the topic of fish self-awareness, non-CURE students participated in small (2-4 person) teams to create a project approved by the teacher.

Analyses and Interpretations: Data were graphed and analyzed using program R. We found differences between CURE and non-CURE student metrics across 2 of the 3 of the given assessments. The linear model assessing scores from TOSLS found no significant differences between CURE and non-CURE classrooms. Factorial ANOVA found differences in PITS responses. Mid-semester assessments were more similar between CURE and non-CURE classrooms than post-course assessments. CURE students marked higher values in PITS surveys in most categories. Metrics from the online survey asking students questions on the impact of their research on the scientific community and their enjoyment of science were markedly different between CURE and non-CURE classrooms. In the CURE course, 0 students responded negatively to questions like; “Do you feel that your research project taught you about how real scientists conduct research?”, “Do you believe your research will have a positive impact on future science?”, “Do you believe your research was relevant to the scientific community?” Conversely, many (30% or more) of the non-CURE students responded negatively to these same questions.

Contribution: We intended to introduce students to scientific discovery using cutting edge topics, where the “right answer” was truly unknown. Our goal was to assess if the research project style of inquiry-based learning enhanced the scientific literacy skills and enjoyment of science students. This project aligns well with current conclusions about CUREs being measurably beneficial to students. The project on fish behavior and self-awareness our students conducted is novel to education and based off peer-reviewed, published literature from 2019.

Session B: Instrument Development

Paper ID: 123

Development of a virtual classroom teaching effectiveness observation rubric

Abha Ahuja (Minerva Schools at KGI)*

As college courses move to video conferencing en masse, how do we evaluate teaching effectiveness? While the fundamental principles of good teaching remain the same, the virtual environment presents some unique circumstances. Therefore existing criteria for the assessment of teaching effectiveness must be adapted for online education. Our goal is to identify specific practices associated with effective teaching in virtual classrooms and develop tools to assess these behaviors. To this end, we describe the development of a rubric to assess teaching in synchronous classrooms taught online via video conferencing.

We studied six instructors teaching the same, highly structured lesson plans for the same general science course in a virtual classroom. We used two approaches to identify critical instructor practices that can be considered examples of effective or ineffective teaching (1) Constant comparative method, an inductive data coding process to categorize and compare qualitative data on instructor behaviors. We also adapted existing observation rubrics for brick and mortar classrooms to guide the observation and coding process. (2) Text analysis of end-of-course student surveys to identify instructor behaviors associated with positive student perceptions.

Through this analysis, we identified several specific best practices for teaching via video conferencing. We classified them into four categories: Presentation (Voice and Facial expression), Class Management, Focus of Attention, and Engagement Techniques, and compiled these into the Virtual Classroom Observation Rubric. We are validating the rubric with another set of instructors from a different course. The Virtual Classroom Observation rubric will be applicable across disciplines and across platforms and can be used for faculty training and evaluation.

To the best of our knowledge, the Virtual Classroom Observation Rubric is the first of its kind assessment of teaching via video conferencing. This rubric fills a critical gap and represents a significant step towards more engaging and rigorous education in remote learning settings.

Paper ID: 136

Validating Science Interest and Identity Items for Use with Diverse Community College Students

Heather Perkins (Purdue University)*

Research Question: Gee (2000) theorized that identities are formed in terms of whether someone is a particular “kind of person” - or in the case of science identity - whether someone is a “science person.” In spite of the deep body of literature suggesting the development of a science identity correlates with success and persistence in science (e.g., Brickhouse 2000), very few studies have explored this construct among community college (CC) science students. Since CC students represent nearly half of all undergraduates (AACC, 2019), this is a significant gap in the BER literature. As part of a larger study examining longitudinal trajectories of CC students’ science identities, we sought to validate two existing instruments that might allow comparisons of science identities across diverse institutional contexts and student populations: Godwin’s (2016) Performance/Competence, Interest, and Recognition STEM identity survey (PCIR) and the Student Assessment of Learning Gains (SALG, Seymour, 2000).

Research Design: We developed an online, department-wide survey to evaluate the science identities of biology students over multiple timepoints at a diverse community college. The survey consisted of items adapted from the PCIR, the SALG Instrument, and additional items assessing learning gains, demographics, and career goals. The survey was administered department-wide in the first and last weeks of four academic terms, with an overall 83% response rate. The final sample was quite diverse: 66% of participants were female and 24% male, with an additional 1% selecting from other provided options. A large group of students identified as Asian (43%), followed by White (21%), Latinx (18%), and Black (3%); the remaining 15% provided custom information (6%) or did not respond (9%).

Analysis and interpretation: Participants’ (n = 1119) pre-test responses were randomly assigned to two groups, allowing us to develop and test the model in separate samples. Consistent with previous work, the PCIR items loaded onto three factors (performance/competence, interest, and recognition); less ideally, the interest factor resolved with only two items when the literature recommends at least three per factor. Several iterations of the EFA were needed for the previously un-validated SALG, but ultimately a three-factor solution of 14 items emerged. Two CFAs were then run to test the final models: for the PCIR items, the two-item interest factor and two recognition items were dropped to improve fit indices (CFI = .962, TLI = .944, RMSEA = .094, SRMR = .033). Similarly, three items were dropped from the proposed SALG measure to produce a well-fitted model (CFI = .962, TLI = .948, RMSEA = .071, SRMR = .042). Altogether, the two measures assess constructs of subject performance/competence, recognition, verbal performance/competence, interest, and scientific approach. Overall, results indicate that the items function well and are valid for use in inferential analyses.

Contribution: Current literature suggests that science identity is correlated with success in STEM courses. This study sought to validate the PCIR and SALG instruments and confirms their power to elucidate science identity in a diverse, CC biology context. By testing these commonly used instruments in this new population, this work fills an important gap in the literature and provides a validated tool for the greater biology education research community, in particular, those interested in science identity.

Paper ID: 154

Defining and Modeling Student Success as a Latent Construct in Learning Assistant Supported Biology Courses

Hannah Huvard (University of Colorado Denver)*; Robert Talbot (University of Colorado Denver); Courtney Donovan (University of Colorado Denver)

Research Problem: Many STEM Intervention Programs (SIPs) are designed to impact both cognitive and social-psychological variables of the learning process. However, SIP assessment typically only includes one cognitive measure of student success (e.g., final course grade or learning gain on assessment). This is problematic in that it limits the strength and type of inference that can be made when evaluating the effectiveness of the SIP. In addition to cognitive measures like course grade, several social-psychological measures (e.g., student attitude) have been shown to be strong indicators of student success among undergraduate science majors. Thus, our primary purpose in this study was to develop a latent construct for “student success” consisting of several cognitive and social-psychological measures in undergraduate science courses that utilize a specific intervention, the Learning Assistant (LA) program. The secondary purpose was to test our developed construct using common predictors of success in these courses.

Research Design: The context of this study was introductory biology courses at a mid-sized public urban-serving university in the western United States. In the fall of 2016, a convenience sample of 972 students was taken from introductory biology courses, both LA-supported and not (608 students were LA-supported). We used Structural Equation Modeling (SEM) to test the dimensionality of our latent “success” construct and to model relationships between observed variables (predictors) and the construct. Our latent construct of success was composed of four student success measures: (a) cumulative GPA, (b) final course grade, (c) learning gains measured by a concept inventory (CI), and (d) student attitudes towards biology. We used student data to measure the predictive ability of several demographic, pre-college, and intervention (the use of LAs) variables on our latent construct.

Analysis and Interpretations: All four student success measures loaded onto our latent construct of success at $p \leq 0.05$, and each measure had a positive relationship with student success. This suggests that as cumulative GPA, course grade, CI gains, and attitude towards biology increases, student success increases as well. Factor loadings reveal a stronger relationship between student success and course grade ($\beta = .35$) and cumulative GPA ($\beta = .34$) than between student success and CI gains ($\beta = .31$) or attitude ($\beta = .23$). With respect to the predicting variables, age, Pell Grant eligibility, minority status, high school GPA, and the presence of LAs all had relationships at $p \leq 0.05$ with our student success construct. Of these, Pell Grant eligibility was the only one to have a negative relationship with success ($\beta = -.23$). Both age ($\beta = .66$) and high school GPA ($\beta = .61$) had the largest impact on student success, while the presence of LAs ($\beta = .26$) and minority status ($\beta = .26$) had relatively smaller impacts.

Contribution: This work serves as an entry point for reconsidering what student success means in undergraduate science education in a more robust way. Furthermore, gaining a more in-depth understanding of which demographic, pre-college, and intervention factors (such as the presence of LAs) impact more than one outcome variable simultaneously in introductory biology courses may aid in how we support students within the science undergraduate pipeline. "

Paper ID: 83

Scientific civic engagement survey validation

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Research Question or Problem: We address the question: Can we construct a valid and reliable instrument to measure undergraduates’ scientific civic engagement? Concerns have arisen that college students are less engaged in their communities and this may translate to lower engagement post-graduation. Of particular concern is whether or not STEM students actually use their science skills and knowledge to help their communities. However, there are currently no instruments that specifically test undergraduates' scientific civic engagement.

Labor of Action theory hypothesizes that civic engagement (CE) is a connection to one's community, a commitment to improving that community, and the act of helping one's community. Actions that enhance the community will feed back to the individual to support their positive development. A college education has historically been one of the key approaches to improving concerned and involved citizens' engagement and can predict the development of students' intention and willingness to be a responsible agent in society. This theory informed the selection and development of survey items (i.e., questions).

Research Design: The first step in our research design involved a literature review of prior CE papers and extraction of survey items relevant to 4 proposed subdimensions: scientific civic self-efficacy, knowledge, action and value. With the help of an expert panel, we reduced the item list and then conducted cognitive interviews to check their face validity. After incorporating all the edits from the interviews, we asked a national sample of undergraduates to complete the survey. To seek appropriate subjects within our contexts of interest, we recruited individuals from various STEM departments, ensuring a portion of recruited students were in civically-engaged classes. We then conducted exploratory factor analysis (EFA) to characterize instrument dimensionality.

Analysis and Interpretations: We generated an initial survey draft with 42 items and a 7-point Likert agreement scale from the literature review. We refined this based on cognitive interviews with 12 undergraduate STEM students. We presented the refined scale to 500 STEM undergraduates. To interpret the factors generated from the EFA, we iteratively looked at their meaningfulness by empirical relevance, and eliminated factors that had loadings below 0.7, low communalities, or any cross-loadings. Currently, our data support a 22 item survey consisting of 3 sub-dimensions: scientific civic self-efficacy, action, and value. Next steps involve gathering responses to conduct confirmatory factor analyses and known groups analyses to ensure the instrument can distinguish students with different civic engagements.

Contributions: Our work expands the focus of undergraduate assessment to address the specific benefits of civic engagement within STEM courses. We ground our research in theory and best practice surrounding community involvement, constructing a new instrument that measures students' likelihood to engage and support their communities using scientific skills. Our work will allow instructors to test the efficacy of civically-focused biology courses for previously unexplored student outcomes, such as engaging with their community as a scientist.

Paper ID: 60

Investigating Self-Efficacy and Approach to Teaching in Teaching Assistants

Cody Smith (University of Nebraska-Lincoln)*; Jenny M Dauer (University of Nebraska-Lincoln)

Research Question or Problem: Teaching assistants (TAs) often have the most direct contact with students and thus are instrumental in student learning. With little to no teaching experience or professional development opportunities, positively influencing teaching assistants' (TAs) self-efficacy is important. Self-efficacy can influence teaching performance as it reflects one's belief in their ability to effectively complete teaching tasks. One's approach to teaching, particularly whether teacher-centered or student-centered, affects how instruction is carried out. Exploring TA self-efficacy and how it relates to their approach to teaching will inform how to best prepare

TAs for instruction. This study sought to enhance this understanding by answering the following question: How do TAs' approaches to teaching relate to their self-efficacy?

Research Design: Nineteen TAs participated in this correlational study by completing the Graduate Teaching Assistant Teaching Self-Efficacy Scale (GTA-TSES) and Approaches to Teaching Inventory (ATI) surveys. The GTA-TSES indicates one's confidence in their ability to complete specific teaching tasks. Subscales of the ATI determine whether respondents are more teacher focused (TF; indicating an information transmission approach) or more student focused (SF; indicating a conceptual change approach). Surveys were administered at the beginning of a semester.

Analyses and Interpretations: Results of each survey were averaged across all participants to give a score out of 5, including averaging the subscales of the ATI so each participant had GTA-TSES, TF, and SF scores. Pearson correlation coefficients showed the GTA-TSES (4.30 0.44) had a stronger relationship with SF (3.47 0.51, $r = 0.48$) than TF (3.30 0.50, $r = 0.23$). These results show that those who are higher in self-efficacy have more confidence in their teaching abilities, leading to less concern with their own actions and more concern toward student learning.

Contribution: The results of this study demonstrate that TAs who are more confident in their ability to effectively complete teaching tasks have a more student-centered approach to teaching than teacher-centered. In other work currently in preparation, a model of TA development demonstrates that TAs with higher self-efficacy view teaching tasks as more manageable than TAs with lower self-efficacy who view them as challenging. This study moves the model forward by connecting self-efficacy more directly to teaching approach by suggesting that high self-efficacy TAs show a greater concern for student learning than their own teaching performance. This potential shift in focus should be further investigated to determine if positively influencing TA self-efficacy leads to student centered teaching practices that improve student learning.

Paper ID: 175

Moving Towards Authentic Assessment in Traditional Classrooms: Identifying How and Where to Make Changes

Justine Hobbins (University of Guelph)*; Kerry Ritchie (University of Guelph); Bronte Kerrigan (University of Guelph)

RESEARCH PROBLEM: Assessment is commonly reported as the biggest influencer on student learning, impacting how students perceive a course, the material they focus on and their approach to studying (Villarroel et al., 2019). In particular, authentic assessment (AA) is a favourable approach as it engages students in deeper learning, problem solving and critical thinking with real-world relevance (Villarroel et al., 2019). However, AA does not have a consistent definition, and is most often described within the context of work-integrated learning (Bosco & Ferns, 2014), leaving one to question whether a more traditional classroom can offer AA. Considering students will experience a variety of course formats throughout their degree, and the benefits of AAs reported in the literature, we sought to determine the prevalence of AA in all courses across two large BSc degree programs.

RESEARCH DESIGN: This study was conducted at a large, Canadian comprehensive university. A literature review identified core elements of AA definitions across a variety of contexts, which informed the development of an AA rubric to classify individual assessments as low, moderate or high on key dimensions of relevance, cognitive challenge (CC) and evaluative judgement (EJ). Three independent researchers applied the rubric to every assessment in 60 courses spanning the Human Kinetics and Biomedical Science Majors, based on institutionally standardized course outlines. Follow-up, semi-structured interviews with instructors allowed for a more thorough understanding of assessment procedures.

ANALYSES AND INTERPRETATIONS: Individual assessments were grouped as either tests or assignments. Most courses (53%) assessed students through a combination of tests and assessments. 30% of courses used test only, and 17% of courses used assignment only. No course had high authenticity in all dimensions for tests or assignments, although low authenticity for all dimensions was seen in 9 courses for tests and in 1 course for assignments.

Within relevance, 85% of assignments scored moderate or above, while only 45% of tests did. No test scored high, but 5% of assignments did. This suggests that assignments are easier to simulate real-world relevance. CC was moderate on tests and assignments in 60% and 71% of courses, respectively, suggesting assessments in these disciplines commonly require students to apply course concepts to new situations, although this is possibly limited to academic contexts. EJ was lower compared to other dimensions within a course. Particularly surprising were the results of low EJ in fourth year courses, where other dimensions were high. Of note, this dimension garnered the most conversation in semi-structured interviews and tended to score low in large classes. Therefore, EJ may be an overlooked dimension of authentic assessment for many.

CONTRIBUTION: Providing AA opportunities within higher education classrooms may be overlooked due to the perception that a workplace component is required. While a fully AA-based course did not exist in our 2 majors, several examples of moderate and high authenticity were apparent within a given dimension, across several course contexts, suggesting that opportunities exist to shift assessments towards a more authentic experience. Decreasing the proportion of grades assessed using tests, and incorporating meaningful feedback on every assessment may be two tangible strategies for instructors wishing to increase authenticity of their assessments.

Session C: Affect: Interest/Motivation/etc. & Professional Development

Paper ID: 108

Promoting Intrinsic Motivation to Learn Biology through Explicit Attention to Students' Everyday Ideas

Ruth B MacNeille (Idaho State University)*; Miranda Kuns (Idaho State University); Anna Grinath (Idaho State University)

Problem: Undergraduates' learning experiences are individually shaped by prior experiences. Science is embedded with specialized practices and discourses. Opportunities to make connections between everyday and science experiences are critical, or biology learning can feel unattainable and irrelevant to students whose everyday experiences are less aligned with disciplinary norms. Elicitation discussions function to "uncover students' prior experiences with a phenomenon, provide insight into their thinking, and pique students' interest in new learning". We designed elicitation discussions into a biology lab course. Our research questions were:

1. What changes occurred in students' motivations and attitudes towards learning biology after a lab course with planned elicitation discussions?

2. How do patterns of change in student outcomes relate to variation in teaching assistant (TA) enactment of elicitation discussions?

Research Design: We studied 30 sections of a nonmajors biology lab at an R1 university. The 15 new TAs were trained in responsive talk moves. We used an explanatory sequential mixed-methods research design, where quantitative data collection and analysis (RQ1 & 2) is followed by qualitative data collection and analysis. This abstract focuses on the quantitative stage. For RQ1, we administered the Science Motivation Questionnaire (SMQ) and the Changes in Attitude about the Relevance of Science (CARS) survey pre- and post-course. The SMQ includes 5 motivation components: intrinsic, career, self-determination, self-efficacy, and grade. CARS has one component. Complete data were obtained from 401 consenting students. We used Rasch Analysis to compute linear person measures for the 6 components, anchoring the pre-course item difficulties onto the post-course model. We conducted Wilcoxan signed rank tests to test for change in pre- to post-course responses. We constructed Wright Maps to evaluate the distribution of item measures and person measures of each component. For RQ2, we use a 1-sample t-test to test if shifts by TA were different from 0. To measure TA enactment, we transcribed an end of semester discussion and coded and counted the number of responsive talk moves. From these analyses, we selected contrasting TA cases for the qualitative analysis to identify aspects of TA-student interaction and classroom norm-setting that promote or hinder positive student outcomes.

Analyses: Students' intrinsic motivation ($p<.05$) and grade motivation ($p<.05$) increased and self-efficacy decreased ($p<.05$). Intrinsic motivation increased in 5 TAs' classes ($p<0.01$). These 5 TAs fell in the top 50% of TAs that used frequent responsive talk moves. For 12 TAs, there was no difference in their students' self-efficacy, but 3 cases decreased ($p<0.05$). Two of these cases were also in the top 50% for responsiveness; 1 was in the bottom 20%. These findings suggest that responsiveness during elicitation discussions can corresponds to positive motivation outcomes, but there are significant factors beyond talk moves. The qualitative analysis will provide insight.

Contribution: Biology instruction must attend to students' everyday ideas, yet concrete strategies are lacking. We described one approach, elicitation discussions, and associated student outcomes. Logistically, we could not include a comparison group, but qualitative analysis of contrasting case studies will identify features of classroom instruction related to variation in student outcomes.

Paper ID: 28

I gave my best effort: Measuring test-taking motivation on the GenBio-MAPS programmatic assessment

Crystal Uminski (University of Nebraska - Lincoln)*; Brian Couch (University of Nebraska-Lincoln)

Research questions: Programmatic assessments provide information about student mastery of biology content knowledge across courses in undergraduate curricula. This information can be used to evaluate biology programs and highlight areas in which curricular changes may be necessary. Programmatic assessments are typically administered in low-stakes conditions, so it is important to understand students' test-taking motivation and behaviors in these settings before using assessment scores to make program-level decisions. This research uses the expectancy-value model of achievement motivation theory which states that motivation to do well on a test depends on the examinee's perception of the test as being important, interesting, or useful. The research questions are: 1) To what extent can surveying students provide a reliable and valid way to measure their test-taking motivation for a programmatic assessment? 2) How does test-taking motivation relate to student performance on a programmatic assessment?

Research design: The programmatic assessment used in this research was General Biology – Measuring Achievement and Progression in Science (GenBio-MAPS). GenBio-MAPS was administered under low-stakes settings to 8,185 students. Test-taking motivation was measured using the Student Opinion Scale (SOS), which was completed at the end of GenBio-MAPS. The SOS is comprised of two subscales, Importance and Effort, that measure how important doing well on the test is to the student and the perceived degree of mental effort that the student put forth in completing the test. Previous administrations of the SOS have provided evidence of the instrument's validity and reliability in a variety of contexts. Mixed-effects models were used to determine the extent to which the SOS scores are predicted by test-taking behaviors and the extent to which SOS captures test-taking motivation and can be used to predict GenBio-MAPS score.

Analysis and Interpretation: Confirmatory factor analysis provides evidence that the SOS subscales represent separate constructs of motivation. The items on the Importance and Effort subscales were analyzed for reliability using Cronbach's alpha ($\alpha = 0.755$; 0.809), and the analyses aligned with values reported in the literature. Test completion time and the amount of rapid-guessing behavior exhibited on GenBio-MAPS were used as predictors of SOS subscale scores. These variables better predict Effort scores than Importance scores. Additional models accounted for test completion time, rapid-guessing behavior, and SOS subscale scores as predictors of GenBio-MAPS score. There were significant ($p < 0.001$) effects of test-taking motivation, test completion time, and the amount or rapid-guessing behavior on GenBio-MAPS score. These predictors should be taken into consideration when interpreting GenBio-MAPS scores at the program level.

Contribution: This research provides evidence of the reliability and validity of the SOS as a way to measure test-taking motivation. The GenBio-MAPS scores from students who self-reported low motivation, spent fewer than 10 minutes on GenBio-MAPS, or exhibited high levels of rapid-guessing behavior may not be representative of the students' actual biology content knowledge. We further provide examples of how filtering will affect interpretation of assessment scores and suggest that departments use filtering techniques to remove this subset of scores from the sample before using assessment data to evaluate undergraduate biology programs.

Paper ID: 21

Mixed effects of a belongingness intervention on student performance, confidence, and instructor empathy in two introductory STEM courses

Sarah P Hammarlund (University of Minnesota)*; Cheryl Scott (University of Minnesota); Sadie Hebert (University of Minnesota); Alyssa Olson (University of Minnesota); Margaret Sleeth (University of Minnesota); Sehoya Cotner (University of Minnesota)

Educational Problem: Evidence suggests that students' sense of belonging predicts both performance and retention in higher education. Introductory STEM courses, however, are often taught in large lecture-style classrooms that do not facilitate a sense of belonging.

Consequently, lower sense of belonging can contribute to doubts about one's ability to succeed, which are disproportionately shouldered by students from marginalized groups. In this way, lower sense of belonging can contribute to social inequities in STEM. Intervening to improve a student's sense of belonging may have positive impacts throughout matriculation. Recently, investigators have focused on belongingness interventions, which aim to bring students to the conclusion that adversity within a course or curriculum is normal, temporary, and surmountable.

Research Question: Belongingness interventions have had positive effects on student performance and well-being in some contexts, but have had mixed or no effects in other studies. This discrepancy sparked a call for further studies to test reproducibility across institutions and populations. Additionally, the impact of interventions on instructors has not been explored. Belongingness interventions may increase instructor empathy, which could in turn benefit students. We address two questions: 1) Do belongingness interventions have repeatable effects on student performance and feelings of belonging? 2) What is the impact of the intervention on teaching assistant empathy?

Research Design: We describe two studies that follow the methods of Binning et al., and were implemented in two STEM courses in Fall 2019. In study one, 30 sections of an introductory biology course—each with 24 students—were randomly assigned to an experimental treatment or "business as usual" control. Each TA (n=15) led both an experimental and a control section. In the experimental section, students wrote about challenges that they anticipated and read vignettes from the perspective of more senior students about how they overcame similar challenges. In study two, methods were similar except the course involved 260 students in two lecture sections of an introductory chemistry course. We gathered qualitative data (student and TA written responses to prompts) and quantitative data (course performance, survey responses).

Analyses & Interpretation: Initial multilevel regression analysis of study one indicates that student performance was not affected by the intervention. However, in study two, students who received the intervention had significantly higher scores. During qualitative analysis, two researchers identified 16 categories for TA reflections on their students' concerns; these were collapsed into two groups—student concerns and TA strategies for addressing these concerns. For example, one TA reported that their students' main concern was "difficult learning material." Their strategy was "explaining details I may feel are obvious in a way that does not come across as condescending." Initial qualitative analyses suggest that reading student concerns boosted TA empathy.

Contributions: Our study advances the dialogue about belongingness interventions by replicating previous studies and exploring TA empathy and students' perceptions of their TAs. We were struck by the students' and TAs' willingness to speak about personal struggles. When performing a belongingness intervention, we advocate for instructors to read students' accounts of anticipated challenges.

Paper ID: 75

The Impact of Group Work on Student Self-Efficacy Towards Quantitative Biology

Alexander Kulacki (University of New Hampshire)*; Melissa L Aikens (University of New Hampshire)

Research Question: The field of biology is increasingly quantitative, yet efforts to build quantitative skills into biology curricula are hampered by low student engagement with math in biology. Theory and empirical evidence suggest that students' engagement and performance on a task is affected by their beliefs about their ability to succeed at the task, or their self-efficacy. Students build self-efficacy through directly experiencing success (mastery experiences), comparing their ability and success to that of their peers (vicarious experiences), receiving feedback from others (social persuasions), or in response to their emotions towards the task (physiological states). Group work is one instructional strategy which can increase students' self-efficacy by fostering collaboration with peers and reinforcing each other's success. However, it is unclear how students experience the different sources of self-efficacy during group work and how each source affects their overall self-efficacy. This exploratory study examines what specific group work experiences positively or negatively impact students' self-efficacy for quantitative biology problems, and how students of differing self-efficacy experience the sources of self-efficacy through group work.

Research Design: We surveyed introductory biology students (n=303) across two sections in Fall 2019. During the semester, students worked in small groups (3-5 students) to complete quantitative biology assignments. Before and after two assignments, we asked students to report their self-efficacy on a sample problem similar to the assignment using a 5-point scale. We also asked students to describe experiences during the group work which increased and decreased their confidence in solving similar problems on their own. We performed process coding on student responses for specific experiences. We examined whether high self-efficacy (HSE) students (SE score ≥ 4) reported different experiences than lower self-efficacy (LSE) students (SE score ≤ 3) using chi-square tests.

Analyses and Interpretations: Students most commonly reported that group work increased their self-efficacy through confirming their success by checking answers with their group mates (49%). They also reported mastery experiences through teaching and guiding each other through the problems (37%) as well as being able to achieve mastery themselves through practice (21%). Few students reported a decrease in self-efficacy; those who did found the social persuasions from a lack of group consensus (32%) and the physiological state of anxiety which resulted from that uncertainty (29%) were most impactful. This uncertainty also followed from failing to achieve mastery, such as realizing their thought process or answer was wrong (19%). HSE students reported more instances of mastery and vicarious experiences than their LSE peers when describing group work experiences which increased (χ^2 (3, n=215) =25.75, $p<0.005$) or decreased (χ^2 (3, n=260) =36.50, $p<0.005$) their self-efficacy. Conversely, LSE students reported more instances of social persuasions than HSE students across both types of experience.

Contribution: This study provides insight on the specific experiences that occur during group work which affect self-efficacy. Better understanding of which experiences students find most salient will enable instructors to better structure group work to promote the development of self-efficacy, especially within the context of quantitative tasks.

Paper ID: 55

Improving life science students' attitudes toward mathematics: Insights from implementation of two biocalculus courses

Melissa L Aikens (University of New Hampshire)*; Carrie Diaz Eaton (Bates College/QUBES); Hannah Highlander (University of Portland)

Research Question: Life science students are often required to take a calculus course to satisfy major or pre-professional requirements, yet many students are not interested in calculus, nor do they understand how it relates to their major or pre-professional program. Expectancy-value theory posits that personal values, such as interest or the perception of the utility of the task for a future goal, affect students' persistence on a task and, thus, their performance. Moreover, students' perceptions of the utility of a task can affect their interest in the task. Therefore, redesigning calculus courses to demonstrate the utility value of mathematics for biological problems may increase life science students' motivation and, ultimately, performance in calculus courses. The goals of this study were to determine (1) how students' interest in and utility value of mathematics changed after taking a biocalculus course and (2) the extent to which students' general attitudes towards mathematics improved and why.

Research Design: The study was conducted with life science majors and pre-med students in two different biocalculus courses developed and taught at two different institutions (n=119). Students responded to pre- and post-surveys containing Likert-type items (5-point scale) and open-response items about their values and self-beliefs toward mathematics. We analyzed four Likert-type items that represented interest (1 item) or utility value (3 items) to determine whether these values significantly changed over the semester using ordinal mixed-effects regression models. To obtain a deeper perspective on how students' utility value and overall attitudes toward mathematics changed, we used inductive coding to analyze the responses to two open-response items. The first item, related to utility value, asked students whether mathematics is beneficial to biologists and why or why not. The second item was only on the post-survey and asked students if their attitudes towards mathematics changed and what influenced any change.

Analyses and Interpretations: Students were 73% more likely to report a higher interest score at the end of the semester compared to the beginning of the semester (β=1.00, p=0.0004); average interest scores increased by 0.41 and 0.33 at the two institutions. None of the three utility value items demonstrated a significant change from pre- to post-survey. However, students' responses about how mathematics is beneficial to biology were more sophisticated in the post-survey, indicating improved understanding of the utility value of mathematics to biology. Additionally, while data analysis was commonly cited as an important science process skill requiring mathematics in the pre-survey, using models or modeling and making predictions were cited almost as often as data analysis in the post-survey. In the second open-response question, about 50% of students reported improved attitudes by the end of the course, and one of the three major reasons for improved attitudes was understanding how mathematics could be applied to biology.

Contribution: The results of this study reveal that demonstrating the utility value of mathematics to biology was important for improving student attitudes toward mathematics. This suggests that taking a more integrative approach to STEM education may enhance students' values toward other STEM disciplines, ultimately leading to greater motivation, engagement, and performance.

Paper ID: 194

The work environment and personal characteristics that affect learner-centered teaching practices

Diane Ebert-May (Michigan State University)*

Research Questions: The intent of many teaching professional development (PD) programs is to guide instructors in the use of evidence-based practices that support student learning and maintain those teaching practices in the long term. In a previous study, we tracked postdoc participants from the Faculty Institutes for Reformed Science Teaching (FIRST IV) program (2009-2013) into their current positions as early-career biology faculty. We found that PD outcomes persisted over time and across a major career transition, and FIRST IV faculty demonstrated significantly more learner-centered teaching than their peers. In the current study, we use the Theory of Planned Behavior to frame our research design examining the relative influence of the faculty work environment and personal characteristics on the use of learner-centered teaching practices.

Research Design: This three-year longitudinal study collected data from FIRST IV and comparison faculty at 35 US institutions. We measured personal characteristics including teaching self-efficacy, and teaching beliefs and intentions. We also collected metrics related to the work environment such as the instructional climate, faculty position requirements, and course characteristics. Finally, we measured faculty teaching practice using the Reformed Teaching Observation Protocol (RTOP). We sought to answer the following research questions using model selection: 1. How do these factors affect changes in FIRST IV alumni teaching practice over time (measured by change in mean RTOP scores from the end of the FIRST IV program to the current study)? 2. How do these factors influence current teaching practices (measured by mean current RTOP score) for all faculty?

Analyses and Interpretations: For estimating changes in FIRST IV alumni (N = 31) teaching practice over time, the average of the best models consisted of four factors (in order of importance): self-efficacy in teaching methods (positive relationship to change in RTOP scores over time), intention to teach using a knowledge transmission approach (negative relationship), course size (negative relationship), and percent teaching appointment (small positive relationship). For estimating teaching practice across all faculty (N = 64), the average of the best models consisted of five factors, several of which were significant at an alpha = 0.05: self-efficacy in teaching methods (positive relationship with RTOP score), intention to teach using a knowledge transmission approach (negative relationship), percent teaching appointment (negative relationship), PD program participation (positive relationship), and departmental instructional support (non-significant relationship).

Our findings suggest that although the work environment plays a role in supporting or constraining faculty teaching, ultimately personal characteristics appear to have a greater impact on shaping teaching practice. In particular, self-efficacy in teaching methods are an important driver of teaching practice, and therefore PD that positively impacts participant confidence in using evidence-based approaches may lead to greater long-term adoption. Additionally, we find that some potential outside barriers to learner-centered teaching, including course size, departmental support, and time available for teaching, appear to play a lesser role in influencing teaching practice. For PD designers, this means that programs that target individual beliefs, intentions, and confidence in learner-centered teaching may be able to reduce challenges presented by the work environment.

Session D: Metacognition, Conceptual Understanding, & Institutional Change

Paper ID: 171

Designing a Questionnaire for Undergraduate Biology Student Epistemologies for Science

Kyriaki Chtazikyriakidou (Florida International University)*; Melissa R McCartney (Florida International University)

Student epistemology and the epistemic climates of classrooms are unexplored areas in STEM, especially in the field of biology education. An important part of college instruction should concentrate on challenging students' existing beliefs about knowledge and knowing in their discipline and helping them develop more favorable (expert-like) beliefs. Prior to investigating shifts in student epistemology, there is a need to establish an instrument for measuring students' epistemological beliefs. The only tool currently available is Maryland's Biology Student Expectations survey (MBEX), which has been previously used to measure introductory biology students' epistemic beliefs about biology science and biology learning.

The MBEX survey includes 24 questions that can be answered on a five-point Likert scale, from strongly disagree (1) to strongly agree (5). The questions are organized into four clusters/dimensions: I. Facts vs. Principles - Ideas about the structure of biological knowledge, II. Independence vs. Authority - Ideas about learning biology, III. Interdisciplinary Perspectives vs. Silo Maintenance - Ideas about the value of incorporating other disciplines into undergraduate biology courses, and IV. Connected vs. Isolated - Ideas about the purpose of education. Although the original survey's structure was extensively validated with qualitative studies, its theoretical framework was simply adopted from a similar tool, the MPEX survey (for college physics students) and no factorial analysis on the structure of the MBEX survey and its clusters/domains, has ever been reported. Thus, the goal of this study was to statistically examine whether the original four MBEX clusters and their items would retain the same structure when administered in a different introductory biology course.

Participants of this study were students of Gen Bio II (second semester of the Gen Bio series) at Florida International University (FIU) during Spring 2019. The original scale of 5 Likert-type choices was expanded to 6 (1 = Strongly disagree, 2 = Disagree, 3 = Slightly disagree, 4 = Slightly agree, 5 = Agree, and 6 = Strongly Agree), in order to increase reliability of responses and to be used for factorial analysis. Exploratory factor analysis (EFA; n=318) and confirmatory factor analysis (CFA; n=211) were conducted using the pre-survey and post-survey data collections respectively. Results from factorial analysis suggested a new four-domain structure of MBEX, while eliminating several items of the original survey.

Current results revealed two new factors originating from Cluster III, each included three items of the original cluster. Another new factor was formed with items from both Clusters I and II and the fourth new factor was formed by two items of Cluster IV. The four new factors seem to rely on the theory that biology knowledge is interdisciplinary, related to real-world matters, as well as concept-based and coherent. These epistemological beliefs about the nature of knowledge should ideally align with students' beliefs about the nature of learning in class.

Because of the limited number of available tools to measure biology student epistemology, there continues to be a need for additional research that would lead to additional items on the newer survey model. We are currently piloting new items to be tested for expansion of the newer model of MBEX and results will be analyzed by the end of Spring 2019. Misaligned epistemic beliefs can perpetuate throughout college and although students may graduate while having mastered some scientific skills, they have certainly not been able to fully develop their intellectual scientific skills.

Paper ID: 102

A survey of study strategies of first-year university students: how strategy choice relates to student demographics and student performance

Adrienne E Williams (UC Irvine)*

Not all students who did well in high school are successful in college, particularly students in science, technology, engineering and math (STEM) majors. This problem strikes hardest in women, first-generation and historically disadvantaged students. Certain study strategies have been shown (in mostly laboratory settings) to produce greater learning, with self-testing emphasized to be the most beneficial. But little is known about how the use of study strategies is associated with course performance, particularly when controlling for student preparation. Even fewer studies have looked for differences in study strategies among different demographic groups.

Our research questions are a) do certain study strategies associate with higher grades in college, and b) are some of these effective strategies used less by underrepresented groups. Our talk gives the results of a survey given to several thousand newly-matriculated students before they began their first courses at a selective, public research university in the United States. The survey asked students to choose their top three study strategies from a list. Students in over 20 courses responded to the survey, with 4352 total respondents who were first-year, first term students. We also have full institutional data on these students, along with the course gradebooks with assessment scores and final scores. The courses range from STEM (chemistry, physics, biology, computer science, math) to social science (economics, psychology) to pure humanities courses. We are analyzing this using a stepwise regression model to determine factors that predict course performance, and then linear effects models to account for the correlation of students nested within classes. Our initial analysis shows three strategies are associated with course grade when adjusting for incoming GPA, SAT math and reading, and GPA of other courses. Self-testing and rereading were both associated with increased grades, and flashcard use was associated with decreased grades. Of particular significance, underrepresented minority (URM) students were less likely to reread than majority students, women are less likely to self-test, and flashcard use was more common in women and URM students. This talk will present the results of our current analysis being carried out now on the full Fall 2019 survey and gradebook dataset.

Paper ID: 146

Evaluating Representations of Scientific Process and Ethics and Responsible Conduct of Research in Common Introductory Collegiate Biology Textbooks

Thomas McCabe (University of Texas at El Paso)*; Kristy J Wilson (Marian university); Jeffrey T. Olimpo (The University of Texas at El Paso)

Research Question: The ‘scientific method’ is conventionally taught and modeled as a linear process where discrete steps lead to irrefutable conclusions or ‘scientific facts.’ Reshaping students’ understanding that authentic research practices are far less linear requires that instructors, instructional practices, and instructional materials represent this process in ways that approximate the reality of “doing” science. In particular, we were interested in how common collegiate biology textbooks attend to this challenge by questioning: how is the scientific process and ethics being represented in textbooks in figures and/or text; is scientific process integrated or separate from narrative text; and are explicit discussions of experimental ethics included?

Research Design: In this study, we investigated the representation of scientific process and ethics in eight commonly-used introductory biology textbooks, three of which are online open educational resources (OER). We employed a modified version of the Scientific Process Flowchart Assessment (SPFA) to evaluate textual inclusion and diagrammatic representations of science process across these texts. This instrument provides a rating for the complexity of the representations as well as a score for the terms and phrases used to explain features of science process. Two researchers searched tables of contents, glossaries, and word searches of digital texts to identify terms and explanations of ethics and responsible conduct of research (E/RCR) and then independently scored the regions of text containing representations of the scientific process using the rubric (IRR: Krippendorff's $\alpha = 0.815$, 95% CI [0.704, 0.923]).

Analyses: A majority of textbooks (62.5%) depicted the scientific process using a simple diagrammatic structure such as the traditional linear or a circuit where conclusions lead back to new questions. Only 25% of texts paired diagrams with explanatory text. We observed consistent trends in the appearance or lack of certain science process features included in these portions of the text. For example, general experimental design terms (e.g. variable types or hypotheses) were ubiquitous (81% of terms scored), while other global science process concepts (e.g. multiple lines of supporting evidence or the use of model systems) did not appeared in the search or samples. Searches of texts did not reveal extended discussions of E/RCR topics. When mentioned, texts either highlighted sensational cases (e.g. gene editing) or stated a need for ethical scrutiny without providing students with a framework to explore the issues. Notably, E/RCR was never paired with scientific process information and was always found in separate locations in the text. The incorporation of scientific process and E/RCR does not appear to be sufficient for students to become scientifically literate consumers or properly prepare students who are interested in becoming professional scientists.

Contributions: Calls to action encourage the use of texts that align with recommendations for 21st century learning outcomes. However, attempts to achieve this alignment have yet to provide introductory students with worthwhile exposure to scientific process or E/RCR concepts. Our analysis highlights an urgent need for textbook authors and publishers to expand and integrate these fundamental topics with subject content. We will highlight and provide information on a sample of resources that deliver content information in the context of the scientific processes and E/RCR practices that generated this information. These data also serve to encourage collegiate Biology instructors and education researchers to remain vigilant for and demand textual updates that effectively attend to recommendations from call documents. To continue monitoring these texts and other instructional materials, we hope that modified SPFA provides others with a ready metric for the quality of depictions of science process and E/RCR topics.

Paper ID: 233

Limited diffusion: How, why, and to whom does knowledge of teaching innovations spread?

Jamie L Jensen (Brigham Young University); A. Kelly Lane (University of Nebraska-Lincoln)*

RESEARCH QUESTION: Despite repeated calls for evidence-based instruction, faculty still primarily teach using a lecture-based approach. For these teaching innovations to spread throughout a department or university, diffusion of Innovations theory suggests that early adopters of evidence-based instructional practices must communicate with faculty who have less knowledge. Furthermore, the effective knowledge transfer framework from the organizational behavior field identifies factors that aid in knowledge transfer throughout an organization regardless of individuals' buy-in to an innovation, such as trust in the organization and a culture of problem solving. In this study, we apply these theories along with principles from social network analyses to investigate how teaching innovations spread through faculty teaching networks. Specifically, we asked the following research questions: 1) What are the network qualities of faculty teaching networks (e.g., how dense are the networks)? 2) Why do faculty who use evidence-based instructional practices speak to other faculty about teaching? 3)

What information about teaching is exchanged during conversations? 4) What factors promote teaching conversations between two faculty members in the same department?

RESEARCH DESIGN: We conducted social network analysis at three institutions to investigate faculty teaching networks by collecting data from three science departments at each institution using both surveys and interviews. These departments were included in the final analysis because they had a survey response rate of greater than 70%. Each institution had an ongoing or recently finished WIDER-PERSIST change project, suggesting that the faculty had access to information about evidence-based instructional practices. Survey data included who faculty talk to about teaching, faculty self-report of their knowledge and use of evidence-based instructional practices, and demographic information. Interviews with faculty who reported relatively high knowledge and use of evidence-based practices included questions about what faculty discuss during teaching-related conversations, why they talk to certain peers about teaching, and the context of these conversations (e.g., where, when, and how frequently). Final analyses included 21 interviews with faculty and data from 192 survey respondents.

ANALYSES AND INTERPRETATIONS: Social network analysis was conducted using the sna R package, which reports network characteristics describing the density of the teaching networks in each department, which individuals are the best connected in the department, and what subgroups may exist among faculty. We used semi-structured interviews to follow-up on the survey responses. Interview transcripts were analyzed by a team of four individuals who summarized responses to each question in a table. From these summaries, teams of two used inductive coding to identify common ideas within a given question. All four team members then looked across questions for broader themes. We found that faculty who have knowledge of evidence-based practices preferentially discuss teaching with peers who have similar teaching philosophies, who they have friendly relationships with, and who they respect as having knowledge or expertise about teaching. This resonated with our analysis using exponential random graph models, a common statistical analysis in social networks, which revealed that knowledgeable faculty had a statistically significant (< .0001) tendency to report discussing teaching with another knowledgeable faculty member. However, they did not tend to discuss teaching with less-knowledgeable peers.

CONTRIBUTION: This interdisciplinary study combines both qualitative and quantitative analyses to investigate the teaching networks of faculty at multiple institutions. One implication of our results is that faculty who have not adopted evidence-based teaching strategies do not appear to have access to the advice and knowledge.

Paper ID: 217

The Social Networks of Lecturers with Security of Employment

Daniel Grunspan (University of Guelph)*; Brian Sato (UC Irvine); Stanley M Lo (University of California San Diego)

A large body of literature has established ways in which teaching practices can be modified to transform undergraduate STEM education. Despite this evidence, the most common form of instruction continues to be traditional lecture. The University of California system has a tenure-track faculty position known as the “Lecturer with Security of Employment” (LSOE). LSOEs are subject to similar merit and promotion reviews as traditional tenure-track research faculty with the main difference being a greater emphasis on teaching. With expertise in evidence-based instruction, LSOEs may be positioned to help drive pedagogical change. One way this may occur is through informal social interactions, which have previously been shown to play a role in behavioral change. Here, we explore the social connections between LSOEs and faculty in their own department and with faculty in other departments. In doing so, we use a theoretical perspective from diffusion of innovations to assess whether LSOEs are situated to drive pedagogical change.

185 faculty across 12 departments and three universities responded to a survey regarding who they talk to about research, who they talk to about teaching, who they receive advice from about teaching, and who they are friends with. In total, over 750 faculty were listed and included in our analyses. We used social network analysis (SNA) to 1) understand how the social positions of LSOEs are similar or different from non-LSOE faculty, 2) test whether the presence of an LSOE changes departmental network structures, and 3) test whether LSOEs serve as important hubs for advice about teaching.

We tested whether the position of LSOEs differed from non-LSOEs using permutation correlation tests on common SNA nodal metrics, including degree centrality and Krackhardt's E/I ratio. We tested the extent to which LSOEs impact departmental networks by measuring vitality; a measure taken by permuting a node removal procedure that allows us to test whether removing LSOE or non-LSOE faculty has the greatest impact on network level metrics. Lastly, we examined whether LSOEs serve as teaching advice hubs through exponential random graph models (ERGMs). ERGMs allow us to control for other potentially important variables, like a faculties length of tenure in the department, while testing the effect of being an LSOE on being listed in the advice network. Both the vitality and ERGM analyses were run for the two departments with the highest response rates (>86%).

We find that LSOEs serve important roles in teaching networks. LSOEs have significantly higher degree centrality within their own departmental teaching networks. They also bridge departments, having a greater number of discussion colleagues from outside the department compared to non-LSOE faculty. This same bridging pattern is seen in the research and friendship networks, where LSOE connections are more heavily distributed toward peers outside of the department compared to non-LSOE faculty. LSOEs have a significantly greater impact on the overall centralization structure of their departmental teaching networks compared to non-LSOEs, but not in the friendship or research networks. This implies that the overall communication pattern around teaching may change upon hiring faculty with teaching expertise. Lastly, LSOEs are significantly more likely to be listed by colleagues as someone they go to for advice about teaching after controlling for years in the department and structural features of the network. Taken together, it appears that LSOEs play a unique role in their university networks that may help drive pedagogical change. We discuss the implications of this work, including whether LSOEs might be driving pedagogical change given their unique social network positions.

Paper ID: 35

Learning to be a scholar: How professional networks shape biology graduate students' perceptions of the research-teaching nexus

Joshua W Reid (Middle Tennessee State University)*; Grant E Gardner (Middle Tennessee State University)

Problem Statement: Graduate school often represents the first socialization experience for graduate students to begin to assimilate and uptake the norms and values related to STEM faculty professional identity. An important component of these norms and values include those related to research and teaching. The research-teaching nexus (RTN) describes the relationship between research and teaching in higher education institutions. Previous research has shown that faculty and graduate student perceptions are often related to one's professional identity (i.e., teacher, researcher, teacher/researcher) and future career plans (i.e., research-intensive or teaching-intensive). However, little attention has been given to how these perceptions are shaped during graduate school socialization. We pose that socialization theories will help inform the factors that lead to development of these perceptions. Socialization theories posit that inclusion and participation in social networks provide social spaces for professional development. This presentation will disseminate findings pertaining to the structure of biology graduate students professional research and teaching networks and the relationship of network characteristics to participant perceptions of the RTN. The research question guiding this study was how do the research and teaching professional networks of biology graduate students compare across teaching and research-intensive universities?

Research Design: We used social network analysis to visualize and analyze the professional research and teaching networks (independently) for biology graduate students. For this study, ego-centric networks (networks that focus on an individual and their social interactions) were created using data from a relational cross-sectional survey of biology graduate students at two post-secondary institutions (n=11 and n=14 for research and teaching university, respectively). This survey also collected data on participants' perceptions of research, teaching, and the research-teaching nexus.

Analysis/Interpretations: Network characteristics (i.e., density, transitivity, interaction frequency, size, actor diversity, and tie multiplexity) were calculated. Statistical comparisons of these variables on teaching and research professional networks both within and between two universities were made. Findings indicate that graduate student teaching and research professional network characteristics are statistically similar to one another, both within and between the two universities. The only statistical difference found was that research networks at the research university were significantly denser than research networks at the teaching university. This might suggest that researcher development is valued over teacher development at research university. The second major finding demonstrated that the number of multiplex ties (a tie between two individuals that serves two purposes; i.e., research and teaching) between a graduate students' professional research and teaching networks was significantly and positively correlated to their perceptions of the RTN. This shows that synergistic perceptions of the RTN (meaning that research and teaching are perceived as self-supporting) can be fostered through the number of multiplex ties a particular individual has in their research and teaching networks.

Contributions: This work contributes to literature on the professional development of biology graduate students and their experiences in graduate school and has implications for graduate education scholars and professional developers. For instance, the lack of statistical differences found is meaningful in that it shows there is not as much of a distinction between research and teaching networks across university types as one might hypothesize. The presentation will have a discussion of the value of network-based approaches to graduate student professional development such as suggestions for building multiplex ties.

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282 **Analyzing students' causal mechanistic explanations across chemistry and biology.** Keenan Noyes (Michigan State University)*; Clare Carlson (Michigan State University); Devin Babi (Michigan State University); Jenna Kesh (Michigan State University); Robert McKay (Michigan State University); Joelyn de Lima (Michigan State University); Melanie Cooper (Michigan State University); tammy m long (Michigan State University); Christina Schwarz (Michigan State University); Jon Stoltzfus (Michigan State University)

285 **Active Learning at a Community College Enhances Student Exam Performance.** Kimberly McClure (Lake Washington Institute of Technology)*

289 **Exploring the Affordances and Challenges of an Instructional-Teams Model in Large-Enrollment STEM Courses.** Susan Hester (University of Arizona)*; Katelyn Southard (University of Arizona); Young Ae Kim (University of Arizona); Jonathan Cox (University of Arizona); Lisa Elfring (University of Arizona); Paul Blowers (University of Arizona); Vicente Talanquer (University of Arizona)

290 **A student-faculty collaboration to promote student creativity in undergraduate zoology.** Jordann Fernandes (University of Calgary); Cody-Jordan Handy-Hart (University of Calgary); Sarah Kulle (University of Calgary); Mindi Summers (University of Calgary)*

293 **Student perceived gain in research skills across four unique course-based undergraduate research experiences.** Austin Ashbaugh (University of Calgary); Ariane Cantin (University of Calgary); Mindi Summers (University of Calgary)*; Kyla Flanagan (University of Calgary)

298 **A novel approach to training inclusive mentors and their interns around their supervisory, educational and advisory relationships.** Karen Leung (City College of San Francisco); Sumitra Tatapudy (University of California, San Francisco); Naledi Saul (University of California, San Francisco); Andrea Goldfien (San Francisco State University); James Lewis (City College of San Francisco); Laurence Clement (University of California, San Francisco)*

301 **Student Use of Vision and Change Concepts in Small Group Interviews.** Megan M Shiroda (Michigan State University)*

303 **Analogical reasoning as an investigative tool to identify student alternative conceptions in biology.** Amos Orlofsky (Queensborough Community College)*

305 **Beyond common misconceptions: naive ideas about human evolution and diet among nutrition students**. Sara M Etebari (Arizona State University)*; Sara Brownell (Arizona State University); Daniel Grunspan (University of Guelph); Anthony Basile (Arizona State University); Hilary Bethancourt (Penn State University); Karen Sweazea (Arizona State University)

306 **Communicating Ideas in Molecular Biology: Novice vs. Expert Representations.** Aeowynn J Coakley (San Jose State University)*; Aidan Link (University of Arkansas); Dina Newman (Rochester Institute of Technology); Kate Wright (Rochester Institute of Technology)

308 **Introducing Learning Assistants to a Large Introductory Microbiology Undergraduate Classroom: Lessons Learned.** Amy E. Cardace (Cornell University); Kathleen Hefferon (Cornell University)*

309 **Implementation of a Peer-Learning Assistant Program in a Gateway Biology Course.** Heidi Sleister (Drake University)*; Shauna Kaplan (Drake University)

311 **Defining Undergraduate Research Experiences and Their Effects.** James Boyett (University of Alabama at Birmingham)*; Cameron Pittenger (University of Alabama at Birmingham); Shannon Lynch (University of Alabama at Birmingham); Marissa Brasher (University of Alabama at Birmingham); Elizabeth R Huckaby (University of Alabama at Birmingham); Christine Loyd (University of Alabama at Birmingham); Samantha Giordano-Mooga (UAB)

312 **Exploring the role that bias in individual exam questions may play in generating performance gaps on exam scores in introductory biology courses.** Christian D Wright (Arizona State University)*; K Supriya (Arizona State University); Min Li (University of Washington); Sara E Brownell (Arizona State University)

313 **Publications CURE all: Student-perceived benefits of co-authoring a peer-reviewed scientific publication stemming from a molecular genetics course-based undergraduate research experience.** Ashley N Turner (University of Alabama at Birmingham)*; Anil Kumar Challa (University of Alabama at Birmingham); Katelyn Cooper (University of Central Florida)

316 **Anatomy of the Anatomy of an Education Study: a content analysis of annotations in an LSE feature.** Rebecca M Price (University of Washington Bothell)*; Clark R Coffman (Iowa State University)

317 **The Genetic Code Kit: An open-source cell-free platform for biochemical and biotechnology education.** Nicole E Gregorio (California Polytechnic State University, SLO)*

318 **Student's perception in the development of professional skills in a graduate interdisciplinary program.** Pardeep Sidhu (University of Windsor)*; Tranum Kaur (University of Windsor)

320 **Counterfactual reasoning task led students to ask more 'bridging' questions.** Sneha Chakravarty (Public school, Gwalior); Anveshna Srivastava (Homi Bhabha Centre for Science Education, TIFR)*; Koumudi Patil (Design programme IIT Kanpur)

321 **The Impact of Professional Development and Precision Mentorship on the Adoption of Evidence-Based Teaching on Faculty from Non-R1 institutions.** Penny Carroll (University of Alabama, Birmingham)*

329 **Creating a centralized database of biology and paleontology teaching specimens** Tilottama Roy (Missouri Western State University)*

330 **Increased self-efficacy, career intentions in science, and science identity resulting from early research experiences, learning communities, intensive mentoring, and equity**

and inclusion interventions for first year STEM students in an NSF S-STEM program. Erica Cline (University of Washington Tacoma)*; Emily Cilli-Turner (University of Washington Tacoma)

331 **The impact of unplanned remote instruction on a CURE paired with cookbook-style laboratory exercises.** Erika L Doctor (Lynn University)*; Melissa Lehman (Lynn University); Cassandra Korte (Lynn University)

332 **Undergraduate Immunology fundamental statements and skills: Development of undergraduate curriculum guidelines for teaching immunology using Vision and Change as a framework.** Justine S Liepkalns (University of Washington)*; Adam Kleinschmit (University of Dubuque); Heather Bruns (University of Alabama at Birmingham); Danielle Condry (North Dakota State University); Glenn Dorsam (North Dakota State University); Samantha Elliott (St. Mary's College of Maryland); David Freier (University of Lynchburg); Lou Justement (University of Alabama at Birmingham); Archana Lal (Labette Community College); Phil Mixter (Washington State University); Rachel Pritchard (Kentucky Wesleyan College); Sarah Sletten (University of North Dakota); Becky Sparks-Thissen (University of Southern Indiana); Rebekah Taylor (Frostburg State University); Thiru Vanniasinkam (Charles Sturt University); Brian Wisenden (Minnesota State University Moorhead); Sumali Pandey (Minnesota State University Moorhead)

333 **Using a graphic syllabus to personalize the process of science and explore science identity in a multi-semester lab course sequence.** Heidi Horn (Edgewood College)*; Janet Batzli (University of Wisconsin-Madison); Michelle A Harris (UW - Madison Biocore Program)

335 **Effectiveness and feasibility of Writing-To-Learn activities in a large-enrollment undergraduate physiology course: A pilot study.** Erin Vasudevan (SUNY Stony Brook University)*; Michael Awad (Stony Brook University); Kerry Lin (Stony Brook University); Robert Watson (Stony Brook University); William Collins III (Stony Brook University)

336 **Student Centered Cooperative Instruction for Improving Taxonomic Comprehension in Higher Education.** Clayton W Hale (Department of Forestry, Mississippi State University)*; Joshua Granger (Department of Forestry, Mississippi State University)

338 **Qualitative analysis of introductory biology students' recollections after a completing a CURE or non-CURE laboratory course indicates that CUREs Framework constructs are salient to students.** Joya Mukerji (California State University, Sacramento)*

ADDITIONAL CONFERENCE ACTIVITIES AND RESOURCES

Access to Recorded Presentations

The Keynote Address, Action Group Self-Study and Action Group sessions, The DBER Scholars in Training Workshop, and many of the talks from July 17th, 23rd, 24th, and 31st, are available here. (note: this resource is available for SABER members only. You will be prompted to log-in to access this content).

SABER Buddy System

The 2020 conference saw the inauguration of the first conference “Buddy System”. The system paired new SABER attendees with veteran SABER attendees to serve as mentors during the conference. Buddy groups met for a virtual mixer and found various ways to stay connected during the conference.

DBER Trainees/Scholars-in-Training

PANEL: What career options do I have in Biology Education Research (BER)?

Invited panelists range in a variety of career pathways in Biology Education including Community Colleges, Centers for Teaching and Learning, Minority-serving Institutions, Tenure-track Research focus, and Tenure-track Teaching focus.

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 (45-minute 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 (2-hours time duration split into 20-minute break-out sessions with a break).

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

Lisa McDonnell (Faculty at an academic in R1 Institution, teaching-focused)

Dr. Lisa McDonnell is an Associate Teaching Professor in the Division of Biological Sciences at the University of California, San Diego. She received her Ph.D. in the Faculty of Forestry from the University of British Columbia (UBC) where she used tools from cell biology, molecular biology, and biotechnology to understand the role of various genes in the production of cellulose. She later returned to UBC as a postdoctoral fellow with the Carl Wieman Science Education Initiative before joining UCSD. Lisa's research in biology education broadly aims to understand how teaching practices influence student learning and development of scientific thinking. Currently, Lisa is investigating how students develop critical thinking skills, how their understanding of biology research is influenced by engaging in research experiences, and how teaching practices influence student learning and development of writing and the ability to form scientific arguments. Lisa actively collaborates with other researchers, such as Dr. Stanley Lo, to investigate these questions in biology lab classes at UCSD.

Tracie Addy (Director for Teaching and Learning Center)

Dr. Tracie Addy is the Director of the Center for the Integration of Teaching, Learning and Scholarship at Lafayette College. Tracie has a background in Biology and Experimental Pathology and earned her Ph.D. in Science Education from North Carolina State University. She was the Associate Director of Faculty Teaching Initiatives at the Yale Center for Teaching and Learning and Co-director of the Summer Institutes on Scientific Teaching. Prior to her work in faculty development, Tracie taught at the undergraduate level for ten years. Her active scholarship centers on faculty development and science education, particularly active learning, case-based learning, the intersections between active learning and technology, and inclusive teaching. Tracie enjoys working with faculty from all disciplines to promote teaching excellence.

Abdi Warfa (Faculty at an academic in R1 Institution, research-focused)

Dr. Abdi Warfa is an Assistant Professor in Biology Teaching and Learning at the University of Minnesota, where he also earned his doctorate. Abdi's research program is interdisciplinary, blending aspects of biology, educational theory, cognitive science, and educational research methodologies to improve the teaching and learning of biological sciences at the undergraduate level. His research group focuses on developing evidence-based teaching strategies and curricular materials to enhance student learning of biology and biochemistry. Abdi has authored several publications in both Biology and Chemistry Education and was named an HHMI Faculty Fellow for Inclusive Excellence. In a personal essay entitled, From Refugee to Ph.D. Abdi pens his early years living in Mogadishu, Somalia and coming to the United States.

Jenny McFarland (Faculty at Community College)

Dr. Jenny McFarland is a Biology Instructor at Edmonds Community College. She earned her doctorate in Physiology & Biophysics and Physiological Psychology at the University of Washington. Jenny is passionate about transforming education in 2-year institutions to be more inclusive by advocating for student study spaces, and building communities of support to increase Community College STEM Student success and persistence. Jenny is actively involved in the Biology Education Research community, where she and her collaborators further champion for greater Community College engagement in biology education research. Jenny

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was recently awarded the Claude Bernard Distinguished Lectureship Award 2018 from the American Physiology Society.

Kimberly Williams (Faculty at a minority-serving institution)

Dr. Kimberly Williams is an Assistant Professor in the Environmental and Health Sciences Program at Spelman College. She earned her doctorate in Neuroscience with a certification in translational medicine at the University of North Carolina - Chapel Hill. Her NRSA funded research focused on neurotrophin regulation of neuroinflammation. Kimberly completed an NIH IRACDA postdoctoral fellowship at the University of Pennsylvania where she conducted research on neurocognitive disorders and was a visiting professor at Lincoln University and Rutgers-Camden University. As a postdoctoral fellow, she was awarded the Burroughs Wellcome, Postdoctoral Enrichment Program (PDEP) fellowship. At Spelman College, Kimberly is a principal investigator and research mentor to undergraduates in a variety of disciplines including health sciences, psychology, and chemistry. She has also been awarded the Young Investigators Award 2018 from both the Society for Neuroimmune Pharmacology and International Society for Neurovirology.

Kristine Callis-Duehl (Director of Education Research and Outreach, science communication)

Dr. Callis-Deuhl is currently the Sally and Derick Driemeyer Director of Education Research and Outreach at the Donald Danforth Plant Science Center in St. Louis, Missouri, where she and her team work to bring high-quality science education to children of all ages and inspire the next generation of scientists in formal, informal and virtual learning environments. Prior to her work at the Danforth center, she was an Assistant Professor of Biology at East Carolina University where she focused on biology education using online/virtual science learning, science discourse, meta-ethics and the influence of early science exposure on biology understanding and misconceptions. Kristine received her Bachelor's and Master's degrees in Botany and Plant Biology from North Carolina State University, her Ph.D. in Biology/Ecology from University of Florida, and continued her postdoctoral research at University of California Irvine and University of California Davis. In 2013, Kristine was awarded a National Science Foundation Small Business and Innovative Research grant and became Partner and Owner of Budding Biologist, a company that developed a series of books and video games that teach biology and scientific thinking to children. She has won numerous awards in teaching and mentorship, has been awarded multiple research grants, including 3-National Science Foundation grants, and has authored ~30 publications.

Diversity & Inclusion Action Group on Place and Racial Justice

SABER convened an Action Group on Place and Racial Justice. This group worked to (1) identify the issues of "place" that confer a sense of safety, or lack thereof, to our members identifying as People of Color and (2) assess actions that SABER and SABER members can take to promote awareness of and action surrounding racial justice in whatever place we select to meet with one another going forward.

During the Virtual 2020 SABER Annual Conference, SABER undertook a racial justice self study. Dr. Kecia Thomas, Professor of Industrial/Organizational Psychology and African-American Studies, the founding director of the Center for Research and Engagement in Diversity, and the Senior Associate Dean of Franklin College of Arts and Sciences at the University of Georgia, facilitated the self-study. Learn more about this process and the results in these videos from the conference. Links to the following resources are available on the SABER website.

- A recording of the Keynote address by Dr. Thomas
- Summary of the results from our self-study
- A report on plans for the future based on the self-study