**Poster Abstracts**

**Saturday**

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

Biology’s information deluge necessitates organizing knowledge into concise models. Mathematical modeling with equations provides an approach that relates often disparate phenomena. As a consequence, biology educators have called for undergraduate training reforms that integrate mathematics into the curriculum. These calls, however, have been met with few empirical investigations that identify the knowledge students bring to such learning environments or shed light on the learning challenges and mechanisms at play when biology students think with equations. The dearth of empirical work on student cognition raises questions regarding the role equations should or might play in biology learning. To gain traction on this question, the present investigation reflects the beginning of a project that seeks to determine the functional role of learning about biological phenomena—membrane potentials—with equations. Coordination class theory predicts that part of developing scientific expertise involves students stabilizing their strategies for reading out information from representations. Prior investigations leveraging this theory demonstrated that students struggled to coordinate equation variables with physical quantities. We are currently recruiting undergraduate physiology students (N=12) for the pilot phase of a series of training experiments—subsequent studies will increase power (N=60). Students in the experimental group (Equations) will self-explain with equations, receive verbal instruction on how equations model the membrane potential, and self-explain again (manipulation check). Students in the control group (Diagrams) will do the same but with diagrams. Students will then complete a 32-item assessment that presents simple variable mapping problems (2 fluid compartments) and complex variable mapping problems (3 fluid compartments). A 2x2 ANOVA should reveal an interaction with the Equations group presenting greater performance than the Diagrams group across levels of problem complexity. This result would support the conclusion that when students compare multiple equations that model the same phenomenon, they learn to coordinate variables with physical quantities. Prior investigations have demonstrated that students map their understandings to mathematical representations. This study illuminates the value of equations by demonstrating their capacity to serve as generative, functional resources that address students’ challenges in science learning.

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

During the past 40 years, much research about learning has categorized a student’s approach to learning as either a deep approach (DA) or surface approach (SA). A deep approach is usually defined as being clearly focused on the understanding of meaning and an intention to comprehend the material, while a surface approach is usually defined as an approach that focuses on bare essentials and reproduction through memorization. John Biggs developed the Revised Student Process Questionnaire (R-SPQ-2F) which categorizes students as either DA or SA. This 20-item instrument is scored on a 5-point Likert scale with subscales of Motive and Strategy. The R-SPQ-2F showed acceptable psychometric properties when developed with undergraduate students in Hong Kong and has been used in many studies since its publication in 2001. We administered the R-SPQ-2F to 3 sections of anatomy & physiology courses at a highest research university in the southeastern United States as part of a larger research project (n=824). A total of 230 respondents completed the full survey. From this pool, we recruited eleven participants (6 SA, 5 DA) to participate in interviews and writing prompts as part of a comparative case study. The first interviews were conducted within 3 weeks of R-SPQ-2F administration; initial review of the transcripts raised concerns among the research team about the validity of the R-SPQ-2F instrument for the current population of undergraduates. We reviewed the individual items, classifying them into the subscale groups for motive and strategy. While Biggs indicates 5 items each for deep motive (DM), surface motive (SM), deep strategy (DS), and surface strategy (SS), our review yielded 2 DM, 0 SM, 2 DS, and 2 SS. An additional six items included components of both motive and strategy. Three items aligned with strategy but the approach (surface vs. deep) was unclear.
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and one item aligned with motive but approach was unclear. The remaining four items aligned with neither motive nor strategy. The interview transcripts were then coded using a priori codes from the R-SPQ-2F items. In all, 21 coding passes were completed: an initial pass to identify for relevant surface/deep/motive/strategy passages and then a separate pass for each survey item. Coding was blinded so that coders did not know the corresponding R-SPQ-F results for each transcript. Results from the coding were then compared to student responses to the R-SPQ-2F items. Findings suggest that the R-SPQ-2F was not able to group students by DA or SA in the context of an undergraduate anatomy & physiology course. SA participants often indicated a desire to really understand the course material and an enjoyment in learning the subject. Some DA participants indicated a desire to only memorize the material, while recognizing the need to go beyond rote learning in order to be successful in the class. In addition, in six interviews (3 DA, 3 SA) we found a new theme of “Surface Leading to Deep” with participants indicating that memorization was necessary for the purpose of gaining a full understanding of the course material. This finding has significant implications for instruction, as memorizing and other surface strategies are often minimized and sometimes discouraged, yet they are an important step in student learning. Overall, the R-SPQ-2F requires additional refinement and testing to be a valid instrument for grouping undergraduate anatomy & physiology students as DA or SA.

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

There has been a collective effort to reform postsecondary biology education to increase student participation in undergraduate research experiences (UREs). These experiences have predominantly been delivered in a laboratory context and have been shown to be effective and accessible vehicles to enhance students’ technical skills, content knowledge, and capacity for scientific and critical thinking. However, logistical and financial constraints have been revealed as potential barriers to the sustainability and scalability of laboratory-based UREs. To address this concern, we developed and implemented a research-driven, upper-division developmental neurobiology lecture course that emphasized project-based learning (PBL) to promote growth in cognitive and affective student outcomes, such as those cited above. Students (n = 26) were required to design a semester-long, empirically-informed yet hypothetical experiment focused on the underlying genes that mediate neural-crest cell development in the context of Treacher Collins Syndrome. Students were likewise required to keep a “NeuroNotebook,” in which they would compile course content and literature salient to their research question as well as maintain a record of the various iterations of their experimental designs. A pre-/post-test approach was used to evaluate students’ conceptual understanding of and affect toward both the content presented during the course and the NeuroNotebooks activity. Paired t-test analyses revealed improvements in students’ developmental neurobiology content knowledge, experimental design competency, and confidence in scientific communication (p < 0.01 for all analyses). Moreover, we collected feedback from students to obtain a nuanced understanding of their perceptions of the course and NeuroNotebooks exercise. Thematic analysis of student responses indicated that they gained an enhanced understanding of the research process and increased scientific literacy resultant from completing the course and NeuroNotebooks project. Likewise, most students (73%) indicated that the NeuroNotebooks project provided them with research experience equivalent to that which they would have received in a laboratory course, citing in-class collaboration and experimental design opportunities. Collectively, these results indicate that research-driven PBL exercises offer an effective and resource-conscious platform that have the potential to yield outcomes similar to their laboratory-based counterparts.
Poster #4

Alluvial diagrams track student reasoning pre- and post-instruction as assessed by the Electrochemical Gradients Assessment Device (EGAD)

Jack Cerchiara (University of Washington)*; Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington) Paper ID: 111

The basis for mastering neurophysiology is understanding ion movement across cell membranes. Students in introductory courses recognize ion concentration gradients as a driving force for ion movement but struggle to simultaneously account for electrical charge gradients. We developed and validated a 17-multiple-choice item assessment of students’ understanding of electrochemical gradients and resistance, Electrochemical Gradients Assessment Device (EGAD). We administered EGAD to 513 students from five institutions nationwide as a pre- and post-instruction formative assessment. We also collected demographic data. We used a generalized cumulatively linked mixed model to analyze how student reasoning changed pre- and post-instruction. Traditionally, tables or histograms are used to visualize change in student answers pre- and post-instruction. We present our results using the more visually informative alluvial, or Sankey, diagrams. These visualize variation of student answers at each time point and track how individual students changed their answers moving from one type of reasoning to another. Aggregating an entire population of students, we are able to track how the population of students changed their reasoning and identify difficult or ‘sticky’ concepts. Five of the 17 questions had significant changes in reasoning post-instruction. There was no significant difference in learning gains by gender, first generation college or underrepresented minority status. Institution was a significant covariate in our model for all but one item, indicating students in one location had significantly larger learning gains than other students. On one item on membrane potential, pre-instruction students often account for concentration and electrical gradients separately. In post instruction, the Sankey diagram allowed us to visualize that students from both of these discrete answer choices moved to the most sophisticated reasoning of integrating concentration and electrical gradients in their answer. We are currently analyzing the instructional practice and tools used at the institution where we observed learning gains post-instruction. EGAD and the Sankey plots allow instructors to monitor student reasoning, identify challenging concepts, and assess the impact of teaching innovations. Our results demonstrate how student reasoning on introductory neurophysiology questions changes after instruction and provide a new way to visualize these changes in student reasoning.

Poster #5

Oaks to Arteries: Principle-based Reasoning Varies with Physiological Context

Jack Cerchiara (University of Washington)*; Emily Scott (Univ. Washington); Mary Pat Wenderoth (University of Washington); Jennifer H Doherty (University of Washington) Paper ID: 113

In physiology, expertise is based on the ability to connect fundamental principles of science with rich content knowledge. However, students often struggle to merge principled reasoning with their physiology content knowledge, instead forming disjointed knowledge structures that lack the cohesive frameworks experts use. In this study, we developed a suite of open-ended assessment items to examine how students learn to reason with scientific principles and physiology content knowledge. Our work is grounded in learning progression research, which describes how students develop sophisticated ideas about a particular topic through time. We focused on the principle of flux (passive movement of substances down gradients and impacted by resistance, both diffusion and bulk flow) and asked students to reason about how fluids in different contexts move through tubes. Our overarching research question was: Does the physiological context of an item influence how students reason about bulk flow? We predicted that students would struggle with reasoning as the complexity of the context of the question increased, and that student reasoning would differ between animal and plant scenarios. Complexity of the context could include anatomical or physiological vocabulary, or specific physiological information. Our suite of assessment questions had three formats: 1) context-free: “fluid” flowing through three generic tubes, 2) simple context: blood flowing in three blood vessels or sap flowing through phloem, 3) complex context: blood flowing through the aorta of three animals or sap flowing through phloem of three tree species. We administered our questions to 100 introductory biology students at a large R1 institution. Seventy percent of students had sophisticated reasoning in the context-free format as compared to only 53% and 56% of students in the simple and complex context animal questions, respectively. Interestingly, when a specific animal example was given (e.g. elk,
camel, giraffe) more students reasoned with more colloquial knowledge, (e.g. “Elk will have the greatest flow because it is the largest animal.”) Contrary to our expectations, 75% of students had sophisticated reasoning in the complex context plant scenario. We demonstrate that the context of questions influences the level of reasoning students bring to solving problems. These results can increase the awareness of instructors to features that distract students from using principle-based reasoning.

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

A flipped classroom generally involves delivery of videos, reading assignments, or other methods of content coverage assigned before class, while class time is instead spent on more active approaches to learning. This technique was implemented for a specific set of review content in an upper division undergraduate pathophysiology course for allied health majors. The prerequisite for this course is a one-semester anatomy and physiology (A&P) course. Although students have to earn a C or better in the prerequisite class in order to enroll in the pathophysiology course, many students continue to struggle with some major topics in A&P, such as cardiovascular physiology and blood pressure control. This makes it difficult to have meaningful discussion of the related pathophysiology without first spending class time reviewing content from the prerequisite course. This project aimed to assess the use of pre-recorded video lectures as a replacement for in-class prerequisite course content review. Short (15-30 minute) video lectures were created and made available through the course management system 1-2 class meetings before the related pathophysiology content was covered in class. Students were required to complete an online multiple choice quiz that included questions from the video lecture content. For this study, data was analyzed for a 19-minute video review of the cardiovascular system and the related quiz and exam questions. Out of 77 students enrolled in the class, 44 (57%) accessed the video through the course management system prior to the specific deadline; an additional 9 students (12%) accessed the video before the unit exam that included that topic. By the date of the exam, 56 students (73%) had watched the entire video. Five students accessed the video but watched less than half of it. Over 90% of students correctly answered the two multiple choice questions associated with this content in the untimed online quiz (91% for one question, 93% for the other question). A different multiple choice question over this review content appeared on the unit exam; 66% of students answered this question correctly. The average grade on this unit exam, which included cardiovascular pathophysiology as well as three other chapters, was 70.6%. In the previous semester, 62% of students (41 of 66 completing the exam) answered the same multiple choice question correctly, while the average on the full exam was 73.0%. These data support a conclusion that shifting review content to a pre-class, video lecture format did not strongly impair student learning. Future studies will expand the number of topics analyzed to further assess the impact of pre-class video lectures for review content on student learning in this course.

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

Reasoning with fundamental scientific concepts about biology is foundational to scientific thinking but challenging for students to do. Instead, many students often use disjointed factual knowledge or colloquial ideas to reason about biological processes. To combat this disconnected view of scientific knowledge, many have advocated for organizing instruction around key ideas that have high explanatory power across systems. One of these key ideas is the principle of matter conservation, which is operationalized through the practice of mass balance to explain how the net movement of materials into and out of a pool determine the amount of material in the pool at any given time. Mass balance is a powerful tool for reasoning about plant and animal physiology because it determines things like blood volume in the body, auxin content in a plant, and the amount of calcium in muscle cells. In this study, we developed a learning progression to better understand how students develop sophisticated, scientific reasoning about mass balance in physiological systems. Learning progressions are
empirical cognitive frameworks that describe how student thinking about a topic gains sophistication through time. We used design-based research to develop our learning progression, which involved an iterative cycle of modeling student cognition, observing student reasoning through written assessment instruments and semi-structured interviews, and analyzing student responses on the assessments through rubric development. We used a “space for time” approach to capture how student thinking evolves by sampling students from introductory to advanced biology courses at both R1 and community college institutions. Instructors from these courses administered online surveys that contained 1-2 mass balance items. To date, we have collected approximately 7,500 individual student responses to our mass balance items. We identified four levels of sophistication in our learning progression. L4: At the highest level of the progression, students recognized that the amount of material in a pool represented the balance of multiple material inputs and outputs (i.e., “net flux” reasoning); L3: Students accurately explained how the magnitude of one flux influenced pool sizes or had inaccurate net flux reasoning; L2: Students conflated pools and material fluxes; L1: Students reasoned with non matter-tracing ideas. In one introductory biology level class (135 students), only 5% of students reasoned about net fluxes accurately by the end of the course. Instead, 52% reasoned at L3 while 37% reasoned at L2. We hypothesize that students that reason at L3 are primed to transition to L4 with additional instruction focused on net flux reasoning since they already have correct ideas about how single fluxes impact pool sizes. L2 students will likely require greater, and different, instruction to progress up levels due to their challenges in reasoning about pools and fluxes. By better understanding how students develop sophisticated reasoning about mass balance, instructors can more directly confront the challenges students face in understanding many physiological phenomena. Our learning progression can serve as a template to inform how students think about mass balance phenomena that occur in other biology subdisciplines, such as water balance in crops in plant ecology or carbon and nitrogen balances in ecosystem ecology.

**Poster #8**

**Assessing the impact of “Osmotion”: an active learning module focused on improving comprehension of osmosis and diffusion for underrepresented minority students**

James Boyett (University of Alabama at Birmingham); Sebastian Schormann (University of Alabama at Birmingham); David Esparza (University of Texas at El Paso); Jeffrey T. Olimpo (The University of Texas at El Paso); Samiksha Raut (UAB)*

In the United States, underrepresented minorities (URMs) face barriers to success in secondary education that result in higher attrition rates and limited representation within the science, technology, engineering, and mathematics (STEM) workforce. Much research has recognized that active learning, as opposed to passive learning, can alleviate this disparity and disproportionately benefit URMs. However, these results were accomplished by revamping entire courses to become highly structured which thereby limits the applicability for other educational programs which may lack the support or funding for a pedagogical shift. We therefore explored if introducing an active learning module for a core yet rarely mastered concept in introductory biology - Osmosis and Diffusion (O&D) - would render a similarly disproportionate effect while being more implementable among educational programs. To test this, students attended one active learning module which included a lecture, graphic organizer, and the “osmotion” kinetic activity where students physically re-enacted the processes of O&D as water and solute molecules. To assess student confidence and comprehension, the Osmosis and Diffusion Confidence Inventory and Osmosis and Diffusion Conceptual Assessment were utilized, respectively. Our findings indicate that, despite significant improvements in both groups, the pre-existing achievement gap between URMs and non-URMs persisted. Additionally, although both groups significantly improved confidence in O&D, the active learning module did not disproportionately benefit URMs as expected. We suggest that additional studies are warranted to determine the appropriate amount of active learning practice needed to close the achievement gap between URMs and non-URMs in introductory biology.
**Poster #9**

**Connecting ideas across courses: Relating energy, bonds, and how ATP hydrolysis can power a molecular motor**

Abby Green (Michigan State University)*; Kristin Parent (Michigan State University); Sonia Underwood (Florida International University); Becky Matz (Michigan State University)  

Paper ID: 225

Core chemistry ideas are often useful tools for explaining biological phenomena. For example, to explain the denaturation of DNA at the molecular level, it is critical to have an understanding of intermolecular forces and forces of attraction. Unfortunately, students often have difficulty understanding these core ideas within general chemistry, and of course connecting these ideas to a biologically relevant situation is more difficult still. Indeed, students often see their general chemistry and introductory biology courses as essentially unrelated. This issue stems in part from a lack of explicit opportunities in these introductory courses for students to practice connecting ideas across disciplines. The goal of this project, then, is to provide a set of opportunities for students that asks them to connect their knowledge across chemistry and biology courses. The central research questions is as follows: In what ways do students use their knowledge of core chemistry ideas to explain biological phenomena?  

To answer this question, we are developing activities that each examine students’ abilities to connect a chemistry idea with a biological phenomenon. Initially, we surveyed local introductory biology faculty to determine which areas of connection between biology and chemistry would be most valuable for them. In this presentation, we describe one particular example highlighted by faculty that focuses on concepts about energy and ATP coupling. Our research team iteratively developed a ~20 minute written activity that first asks students about their knowledge of the role of energy during the breaking and forming of covalent bonds (which has been shown within both chemistry and biology to be a difficult subject). Within the context of a molecular motor that packages DNA within a bacteriophage, students are then asked a series of scaffolded questions about their knowledge of ATP and why ATP interactions are important to help power this motor. That the energy released during ATP hydrolysis is physically proximate to and useful for powering the molecular motor is a point of connection between biology and chemistry. The activity was completed by 110 students in an introductory cell and molecular biology course at a large, public, research-intensive university; students were either co-enrolled or previously enrolled in general chemistry. Follow-up interviews for validity about the activity (among others) were conducted with seven students and showed that students were interpreting the questions as intended and that they valued the activities as an opportunity to connect ideas across courses. The preliminary results show that students used the concept of energy in various ways when discussing interactions between ATP and the molecular motor. For example, students explain the function of ATP as giving energy to power the motor, being the energy source, allowing energy transfer, and being the currency of energy. The range of responses is being used to iteratively develop a coding scheme that relates students ideas about bond breaking and forming to the role of ATP in powering the molecular motor.

**Poster #10**

**A Comparison of Instructional Design Approaches for Teaching Noncovalent Interactions in Biochemistry**

Stephanie Halmo (University of Georgia)*; Sasha Stogniy (University of Georgia); Logan Fiorella (University of Georgia); Paula P. Lemons (University of Georgia)  

Paper ID: 175

Active learning increases student performance in STEM courses. However, we still do not know the most appropriate and efficient type of active learning for certain topics or student populations. One challenging topic for biochemistry students is the physical basis of noncovalent interactions (PBI). PBI deals with the fact that all noncovalent interactions (e.g., hydrogen bonds) form due to the attraction of opposite charges, despite variation in the nature of these charges. Students struggle to make predictions about noncovalent interactions that include causal mechanisms for their formation. We aimed to address these difficulties through instruction. We investigated three types of instruction arising from two theoretical perspectives. Worked examples followed by problem practice (WE) and productive failure (PF) come from cognitive load theory (CLT). CLT asserts that instruction should minimize the demands on learners’ limited working memory and provide scaffolding that connects prior knowledge with new material. Guided inquiry (GI) comes from constructivism, which asserts that learners must construct knowledge for themselves. All three types of instruction incorporate problem-solving
activities, engage students cognitively, and have been demonstrated to enhance student learning. Yet the type of support provided by the instructor and the sequence of activities varies. In WE, students receive instruction on how to solve a problem through an expert solution, and then practice solving problems independently. In PF, students explore problems and generate solutions on their own prior to receiving direct instruction. In GI, instructors guide students in groups as they actively engage in scaffolded activities. The following research question guided our investigation: What are the comparative impacts of WE, PF, and GI instruction on student learning about PBI? We implemented each lesson type and compared student learning of PBI. We measured retention and application using problems developed with feedback from students and experts. A pilot study with 123 students from the end of an introductory biology course revealed shortcomings with our initial implementation of GI. We revised the GI lesson and repeated the investigation. In Spring 2019, we recruited 180 students from an organic chemistry course. We assessed prior knowledge before the lesson and randomly assigned participants to WE, PF, or GI conditions. Immediately following the 45-minute lesson, participants completed assessments measuring retention and application of PBI. We conducted ANCOVA to compare performance among the three conditions with measures of prior knowledge, spatial ability, and academic preparedness as covariates. We hypothesize that students in all three instructional approaches will perform similarly on retention problems because retention problems can be solved using an approach like the problems in the lesson. We hypothesize that students in the PF and GI groups will outperform students in the WE group on application problems. Application problems require new types of solutions, and only PF and GI allocate time for students to consider the underlying concepts of a problem. Testing these hypotheses is a first step toward determining the most appropriate and efficient type of active learning for a specific topic. This research will interest researchers who investigate student reasoning, problem solving, assessment, and evidence-based practice.

**Poster #11**

**Collaborative Active Learning Spaces Foster Increased Relatedness and Participation in Introductory Biology Students**

Kim M Pigford (NC Wesleyan College)*; Miriam Ferzli (NC State University); Margaret Blanchard (NC State University); Michelle Nugent (NC State University) Paper ID: 220

There is little debate at this point on the efficacy of active learning in undergraduate college science classrooms. It is well accepted that students are more successful in courses using active learning compared to those taught in traditional, teacher-centered environments. Research interest has now shifted to identifying the specific mechanics of the successful active learning environment, as well as, identifying different types of active learning which are more or less effective than others. Some classroom environments are now being specially designed and built to incorporate and allow for increased active learning. Considering this, examinations of these classrooms and the benefits they give to students deserves attention. This study examined the benefits of a SCALE-UP classroom (Student-Centered Active Learning Environments with Upside-down Pedagogies) for introductory biology students. SCALE-UP rooms are specially designed to encourage collaborative team-based learning. Students sit at round tables each accommodating nine students and work in teams of three throughout the semester. Undergraduate and graduate teaching assistants are available each class period to give students more one-on-one attention than they would otherwise receive. This mixed-methods study utilized a self-determination theory framework to compare performance and motivation between students enrolled in a section of introductory biology taught in the SCALE-UP classroom and those enrolled in an active learning section taught in a traditional lecture hall. Both courses were taught by the same main instructor, covered the same material, and were given the same assessments such as quizzes and exams. Classroom observations were also conducted using COPUS (Classroom Observation Protocol for Undergraduate STEM) to measure the amount of and type of active learning occurring in each class and written free-response surveys were given to students at the end of the semester to determine which aspects of the course the students found most useful to their learning. Results between the two courses revealed some significant positive differences for students enrolled in the SCALE-UP section. Students reported higher levels of perceived relatedness and had higher participation scores. However, there were no significant differences between the two sections regarding interest, autonomy, competence, and overall performance, providing support for active learning regardless of classroom space. Qualitative results revealed that students in SCALE-UP spent more of their time engaging in collaborative-based active learning and consciously appreciated the feeling of being part of a learning community that included extra access to instructors and peers.
The results of this study lend credence to the creation and use of specially designed collaborative, active learning classroom spaces for their ability to foster a sense of classroom community including direct interaction with the instructor and teaching assistants/peer facilitators.

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

BACKGROUND/SPECIFIC AIM: While the traditional setting of a student engaging in a research study in a laboratory or in the field is the gold standard in participatory learning in STEM, most institutions lack the resources, facilities, and faculty to provide these opportunities to all students. As a result, education researchers have begun to explore alternative models that could prepare students for or serve as extensions of laboratory experiences. Field trips, which bring students to locations and settings that cannot be duplicated in the classroom, are laboratory extensions that are effective ways of increasing student interest and engagement with the subject. Students are often able to connect the field trip’s experiential learning with the content that was taught in the classroom. The benefit of a field trip compared to an authentic research experience is lower cost, less investment of class time, and the ability to include a large number of students. At FIU, students enrolled in General Bio 2 have the option to take a guided tour of Fairchild Tropical Botanic Garden (FTBG). What are students experiencing during these tours? METHODS: In the summer 2018, all students enrolled in General Biology 2 completed a pre-course questionnaire at the beginning of the course. Data collected through this questionnaire included whether or not students feel that botany related to their career or major and how students rate their interest and competence related to botany. Upon completion of the FTBG tours, students completed a second questionnaire related to how learning botany at FTBG was different from learning botany in a classroom. 54% of students participated in the tours. At the end of the course, all students were given the same questionnaire as in the beginning of the course in order to see how or if their answers changed over the duration of the course. RESULTS: We saw a significant increase in students participating in FTBG tours reporting that botany was relevant to their major and career. There was no change for students not taking the tour. Additionally, students who took the tour reported being more confident in succeeding in the course itself. There was a significant increase in interest in botany among students who took the tour, with no change in students who did not take the tour. Interestingly, we see a decrease in competence for all students, regardless of participation in a tour. CONCLUSION: This study suggests that participation in the FTBG tours as part of General Biology 2 positively influences student’s views of botany. We are currently analyzing short answer responses from all students as a way to learn more about how/why their views of botany change over the course of the semester.

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

Metacognitive knowledge, an awareness of one’s own knowledge, is a key aspect to student academic success; however, increasing student metacognition is a difficult task. This study examined whether requiring students to identify their metacognitive knowledge through the use of knowledge surveys would impact their content knowledge. This study also examined students’ metacognitive knowledge, assessed in their homework assignments, in relation to their personal demographics and their performance in the course. The data from this study indicate that making students aware of their knowledge gaps before an exam did not significantly impact their performance on that exam. Students who participated in knowledge surveys did not score higher on exams over that same biology content than students who did not participate. Interestingly, students who participated in knowledge surveys also did not show a significant increase in their metacognitive abilities throughout the course, thus demonstrating the difficulty in impacting student metacognition. However, the results did indicate that students with different demographic characteristics had significantly different metacognitive skills. For example, Latinx students had lower levels of metacognition as compared to their white peers and also performed lower on...
course exams. We also found that first generation students had lower metacognitive abilities than students whose parents had some college experience. This information could be used by instructors to target metacognitive training to specific groups of students in an attempt to decrease the equity gap in their classrooms.

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

Asking questions about the world around us lies at the core of the scientific method. What makes us feel hungry? How does caffeine work as a stimulant? Why do tree leaves turn color in the fall? Curiosity questions like these are what fuels the process of scientific discovery. Yet, little attention in the undergraduate science classroom is dedicated to developing scientific questioning skills. Development of this skill is especially valuable for non-science students. Often, the goal of a non-science majors course is not necessarily content-related, but rather emphasizing the application of the material in society. By highlighting the application of material, educators hope to promote scientific curiosity and develop scientific questioning skills students need to understand the world around them. In this study, we analyzed written questions generated by non-majors biology lab students through a weekly reflection activity. By analyzing student responses with a coding rubric, we: 1) classified question complexity, 2) determined if question complexity changed throughout the semester, and 3) determined if question complexity related to academic performance. We determined that questions asked by students varied based on the lab content covered week by week. Some lab content lent itself to deep, conceptual questions while other content lent itself to questions more factual in nature. Also, students in the lower tertile tended to ask more superficial, factual questions, while students in the upper tertile tended to ask deeper, conceptual questions. Characterizing student-generated questions could help inform instruction on cultivating scientific questioning skills in non-science major students.

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

In the Fall of 2013, a two-semester integrated introductory biology and chemistry program was implemented for life science majors at the University of Delaware, which grew out of an HHMI grant. The program evolved to incorporate many aspects of the Vision & Change call to action, including a focus on interdisciplinarity and student-centered learning. The integrated program features inquiry-based labs that link the chemistry and biology curricula with the goals of: 1) improving learning in introductory biology and chemistry; 2) increasing understanding of the interdisciplinarity of biology and chemistry; 3) increasing long-term persistence in STEM. Following the five-year development process of this program, we have begun to take a primarily quantitative approach towards answering the following questions: who are our students, how have they performed in our program over the last five years, and what are their perceptions of the interdisciplinary nature of biology and chemistry? Student demographics in the program’s first five years (2013-2017) were similar to the university’s overall demographics. DFW rates for this first integrated cohort in introductory chemistry and biology, as well as core upper-level courses, matches that of the previous cohort who took non-integrated biology. Initial data from the CLASS-Bio survey in fall 2018 showed a shift towards more expert-like thinking by students in the first semester in the program in the category of problem solving. We also conducted a survey focused specifically on interdisciplinarity, in which student responses indicated that chemistry was somewhat more important to learning biology than the reverse relationship; however, students thought that chemistry and biology were more important to learning each other than physics was to either. This indicates that taking interdisciplinary courses coincides with an increased awareness of the importance of that interconnection, but it is unclear if that is solely attributable to our program. As we enter our second stage of assessment, we are examining student learning in three of the core competencies in Vision & Change (Interdisciplinary Nature of Science; Process of Science; Modeling and Simulation) by assessing student benchmarks at regular intervals throughout the program.
**Poster #16**

**Osmosis and diffusion: Examining the effects of instruction on student engagement and knowledge retention in an introductory biology laboratory course.**

Aakanksha Angra (Georgia State University)* Paper ID: 171

Given the benefits of long-term retention and interest in science, there has been a movement to adopt inquiry-based biology labs over traditional, cookbook labs. In this study, we utilized the latest tools published in the last ten years to evaluate the introductory laboratory curriculum at our University. Specifically, we were interested in understanding if there are: a) differences in levels of student engagement in the traditional and the inquiry-based lab classrooms and b) differences in the amount of information students retain about osmosis and diffusion one week, three weeks (midterm exam), and twelve weeks (final exam) following completion of the module. To answer our research questions, we used the context of the osmosis and diffusion lab because of the historical documentation of student difficulties with these concepts. We compared the traditional with the inquiry osmosis and diffusion lab model and mapped the ACE-bio model of competencies on both models of this lab. To assess student and TA engagement, we used the Laboratory Observation Protocol for Undergraduate STEM (LOPUS; Velasco et al., 2016). To assess content retention, we developed our own pre- and post-module knowledge survey and integrated questions from the Osmosis and Diffusion Conceptual Assessment (ODCA; Fisher et al., 2011) into our midterm and final laboratory practicum. Preliminary findings from LOPUS do not reveal any major differences between TA and student behaviors. TAs in both models of lab spent an equal amount of time lecturing, answering individual student questions, but interestingly, TAs in the inquiry sections posed more questions to either individuals or a group of students. Students in both lab models spent equal amounts of time performing the lab activity, taking notes in their lab manuals, and asking the TA specific questions related to lab. Preliminary findings from pre and post assessment surveys reveal that students are competent with including components necessary to draw the process of diffusion and osmosis but struggle with using arrows to show the movement of solute molecules and articulating their drawing in words. While preliminary findings from this study do not reveal differences in levels of student engagement in the traditional and the inquiry-based lab classrooms, the differences in TA behaviors may inform future TA training modules. Analysis of student performance on the midterm and final exam ODCA questions are needed to understand the impact of the traditional or inquiry lab model on student learning and content retention for the osmosis and diffusion topics.

**Poster #17**

**Making Biology a Game Worth Playing**

William E Falkner (Central Michigan University)*; Debra L Linton (Central Michigan University) Paper ID: 173

Gamification of teaching practices is becoming more common despite a dearth of research corroborating its effectiveness. Under the gamification umbrella, using fictional narratives to deliver content and situate learning activities is one of the least understood of these pedagogical tools. This study reflects on the outcomes of redesigning an introductory biology laboratory course with a fictional narrative spanning the entire semester. Student learning data and survey data was collected to help elucidate the effects a fictional narrative may have on student learning, affective engagement, and attitudes towards science. This study was conducted over two semesters, Fall 2017 and Fall 2018, on the laboratory sections of an introductory biology course for elementary education students. The same instructor taught all of the laboratory sections examined. The Fall 2018 laboratory experience was modified with the addition of a fictional narrative. Modifications included weekly story updates and redesigning the laboratory manual to include story excerpts to give context to laboratory activities. Activities included in laboratory exercises and assessment questions did not differ between laboratory exercises. Data were collected for each laboratory exercise using an intrinsic motivation inventory to measure student interest, effort, pressure, and value from the overall laboratory experience. A pre/post science attitude survey was also used to assess whether student attitudes towards science improved after taking this course. Finally, assessments from laboratory exercises and exam questions pertaining to laboratory exercises were also included for analysis. Preliminary t-test results suggest that students in a gamified laboratory setting perform significantly better on exam questions pertaining to lab topics, have improved attitudes towards science, and have increased interest and value regarding their laboratory topics. Therefore, fictional narratives may serve a function to improve both student affective engagement and learning outcomes.
Poster #18
Modeling Global Citizenship Education in the Tibetan Buddhist monastic science classroom
Kelsey Gray (Emory University)*; Jacob Shreckengost (Craig H. Neilsen Foundation); Carol Worthman (Emory University); Arri Eisen (Emory University)  Paper ID: 234

In an increasingly interconnected world, human rights violations, inequality, and poverty continue to threaten peace and sustainability. The Global Citizen Education (GCED) model informs the role of science education in addressing these problems and has been used as a framework to implement United Nations Educational, Scientific and Cultural Organization (UNESCO) Sustainable Development Goal 4 – Quality Education. GCED proposes education must shift from a focus on Western topics through a Western lens to perspectives of globalism and glocalism. This framework is especially well-suited for work with Tibetan Buddhist monastics because 1) GCED incorporates values of human rights, peace, and social justice in addition to preparing students for an internationally competitive market, and 2) GCED includes a historical-critical position. GCED supports development and assessment of approaches to integrate global perspectives into current teaching practices and thereby broaden students’ frames of interpretation. Characterization of Tibetan Buddhist monastic perceptions of the relevance of science education using surveys and interviews deepens our understanding of the possibilities for such approaches. In preliminary surveys the Dalai Lama’s Tibetan Buddhist monks, who are students in a novel six-year science curriculum taught in their monasteries, reported their science experience, interest levels in learning biology, and perceptions of relevance on a four-point Likert-type scale. 93% of first year students (n=253) reported no to low previous experience with science. 53% of all students (n=775) indicated high interest in learning biology, while fewer students, 36%, believed this experience to be highly relevant to their monastic studies. To better leverage students’ high interest in learning biology, we selected items from the Relevance of Science Education (ROSE) questionnaire for a secondary survey. The ROSE questionnaire was validated in a variety of cultural contexts and the intended use of the original survey aligns with the goals of GCED and the monastic science curriculum. An overall science relevance score of 3.16 ± 0.02 (SEM) was calculated from student responses (n=616) to all survey items using a four-point Likert-type scale indicating low (one) to high (four) relevance. All eight survey items had an average score above 2.5, with “Science and technology will help to eradicate poverty and famine in the world” scoring significantly lower than all other survey items (2.54 ± 0.04; ANOVA, p<0.01). The average score for this item remains constant regardless of the number of years of participation in the science curriculum. Interviews revealed that several factors contributed to the relatively low score for this item including the absolute nature of the term “eradicate”, the idea that correlational evidence does not support this statement, and student acknowledgement that eradication of poverty and famine is a difficult and complex task. These data provide a foundation for building our understanding of science in the context of GCED. As we add to our knowledge of science education beyond the Western classroom we simultaneously enrich our ability to create inclusive learning spaces that broaden students’ worldviews in all places. Student interviews, focus groups, additional surveys, and classroom observations will provide insight into the design of interventions targeted at integrating global perspectives into current teaching practices.

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

Expectancy-value theory posits that students’ expectations for success on a task and their values for a task will influence their motivation and, ultimately, their achievement on a task. Cost is one component of values, but has been understudied compared to intrinsic value, utility value, and attainment value. Additionally, when cost has been examined, it has often been treated as a unidimensional construct, but it was originally theorized to have three dimensions. The goal of this study was to examine two dimensions of cost, task effort cost and emotional cost, and their relationships with student gender and performance on quantitative tasks. Task effort cost refers to the time and effort needed to complete a task, and emotional cost refers to worry or anxiety that would occur when engaging in a task. Specifically, the objectives were to determine (1) whether task effort and emotional costs related to quantitative biology represent two distinguishable dimensions of cost and (2) how gender, task effort
cost, and emotional cost predict performance on a quantitative biology assessment. Introductory biology students completed a survey with modified versions of a task effort and emotional cost scale, and then completed the BioSQuaRE quantitative biology assessment. Confirmatory factor analysis (n = 502) confirmed that task effort and emotional cost are distinguishable as two different dimensions. Multiple regression, including highest math course taken in high school to control for math preparedness, demonstrated that women scored significantly lower on the quantitative biology assessment than men (n = 354, B = -1.16 (0.52), p = 0.03). I therefore tested whether task effort cost and emotional cost mediate the relationship between gender and performance, controlling for math preparedness. Emotional cost, but not task effort cost, differed significantly by gender; women reported greater emotional cost than men (B = 0.67 (0.18), p < 0.001). When emotional cost and gender were included together in a regression model to predict performance, lower emotional cost significantly predicted greater performance (B = -0.49 (0.15), p = 0.001), but performance no longer differed significantly by gender. These results suggest that emotional cost partially mediates the relationship between gender and quantitative biology performance. Therefore, instructional strategies that reduce worry and anxiety about quantitative tasks may be particularly beneficial for female students.

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

Addressing current and future societal needs will require a multidisciplinary approach that focusses on the intersections across natural, built, and human environments and systems. However, the best methods for teaching the skills necessary to foster interdisciplinary thinking and problem solving remain a challenge. Course-based undergraduate research experiences (CUREs) are a way to expand the benefits of scientific inquiry (e.g., retention, interest in science, NASM 2015) to a broader set of students than possible under a traditional mentor-mentee individual relationship (Shortlidge et al., 2017). Here, we implemented a semester-long CURE in a non-majors, general education environmental science course (BIO 111-Science, the Environment, and Sustainability). We measured the effects of conducting original research on student learning outcomes in 2 main areas: scientific literacy and interdisciplinary problem-solving. Students in the course generated hypotheses related to watershed land usage and stream water quality in a local stream, designed experiments related to those hypotheses using both lab experiments (indicator species) and field observation, collected, analyzed, and presented a poster with watershed management recommendations at the campus research day. We assessed scientific literacy using a pre- and post-module application of the “Test of Scientific Literacy Skills” (TOSLS, Gormally et al., 2012). Interdisciplinary thinking was assessed longitudinally through the semester using student-generated concept maps prior to implementation of the project and a final scoring of the poster presentation for thoroughness of disciplinary grounding, cross-disciplinary linkages, and quality of interdisciplinary connections in their final recommendations (see Mueller et al., 2014 for rubric frameworks). Gains in learning and interdisciplinary competencies (as measured by the TOSLS and pre/post project rubric scores) were analyzed using mixed effects models. Preliminary data suggest that students possess some subject-level knowledge (Environmental science, economics, and policy) but lack strength in their ability to make cross-disciplinary connections between concepts. Ongoing data collection and analysis may show gains in interdisciplinary thinking (measured as depth of subject understanding and strength of cross-disciplinary connections) and changes in students’ ability to critically analyze scientific evidence and evaluate arguments.

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

Team-based learning is an effective way to learn in STEM. We examined the relationships of team scores and individual scores and also whether sex or personal strengths affect individual scores or team scores. In the team-based introductory biology course for majors we studied, semester-long teams collaborate daily on in-class
activities, take weekly quizzes, and work on a semester long project. To encourage development of team skills and personal accountability, every week student roles on the team rotate and team members note each other’s contributions. At the end of the semester students peer evaluate teammates’ contributions. We collected data from 357 students in three course sections and analyzed the elements of team scores that distinguished one team from another. To achieve a high degree of diversity in team makeup, we sorted students based on apparent race and sex (from student pictures on course registration lists), honors status, geographic and cultural diversity, and personal strengths. We based geographic and cultural diversity on students’ first language and on where they attended high school, reported on a pre-class survey. Another survey question asked them to identify a personal strength that we matched to the categories or “guilds” (Administrator, Artist, Communicator, or Expeditor) laid out in Wright and Boggs 2003. At the end of the semester, team members indicated who exhibited traits characteristic of each personal strength category. • Individual and team scores were not correlated. • 4% had a lower distinguishing team score than distinguishing individual score. • Men and women had no significant difference in scores. • With the exception of Artist, there were no score differences among personal strength categories. • Peer-evaluation score and team score were not correlated. • Peer-evaluation score and individual score were positively correlated. • Peer-evaluation scores were not different between men and women. • All teams identified individuals who contributed to teamwork according to each personal strength category. • Self-identified personal strength and team-identified personal strength often did not correspond. A wide variety of students can be successful in this course, which emphasizes personal accountability and team skill development. There is no apparent correlation of sex or personal strengths, with individual or team scores. Students can display traits that they might not recognize as one of their primary strengths.

Poster #22

Fear of negative evaluation: A novel construct underlying student anxiety in active learning college science courses

Katelyn M Cooper (Arizona State University)*; Virginia Downing (Arizona State University); Logan Gin (Arizona State University); Sara E Brownell (Arizona State University)  Paper ID: 46

Over the past decade, the prevalence of anxiety has increased among college-aged students and college counseling centers have become increasingly concerned about the negative impact of anxiety on students. College science classrooms have the potential to be especially anxiety-inducing because of the sometimes chilly and competitive environment of the class. Further, college science courses are increasingly being transitioned from traditional lecture to active learning where students take an active role in their learning, often through participating in activities such as clicker questions and group work. Studies have demonstrated that active learning can both increase and decrease student anxiety, however no studies have thoroughly explored why active learning affects student anxiety. In two exploratory studies we interviewed over 50 students enrolled in large-enrollment active learning college science courses at an R1 institution and over 40 students enrolled in small-enrollment active learning college science courses at a community college. In the interviews, we investigated elements of active learning college science courses that increase and decrease student anxiety. We identified fear of negative evaluation, or a student’s sense of dread of being negatively evaluated in a social situation, as the major factor underlying student anxiety in active learning college science courses. Fear of negative evaluation has never been explored in science active learning classes. In order to further conceptualize this construct in the context of active learning science courses, we surveyed over 500 students from two large-enrollment active-learning introductory biology courses at an R1 institution about their fear of negative evaluation in active learning biology and interviewed students with low, medium, and high fear of negative evaluation. This interview study is currently being expanded to sample from a variety of large- and small-enrollment active learning courses offered at different types of institutions. Here, we will present our current model of fear of negative evaluation in active learning that we will continue to build upon with the collection of additional data. Together, these three studies shed light on an important construct underlying student anxiety in active learning and provide a novel framework that can be used to further understand student experiences and performance in active learning college science courses.
Poster #23
Examining the Landscape of Anxiety in Introductory Biology Classrooms
Beth Schussler ("University of Tennessee, Knoxville")*; Brianna Reynolds (University of Tennessee, Knoxville)  
Paper ID: 55
Anxiety is increasingly reported by college students. The Control-Value Theory of Achievement Emotions suggests that anxiety arises from student appraisals of task value and perception of control, and influences achievement. Students have anxiety towards both formative and summative classroom assessments, but what remains unexplored is the extent to which these anxieties vary spatially in classrooms. Given that engagement and performance are higher in the front of classrooms, we predicted anxiety may also be higher here. Our research question was: Are there differences in anxiety levels among students who sit in different classroom locations? This study was conducted in spring 2017 in 6 introductory biology classes at a large public university. Five of the classrooms had stadium-style 230-seat rooms with symmetrical entrances; one had 70 seats with one side entrance. In week 4 of the classes, students took an online survey to measure: general, communication, social, and test anxiety, and anxieties toward various active learning pedagogies. They also reported where they preferred to sit. The measures of anxiety were averaged among students who preferred each of nine room locations. These averages were compared via ANOVA with posthoc analysis by Tukey’s HSD. Effect sizes were calculated via eta-squared. The 665 students who completed the survey were mostly freshman, female, and white. There were no differences in general or communication anxiety by room location. The back-left had higher test (p=0.028), clicker (p=0.009), social (p=0.035), and group work (p=0.036) anxiety compared to other locations. The middle-right had higher anxiety for answering questions (p=0.039). The front-middle had higher test anxiety (p=0.041). All effect sizes were between small to medium (0.031-0.038), except clicker anxiety, which had a medium effect size (0.056). In contrast to our prediction, the front row had generally lower anxiety than other areas of the room. Instead, anxiety was concentrated in the back-left of the room. These results suggest a link between seating preferences and anxiety useful for teachers when implementing active learning practices during class. The work also adds to the growing literature on anxiety in introductory biology, once again suggesting that student anxiety is not uniform and differentially impacts students in these classes.

Poster #24
Creating inclusive classroom environments through institutional change towards adopting active learning practices
Kelly M Schmid (Syracuse University)*; Jason Wiles (Syracuse University)  
Paper ID: 149
Ample, robust research has shown that implementing active learning strategies in undergraduate STEM courses, instead of traditional lecture, can foster a more inclusive learning environment. Initiatives to promote such strategies have been increasing in light of the growing evidence of their efficacy. Such initiatives include grants to promote institutional change in the STEM fields towards adopting active learning and other inclusive strategies. Funded by an Inclusive Excellence grant from the Howard Hughes Medical Institute (HHMI), Syracuse University is committed to incorporating active learning strategies into their core large-enrollment courses in the Biology and Chemistry Departments, as well as creating more course-based undergraduate research experiences (CUREs) in these departments. This initiative, titled Collaborative High-Impact Activities in Natural Science Education (CHANCE), provides faculty training and incentive in support of the development and implementation of active learning strategies for core courses and CUREs. Further, it works to ensure that these changes are effective and sustainable. In the first year of this project, we have initiated the process of expanding active learning activities in the first-year, Introductory Biology sequence (BIO 121 and 123) as well as incorporating substantial active learning activities in two of the large-enrollment core courses, Genetics (BIO 326) and Ecology & Evolution (BIO 345), which are required for the Biology major and related programs. Along with professional development for all Biology and Chemistry faculty, in the first year of this project, the five faculty members who teach these gateway courses have been provided with specific training, access to resources, and graduate student support. Well over 1,000 students have been provided active learning strategies in these courses. Newly adopted active learning activities have included thoughtful “clicker” questions paired with small group discussions, problem sets, online simulations, case studies, article analyses, videos with associated assignments, and HHMI BioInteractive materials. We will report on the specific active learning strategies used, which activities were successful in our
courses, and the long-term goals of the project. These are the first outcomes of an institutional initiative to promote an inclusive environment within STEM courses that will be sustained into the future.

**Poster #25**

**Developing a questionnaire measuring university students’ sense of belonging and involvement within their home department**

Melissa R McCartney (Florida International University)*; Eva Knekta (FIU); Kyriaki Chtazikyriakidou (Florida International University)  
Paper ID: 189

Many theories state, and previous research has shown, that a key factor for students’ success include involvement and a sense of belonging or relatedness. However, the majority of these studies have been conducted at the larger level of the university or the smaller level of individual classrooms, leaving departmental engagement mostly overlooked. The aim of this study was to develop an instrument specifically measuring college students’ sense of belonging to and involvement in a university’s department, as well as to collect initial validity evidence supporting the purpose of the instrument. Based on Goodenow’s sense of belonging scale and involvement items assembled from different sources, an instrument targeting college biology students’ sense of belonging to (21 items) and involvement (14 items) in their department was developed. Sense of belonging items include statements such as: “Faculty and staff at the biology department value my opinions,” and “Students in the biology department help each other to succeed.” Involvement items include statements such as During this academic year, it is likely that I will: “participate in undergraduate research (paid or unpaid) in the biology department” or “attend the office hours of a biology faculty member.” The questionnaire was distributed in Spring and Fall 2018 to biology students approximately 3-4 weeks before the end of each semester. In Spring 2018, the survey was completed by over 201 biology majors and 166 non-biology majors. An exploratory factor analysis based on the biology majors dataset indicated a three factor solution; specifically two factors loaded with 6 and 10 sense of belonging items, respectively, and another factor consisting of 13 involvement items. For this initial evaluation of the instrument we used a pattern coefficient cutoff < 0.40 for retention of items and cross-loadings cutoff at 0.30. A confirmatory analysis based on a slightly updated survey and new data collected in Fall 2018 is currently being conducted to further verify the EFA results. The updated survey was completed by 670 biology majors and 160 non-biology majors. Comparisons between biology and non-biology majors will be completed to investigate whether the differences in sense of belonging and involvement items are significantly different or not. This study’s findings will validate the use of the developed instrument for comparing different groups of students’ sense of belonging and involvement in university departments. Examples of how the instrument has been used in several pilot studies will be discussed.

**Poster #26**

**Effect of Using Centralized University Testing Centers on Student Test Anxiety, Performance, and Study Time**

Elizabeth G Bailey (Brigham Young University)*; Josh Payne (Brigham Young University)  
Paper ID: 205

Brigham Young University houses the largest testing center among college universities and has been the forerunner in the use of centralized university testing centers since its dedication in 1925. This makes BYU a perfect university for conducting experimental research on testing center effectiveness and provides the opportunity to inform and educate other universities on testing center use. However, there is currently no research on testing centers and their impact on student test anxiety and performance. In order to determine whether administering course exams in a testing center or in class is a more effective method, we used a quasi-experimental design with two sections of an introductory biology course for non-majors. To examine section equivalence, students in both sections took a pre-survey to assess scientific reasoning skills, testing anxiety, and demographic information. No significant differences were found between the two sections. The two sections of the course shared a course instructor, teaching assistants, course structure, assignments, tests, and in-class activities. The first section took the first three unit exams in the testing center while the other section took the same exams in class. The testing locations were then reversed for the second half of the semester, with the first section taking the last three unit exams and the final exam in class while the second section took the same exams in the testing center. Students took a short survey immediately following each exam which included questions.
about their study habits and the testing anxiety subscale questions from the MSLQ survey (which assesses both cognitive and physiological components of test anxiety). Preliminary results suggest that testing location (in class versus the university testing center) did not have an impact on student exam scores. However, students who would be taking an exam in the testing center spent significantly more time studying for the exam than those who would be taking it in class, and student test anxiety was slightly increased when they took the exam in the testing center. Multiple linear regression will also be performed to investigate more complex interactions between freshman status, testing location, test anxiety, and study time on test scores. Final attitudinal data will also reveal student affect toward centralized testing centers and their use for course exams.

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

Many of the global challenges facing humanity will require a diverse array of scientific approaches and solutions. Yet the workforce in most STEM fields does not represent the broad demographic diversity of the United States, much less the world. In order to retain a greater diversity of students in STEM fields, we need to be more aware of the affects, interests, and motivations students use to succeed in introductory science courses. Using the self-affirmation theoretical framework proposed by Steele and the community cultural wealth framework developed by Yosso and others, this research examines the values and assets students rely upon in their introductory science courses at a mid-size public research university. With an undergraduate population that is 73% first-generation and 60% underrepresented minorities, researchers at this institution are well positioned to investigate best practices to increase persistence rates in STEM. This work builds on previous investigations into student self-efficacy in an introductory biology course. In this study, researchers measured student values with a writing exercise at the beginning of the semester, measured student perception of their assets with a cultural wealth survey at mid-semester, and concluded with a survey evaluating student sense of belonging at the end of the semester. Coding the student values affirmation data has revealed that the most important values to these students are their relationships with family and learning or gaining knowledge. Students rated the cultural wealth assets of family, navigational and resistance as their strongest personal resources, with 84-88% of students agreed or strongly agreed with statements corresponding to these assets. Students regarded social and aspirational resources slightly lower at 78% and 80%, and their linguistic assets were rated the lowest at 44%. At the end of the semester, 71% of the students agreed that they felt like they belonged to the class community. The values affirmation and the cultural wealth assets align on several aspects indicating that family and social resources are highly valued in students’ lives. This study seeks to contribute a better understanding of students’ perceived values and assets, in order to determine effective and explicit practices to address and remove barriers and move toward more equitable and inclusive classrooms.

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

As instructors we often ask ourselves what leads to student success. A student’s mindset has shown to be related to his or her motivation, engagement, and effort. As a result, it is likely that students’ mindset affects their study habits and approach to learning, e.g. problem solving skills, and consequently their learning and success. In this study I investigate the relationship between student mindset, their study habits, problem solving strategies and achievement in undergraduate students. I used a self-reflective survey with Likert-scale statements to measure mindset, study habits and problem solving strategies. The survey was taken by 78 students as part of in-class individual midterm reflection activities in an introductory course in Biology at Red Deer College, Canada, during winter 2018. A student’s mindset was investigated using 12 statements such as: “I believe I can eventually get really good at something that I am currently quite bad at”, and “When something is difficult, I get motivated to work hard on it”. Study habits were investigated using 9 statements such as: “I use the learning outcomes as a guide when I study”. Problem solving strategies were investigated using 9 statements such as: “When I answer questions or solve problems I plan my answer before I start writing”. There was a significant correlation between
mindset and study habits ($r=0.496$, $p<0.001$), where students with a high mindset score, i.e. students with a growth mindset, were more likely to respond positively to statements such as “When I study I test my understanding of concepts so that I find out what I know and what I don’t know”. In addition, there was a significant correlation between mindset and problem solving strategies ($0.311$, $p=0.006$), where students with a growth mindset were more likely to “...check their exam answers several times to make sure that they make sense”. While there was no correlation between mindset score and achievement, there was a correlation between study habits and final exam scores ($r=0.293$, $p=0.009$) and final grade ($r=0.304$, $p=0.007$). On the other hand, there was no correlation between problem solving strategies and achievement. This study suggests that a teaching strategy that fosters a growth mindset as well as efficient study skills will increase student success. However, the relationship between students’ self-reported problem solving strategies, their attitudes towards problem solving and success need to be investigated further.

**Poster #29**

**The Dreamcatcher Conference: promoting transfer student success in the biological sciences**

Marina Crowder (University of California, Davis)*  Paper ID: 115

A significant proportion of University of California (UC) students complete lower-division degree requirements at California Community Colleges (CCC). These transfer students, who have increased representation of first-generation, low-income, and underrepresented minorities, have the challenging task of acclimating to a new institution and campus community while entering upper-division courses. There are structures in place to facilitate admission of qualified students from CCCs to the UC system, such as the transfer admission guarantee agreement, however, there is a lack of collaboration in bridging curriculum with little to no opportunities for cross-institutional partnerships that support the transition and success of transfer students. To initiate regional partnerships between stakeholders across the CCC and UC systems, a two-day conference was held to discuss transfer student challenges, instructional and advising practices, and curriculum alignment. Here we present a qualitative analysis of the outcomes from this event with respect to identifying the prominent challenges biology transfer student experience, which include 1) challenges of acclimation post-transfer to faster-paced, more rigorous courses with vastly different assessment structures, 2) lack of social and community integration after transferring; 3) challenges in gaining access to research opportunities; and 4) lack of faculty awareness of curriculum structure and requirements across institutions. Together, these findings identified major challenges biology transfer students experience and revealed gaps in support that institutions, departments, faculty, and advisors can take action on in order to better support transfer student success. Action on each of the key findings requires continued partnership among faculty and advisors across the CCC, CSU, and UC system. In addition, these findings highlight the apparent lack but essential need to build networks and cross-institutional partnerships between stakeholders in order to address the challenges biology transfer students experience along their complex academic paths.

**Poster #30**

**Do I Belong Here? Examining If STEM Support Programs Impact Sense of Belonging Among Undergraduates**

MacKenzie Gray (Portland State University)*; Emma C Goodwin (Portland State University); Suzanne Estes (Portland State University); ERIN E SHORTLIDGE (PORTLAND STATE UNIVERSITY)  Paper ID: 283

National calls have been made to strengthen our nation’s Science, Technology, Engineering, and Math (STEM) workforce by improving preparation and increasing STEM graduation rates. Nearly half of all undergraduate students in our nation are currently attending community colleges. Community-college transfer students may perceive a loss of support and a drop in GPA during their first term post-transfer, elements of what is known as “transfer shock.” Transfer shock can keep already at-risk students from succeeding in STEM. As a part of a new STEM support program aiding three cohorts of high-performing, low-income STEM community-college transfer students, we aim to measure if high-impact STEM support programs can mitigate factors related to transfer-shock and support student sense of belonging. Direct impacts of the STEM transfer-support program are being assessed qualitatively (e.g. focus groups, reflections), and preliminary results for our first cohort indicate strong bonds among the cohort and feelings of success. We used a survey to examine how students supported by this program and other high-impact STEM support programs compared to other STEM students who are not
supported by a program. For the survey development, we used scales published in the literature as well as think-aloud interviews with our students to ultimately measure: science self-efficacy, scientific identity, scientific values, STEM involvement, and sense of belonging. The survey was disseminated to students in Fall 2018 and will be repeated in Spring 2019. Initial survey results (n=933) allow us to compare traditional four-year students (n=291) and community college transfer students (n=398). We will also compare student responses for students supported (n=93) or unsupported (n=840) by high-impact STEM support programs. Participants were asked to self-report the group or department that they thought of when responding to sense of belonging questions. Preliminary results indicate that students supported by high-impact STEM programs are reporting a significantly higher sense of belonging, both at PSU (p < 0.05) and in self-reported STEM groups (p < 0.01), compared to unsupported students. Efforts by high-impact STEM programs to improve student experiences academically, financially, and particularly socially, may ultimately lead to a new cohort of graduates and STEM workers who do feel as if they belong in STEM.

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

In recent years, there have been repeated national calls to increase the diversity of the American workforce, particularly in STEM disciplines. For this, it is necessary to increase retention and success of undergraduates from underrepresented minority groups pursuing STEM majors. A sense of belonging to a classroom and community of practice has been shown to play a key role in promoting student retention and graduation. However, there is no consensus as to what practices are more effective in promoting inclusiveness in the classroom, nor validated tools to assess inclusiveness. Furthermore, the definition of inclusiveness varies depending on context, with definitions differing even when comparing K–12 and higher ed. The purpose of this study was to collect student perspectives on inclusiveness across various disciplines to identify different student-driven themes or categories that contribute to the achievement of an inclusive classroom. Students (n=200) were asked an open ended question about their perception of inclusiveness in college classrooms and their answers were coded using a grounded theory approach to identify 5 overarching themes: Classroom climate, Instructional Structure, Equity, Instructor Immediacy, Diversity of student body. Several of these themes were themselves divided into sub-themes, to better organize student perspectives. The frequency of occurrence of the different categories was calculated to try to assess the relative importance of these different aspects of classroom activities/characteristic to students’ feelings of inclusiveness. The poster will present this initial coding structure as well as example of student responses for both a STEM and a non-STEM course.

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

In environmental science courses, students encounter evidence and narratives that we face major environmental problems that we, as individuals and societies, are responsible for. Narratives of human-caused environmental harm such as climate change that are near-unanimous among practicing scientists and accepted with concern and caring by many students are denied by many other students. I hypothesize that these alternative outcomes – acceptance or denial – hinge on whether painful truths of our environmental impacts are met with compassion or judgement. A compassionate view, including an understanding of the historical and cultural factors that have shaped our harmful actions, can allow us to meet emotional pain, grieve for harm, and see ways in which we can contribute to positive change. In contrast, a judging view results in shame that adds emotional pain and leads us to deflect away from the pain by denying the issue or our responsibility, resulting in hopelessness and cynicism. I am testing whether empathy and compassion training, emerging from the fields of social and emotional learning and contemplative pedagogy, can increase acceptance of controversial scientific conclusions as well as agency and caring around these issues. Increasing compassion entails transforming understanding of oneself and one’s relationships to the world, and falls within the burgeoning fields of transformative learning and relational values. Doing so in the context of environmental issues falls within feminist environmentalism. First, in summer
2019 I will examine whether a single-section environmental science course I teach including compassion training affects acceptance, caring and agency around controversial scientific topics in a population that is particularly diverse in age and ethnicity by comparing pre- and post-course surveys of a) compassion and b) acceptence, caring and agency. Second, to separate the role of compassion training from environmental content, I will collaborate on a larger four-section environmental science course to add compassion training to just two of the four sections. I will test for larger increases in metrics of a) compassion and b) acceptance, caring and agency in the two sections receiving compassion training. I will report results from the pre-course survey for the single-section study, and welcome input or collaboration on the expanded multi-section study. This work will address the question of whether relatively stable relational values such as compassion can be transformed in adults by training during a college course and whether this impacts acceptance of biological content and caring and agency around associated environmental issues. If compassion training does increase these metrics, it will be a valuable tool in advancing biology and environment education and environmental sustainability.

**Poster #33**

**Figure of the Day: An Enjoyable Classroom Activity that Improves Students' Figure Creation Skills**

Caitlin Kirby (Michigan State University)*; Peter J.T. White (Michigan State University); Arietta Fleming-Davies (University of San Diego) Paper ID: 102

Creating and interpreting visual displays of data is an important component of quantitative and scientific literacy, and is a particularly important skill for students pursuing science careers. To encourage the development of undergraduate biology students’ figure creation skills, we implemented a figure-analysis activity called “Figure of the Day” (FotD). Introductory biology laboratory courses were divided into treatment (n=81) and control (n=82) sections. In the treatment FotD activity, instructors facilitated students’ interpretation of figures with contextual information missing (e.g. titles, labels, legends). In the control FotD activity, instructors guided students’ interpretation of figures with no contextual information missing. Students completed pre- and post- assessments where they created a figure representation of a given data table, with resulting figures scored on their completion and accuracy. Data analysis included quantitative measures of students’ figure creation abilities and qualitative measures of students’ perceptions of the activity. Students made significant gains in their figure creation abilities with a Wilcoxon Signed-Rank test showing large effect sizes, r, in both the treatment (r=0.708) and control (r=0.688). Student self-assessment showed that they enjoyed the FotD treatment activity and associated it with improved figure interpretation and creation skills. These results suggest that regular interaction with figures in the style of the FotD activity can improve student figure creation skills in a meaningful and enjoyable way.

**Poster #35**

**Knowledge of learning makes a difference: a comparison of metacognitive regulation in introductory and senior-level biology students**

Julie Dangremond Stanton (University of Georgia)*; Kathryn Morris Dye (South Georgia State College); Me'Shae Johnson (University of Georgia) Paper ID: 166

Metacognitive regulation is how you control your thinking in order to learn. Students with strong metacognitive skills are positioned to learn more and perform better than peers who are not metacognitive. Metacognition can contribute to undergraduate success in biology majors, but many first-year students have not yet developed these skills. We conducted a cross-sectional study to examine how metacognition might develop in undergraduates at a public doctoral university. Specifically, we asked how introductory biology students (n=141) and senior-level biology students (n=174) compare in their use of the metacognitive regulation skill of evaluation. Evaluation is the ability to appraise the effectiveness of an individual learning strategy or an overall study plan. Data were collected using an exam self-evaluation assignment with 12 open-ended questions designed to measure metacognitive regulation skills. Magnitude coding was used to label the degree to which student answers provided evidence of evaluation (i.e., codes of sufficient evidence, moderate evidence, or insufficient evidence). The three-level magnitude coding provided categorical data that were analyzed using 2 x 3 chi-square tests of independence. We found that introductory and senior students did not differ in their ability to evaluate the individual learning strategies they used that were effective (p=0.29). They also did not differ in their ability to evaluate the individual
learning strategies they used that were not effective (p=0.93). Yet senior-level students were better at evaluating their overall study plans than introductory students (p<0.01). Descriptive and pattern coding were used to examine the reasoning behind students’ evaluations. We found that senior-level students used their knowledge of how people learn to evaluate effective strategies, whereas introductory students considered how well a strategy aligns with the exam to determine its effectiveness. Senior-level students evaluated the way they used ineffective strategies and considered modifying their use to improve their learning, whereas introductory students abandoned strategies they evaluated as ineffective. Many students in both groups used exam performance to evaluate their study plans, rather than their own internal appraisals. When evaluating, some students from both groups used their feelings of confidence or preparedness as a proxy for metacognition. These data reveal differences between introductory and senior students, which suggest ways metacognition might develop over time. We contextualize our findings using research from cognitive science and offer suggestions for instructors based on our results.

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

Participation and success in the classroom directly influence a student’s sense of belonging in their field of study. Previous research has shown that there are gendered gaps in achievement as well as participation in STEM fields. However, the explanation for this phenomenon is complex and warrants further investigation. Research suggests that stereotype threat activation, females’ experiences with peers and faculty, availability of helpful role models, and other factors can all influence these gender gaps, but explanations may vary for different STEM fields and different student populations. Previously, our lab examined female participation and performance in bioinformatics classes at a large religious university. Bioinformatics is a younger interdisciplinary field that combines methods of computer science (a more quantitative STEM field with large gender gaps in favor of males) to understand and solve problems in biology (a STEM field with large female representation in terms of undergraduate enrollment), so we predicted that bioinformatics gender gaps would be larger than those in biology but smaller than those in computer science. Our research found that gender gaps in participation and performance varied greatly by class, especially since some bioinformatics courses were housed in the biology department and some in the computer science department. Because results were so class-specific and not easily predicted by obvious classroom characteristics, this qualitative study aims to use semi-structured interviews of female bioinformatics students to better understand why these females do or do not participate and what impacts their academic success in these different courses. The interviews include questions about students’ sense of belonging in their bioinformatics classes, factors that influence their participation in class, environments that foster academic success, and their perception of their performance in comparison with their peers. Interviews will be analyzed using inductive thematic analysis to discover new ideas about the experiences of female bioinformatics students in a conservative, religious population. These results will eventually inform the design and implementation of interventions to increase the success and sense of belonging of these female students in this interdisciplinary field.

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

Elementary education majors who become teachers will have a significant influence on student learning. Once in the classroom, teacher beliefs and attitudes can affect their teaching practices including which subject are included and how subjects are taught. This is of particular importance for science disciplines as teachers can often have negative attitudes towards science which can lead to a tendency to avoid teaching these subjects. Although, examining in-service teachers is valuable, elementary education majors provide a unique and important population that allows for the examination of attitudes and beliefs towards science prior to entering into their profession. The aim of this study is to examine elementary education students’ views of biology and the importance of teaching biology in their future classrooms. This study was conducted in an upper-level biology course designed specifically for this population. This course models effective teaching practices, is primarily project- or lab-based and often inquiry in nature. Students complete this course before being accepted into the
teaching program and is their only biology requirement. Students completed a survey following a pre-/post-test design. The survey included the CLASS-Bio and questions designed to elicit the importance students place on teaching and time planned to teach biology compared to other subjects. There were significant improvements in overall favorable responses ($\chi^2 [2, N=1705]=52.900, p<0.0001$) and for individual categories on the CLASS-Bio. Enjoyment had the lowest favorable response rate on the pre- and post-test but exhibited the largest gain. Enjoyment also had a significant relationship with how students ranked the importance of biology on the post-test ($F_2, 26=5.8328, p=0.0086$). The importance placed on teaching biology in future classrooms also increased ($\chi^2 [2, N=55]=11.314, p=0.0101$) from the pre- to post-test. Students who held higher favorable views on the CLASS-Bio placed a higher importance on teaching biology on the post-test ($F_2, 26=9.1421, p<0.0004$). By understanding attitudes and beliefs prior to students becoming in-service teachers, instructors have an opportunity to help facilitate positive views of science that have the potential to impact future classrooms. This study not only provides insight into the views elementary education majors hold regarding teaching biology but also the attitudes or beliefs that can impact their development.

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

Not all students who start at a 4-year university successfully graduate, particularly in STEM disciplines. It is reasonable to predict that students who arrive with study strategies that have been shown to increase learning will get higher grades in their first university courses than students who arrive with less effective study strategies. The current paradigm is that retrieval practice (such as testing oneself or using flash cards) is more effective than re-reading. Also, spacing of studying has been shown to produce more long-term learning than cramming before an exam. Most surveys of university students that ask about evidence-based study strategies are limited to single courses (usually Psychology) and do not use demographic and institutional data as part of the analysis. In this study, we surveyed over 2200 incoming first-year students in nine large introductory lecture courses on their most-used study strategies. Our research questions were: 1) do students of different demographic characteristics tend to use evidence-based study strategies at the same frequencies, 2) are the evidence-based study strategies correlated with increased course grades when holding student preparation variables constant, and 3) do successful study strategies differ in STEM versus non-STEM courses. We used a linear mixed model to control for demographic and course variables with study strategies. Our results indicate that women and URM students do choose different study strategies than men and majority students. Two study strategies do show a significant relationship with higher course grades, and this relationship is mediated by whether the course is a STEM course.

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

There is growing evidence that active learning in flipped classrooms can increase student engagement. Traditional lecture-based teaching (TT) was compared with that of flipped teaching (FT) in a 400-level course titled Biology of Cardiovascular and Metabolic Diseases, for majors in the Exercise Science program. Since class met three times per week, the first FT approach was to flip every single session (FT3X). Students expressed that they were overwhelmed with the FT3X approach as it consisted of three quizzes, three group activities, and three sets of lectures to prepare during each week. The exam grades between TT and FT3X were compared. However, students’ grades between the two teaching approaches were not significantly different. In the second version of FT, the three flipped sessions were consolidated into one by assigning the week’s lecture as one bundle for students to prepare, and complete one quiz, and one group activity per week (FT1X). This new course design also had a built-in study time by having one of the three sessions as optional where there was no quiz and no group activity but a review of the content that was already assigned. Students had the option of attending this review class or using the class time as dedicated preparation time. When the exam grades were compared with that of TT, the student scores were significantly higher with the FT1X format in the first two exams. Further modification of
the course was considered where retrieval strategy was combined with FT1X. In order to learn if retrieval practice combined with FT1X (FT1X-RP) would increase student performance further, students were given weekly quizzes in class where they were not allowed to use any resources. In the FT1X format, students completed an online quiz where their access to content was not monitored. Similarly, the in-class group activity was expected to be completed without using any resources in the FT1X-RP teaching method unlike in the FT1X format where students could access their computers and/or notes. The FT1X-RP helped students perform significantly better in the first two exams but not in their third exam. However, when all three exam scores were combined and compared with TT, student performance was significantly greater in both FT1X and FT1X-RP (p<0.0001). This suggests that FT1X and FT1X-RP are better than TT as both increased student performance compared to TT. The retrieval strategy, however, is expected to help students recall information and thus retain information.

**Poster #40**

**Preventing Student Procrastination Via Positive Reinforcement**

Carlos Rojo (San Jose City College)*  Paper ID: 16

Procrastination is an irrational, self-defeating strategy. Despite the fact that most students want to overcome their procrastination and despite being reminded of the negative consequences by their instructors, procrastination continues to be an overwhelming obstacle for many students. How, then, can instructors effectively help students alter this behavior and reduce the extent to which they procrastinate? While there has been work towards understanding the basis and psychology of procrastination, simple yet effective strategies to counter student procrastination have remained elusive. This study investigates the value of positive reinforcement as a tool to motivate action (as opposed to the common strategy of highlighting the negative consequences of inaction, such as failing an exam). Towards this end, we surveyed the daily study habits of a diverse population of physiology students at a community college and assess whether positive reinforcement can help alter the likelihood of student procrastination. 58 students across two physiology sections completed a daily online survey, reporting if they studied at least 20 minutes that day (students were not penalized if they reported not studying, encouraging honest submissions). For those who reported not studying they also stated if it was due to procrastination or conflicting factors like other work, personal, or academic responsibilities. These reports provide a more thorough view into the study habits of students throughout the semester, and reveal trends:

- procrastination is very common (our data show that it is the 2nd most cited reason for students not studying with 29% of the students revealing it was the primary factor) and procrastination dramatically decreases in the 2-3 days before an exam (with 95% of students in these sections studying daily in the lead up to the exam, revealing that students can overcome the urge not to study if given sufficient motivation). With this data in hand, we implement a simple, positive reinforcement-based strategy and assess whether it alters studying behavior. While all students continue to report daily, at the midway point of the semester students in one of the sections (n=30) begin to receive a daily summary email report showing them the percentage of their classmates in their section who studied that day. Students in the other section do not receive a summary report but continue to report their behavior daily. While studies have shown that this sort of immediate, positive, and daily feedback induces behavior change in a variety of settings, it is unclear if it also influences student procrastination. Our hypothesis is that students who receive daily summary reports will be more motivated to make changes in their procrastination, motivated by the desire to see the report improve daily. Results of the comparison of these two course sections, upon completion of the spring 2019 semester, will be presented.

**Poster #41**

**Can video introductions from authors can enhance student understanding of primary scientific literature?**

Melissa R McCartney (Florida International University)*; Kiana Kasmai (Florida International University)  Paper ID: 19

Introduction: Primary scientific literature (PSL) is a source of information of current research. Most universities don’t require students to read PSL; this is especially true for non-science majors. Our lab is interested in developing new strategies for increasing student interest in reading PSL. This study investigates whether students would be interested in seeing a short video interview of the author of the paper, and if so, what would students like to hear
the author say? Methods: Two groups of students were tested; one group of biology majors (n=360) and another group of non-biology majors (n=20). Students read a selected annotated PSL article and then completed a questionnaire asking students about their response to annotated PSL and what, if any, other learning styles could help them engage better with PSL. Quantitative and qualitative research methods were chosen as a way to further understand how participants would want to incorporate other study techniques such as audio or visual aids. Results: Both biology and non-biology majors prefer visual learning styles (72% biology and 80% non-biology). Verbal learning styles were also somewhat preferred (43% for biology and 65% for non-biology). Students were asked “if you could ask the author of your paper one question, what would it be?” Qualitative analysis indicated that student responses fell into six major categories: 1) experimental design, 2) future outcomes of the research, 3) career progression, 4) Advice column, 5) research interest, and 6) general summary. Conclusion: Based on these data, I will develop short author interviews that (1) aid in the explanation of the research and (2) put a face to the research. I predict that having additional information from the authors can be beneficial for all students as they read PSL. The additional clarification would aid both students that wish to pursue science and students that wish to better understand the world around them.

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

Flipped teaching (FT) has a growing body of evidence showing improvement on student performance as compared to traditional lecture in higher education. There is limited evidence on FT effectiveness at community colleges, especially in STEM. We compared the performance and attitudes of 62 students in an Introduction to Human Anatomy class with 25% flipped and 75% traditional lectures. These 62 students came from 2 classes. The first class, with 30 students, had FT on the Nervous System while the rest were in traditional lecture format. The second class had FT on the Digestive, Endocrine, Reproductive, and Urinary Systems while the rest were in traditional lecture format. Different topics were flipped in both classes to minimize the bias that the flipped contents were more difficult than the traditional lecture contents. All students had access to PowerPoint slides with voice annotation and assigned reading. For the flipped portion, students were expected to study on their own before coming to class so they can participate in question and answer discussion and active learning activities during class. For the traditional lecture portion, they were not expected to study prior to class. Pre-class and post-class quizzes, worth 12% of the total grade, were given daily. Comparison of student performance on quizzes showed a slight improvement (5%) in FT and performance on unit exams did not show a significant difference between the FT vs. traditional lecture. More than half, 60%, preferred the traditional lecture over FT and yet, 65% felt participating in the active learning activities were helpful. These findings suggest that although FT may yield stronger student performance in some institutions, it may not be so at community colleges. Barriers to student success with FT in community colleges should be explored in future studies.

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

Participating in undergraduate research is one of the most lucrative activities that a biology student can engage in because of the wide array of benefits that research can provide. While researchers are more likely to persist in science than their peers who do not participate in research, there are still many students who participate in research who do not pursue research-related careers. Studies have demonstrated that the length of a student’s research experience is a positive predictor of persistence in science, but it is unclear what causes students to persist in their research experiences and what factors cause them to leave their experiences prematurely. In this study, we sampled from 26 public research-intensive (R1) universities and surveyed 768 biology students who had participated in a research experience during the academic year. On the survey, students reported whether they had ever considered leaving or left their first undergraduate research experience and their reasons for leaving or considering leaving. We asked all students who had chosen to stay in research what caused them to stay.
Students also answered the extent to which they currently planned to pursue a science-related research career. We used open-coding methods to identify common themes about why students stay in or leave their research experience. We used linear regression to examine the relationship between a student’s intention to pursue a science-related research career and whether they never considered leaving, considered leaving, or left their first undergraduate research experience. We found that students who considered leaving their first research experience were less likely to plan to pursue a research-related career in science compared to students who never considered leaving their first research experience. Additionally, we found that students stay in research because they appreciate aspects of their mentor, their research, or the lab environment and because they perceive they are benefitting from the experience. However, we found that students leave research because of concerns regarding their mentor, their research, or lab environment, because they perceive they are not benefitting, due to a personal issue, or because they intend to seek a different research opportunity. This works illustrates the factors that contribute to student decisions to leave undergraduate research, which can be critical experience for undergraduate students.

Poster #44

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

Previous research by others (Schinske et al., 2016) has demonstrated a strong positive impact on biology students’ perceptions of “who does science” and an enhanced sense of personally relating to scientists through the inclusion of ten homework assignments featuring counterstereotypical examples of scientists (“Scientist Spotlight” assignments) in an introductory biology class. The current project seeks to extend the results of previous work by investigating if similar shifts student perceptions can be achieved by incorporating fewer number of similar assignments. To examine this question, four Scientist Spotlight assignments were incorporated in two offerings of a 16-week an undergraduate introductory biology course for health sciences majors (Spring 2017, Spring 2018), and six Scientist Spotlight assignments were incorporated during one offering (Spring 2019). As with the previous study, no explicit instruction regarding scientist stereotypes took place in these classes. At the beginning and end of the class, students were asked to respond to the same prompts used in the original Scientist Spotlight research: a stereotypes prompt, and a paired relatability prompt that consisted of a Likert scale and an open response field: Stereotypes prompt: “Based on what you know now, describe the types of people that do science. If possible, refer to specific scientists and what they tell you about the types of people that do science” Relatability prompt: “I know of one or more important scientist to whom I can personally relate,” followed by a Likert scale including “agree,” “somewhat agree,” “somewhat disagree,” “disagree,” and “I don’t know.” Following the Likert scale: “Please explain your opinion of the statement” The initial results of quantitative analysis of the pre- and post-semester open-ended responses to the two prompts across the three different semesters of implementation, as well as qualitative analysis of the Likert-scale item will be presented and contrasted with the results obtained in previous studies.

Poster #45

**Exploring URM Students’ Preferences for Learning Events Incorporated in Introductory Biology**
Michelle Nugent (NC State University)*; Miriam Ferzli (NC State University)  Paper ID: 126

As institutional diversity continues to improve, it is necessary to also improve persistence of traditionally underrepresented minority (URM) students, particularly those who have historically higher attrition rates in science, technology, engineering, and mathematics (STEM) majors. This includes individuals who belong to one or more of the following categories: transfer student, first-generation college student (FGCS), racial minority, need-based financial aid recipient (NBFA), member of the LGBTQ community, or a student with a disability. Active-learning (AL) is identified as an effective way to strengthen persistence but instructors often face implementation challenges in large-enrollment courses, leaving these courses as more impersonal and less engaging than smaller classes. If students have positive perceptions of AL experiences in the classroom it can impact their level of engagement, motivation, and learning gains. Identifying and understanding which AL strategies are most valued by
URM students can serve to enable educators in providing a more impactful learning experience. In this study, we attempt to investigate which "learning events" URM students find most beneficial in a classroom setting that integrates active learning strategies with traditional lecture-based instruction. Participants were enrolled in an introductory biology course required for life science majors. The study included two sections taught by the same instructor, both of which incorporated AL strategies. One section (250 students) was taught in an auditorium-style lecture hall, and the second section (96 students) was taught in a Student-Centered Active Learning Environment with Upside-Down Pedagogies (SCALE-UP) classroom. Students were asked to complete a survey at the end of the semester to rank 13 “learning events” that had taken place in class from most beneficial to least beneficial. The learning events ranged from traditional listen to the instructor lecture to peer-based interactions such as discussing TopHat questions with peers. Ranking analyses were performed between URM and non-URM groups of students as well as between course sections. For each URM classification, individuals in SCALE-UP ranked activities that involved peer interactions more favorably than their non-URM classmates and the same URM group in the lecture section. However, URM students in lecture typically ranked peer activities less favorably than did their non-URM classmates. Most URM students in SCALE-UP ranked asking peers questions as more beneficial than asking the professor questions, while URM students in the lecture section ranked both of these items among the least important events, with asking peers as less helpful than asking the professor. In many large-enrollment, auditorium-style classrooms, building a sense of classroom community is difficult to achieve. Engaging in peer activities and asking questions during class both lead to improved understanding, but require students to be vulnerable; which can be difficult without a sense of community support. As seen with the URM groups in SCALE-UP, classrooms in which AL tasks occur routinely and require more peer accountability and trust-building result in more positive perceptions. Integrating these community building aspects into traditional lecture halls may be key in improving the learning experience for all students.

**Poster #46**

**A Network for Three Communities Centered on Visualizations for Biology Education**

Susan Keen (UC Davis)*; Gael McGill (Harvard Medical School); Jodie Jenkinson (University of Toronto)  
Paper ID: 129

We are developing a collaborative network centered on visual media used in undergraduate biology education. We seek to connect three groups of people: the scientific research and teaching community, scientific visualization practitioners, and the educational research community. While all three groups contribute to instructional media use, creation, and evaluation, members have limited understanding of each other’s constraints. Media design is a complex process guided by traditions of medical and scientific illustration as well as techniques from animation industries. Research examining the efficacy of educational multimedia has very little bearing or influence on real world practice. Visualization designers working in industry are not generally aware of findings in the educational research domain. Educational researchers have little exposure or access to documentation describing the decision-making process behind the design of scientific visualization. Gaps among three largely siloed communities underscore a need for greater interdisciplinary collaboration. Our ultimate goals are to improve the quality of instructional media (and thereby increase learning outcomes in students), and to support the educational research community with the availability of higher quality research stimuli. Key questions for the network are: How can we document the design and production decisions made during the creation of educational biovisualizations such that instructors who routinely leverage these materials in their classrooms can better select examples to meet their learning objectives? How can instructors communicate intended learning outcomes to designers? How do we create media that will be useful for a range of classrooms and teaching styles? What methodologies should be deployed to assess the impact of these biovisualizations on learning outcomes in the undergraduate biology classrooms? Can we create a community of practice that facilitates connections between educators, as consumers of media, and educational researchers, as analysts of media’s value, to improve assessments? How do we identify, and recruit, others interested in these and related topics to our network? How can we reach young faculty, postdoctorals, and graduate students in order to increase the diversity of practitioners and maximize future impacts on the three fields of interest?
Poster #47
A Qualitative Investigation of Students’ Motivation to Engage in the Critical Experiences Required for Persistence in a Biology Career Path
Ashley A Rowland (University of Colorado - Boulder)*; Katie Franks (University of Colorado at Boulder); Sarah L Eddy (Florida International University); Lisa A Corwin (University of Colorado Boulder)  Paper ID: 74

An undergraduate biology degree track prepares students for a wide variety of careers in diverse fields like ecological conservation, healthcare, or basic research. As such, students are motivated to pursue biology degrees for very different reasons (i.e. a fascination with knowing how living things work vs. helping people or animals). To be competitive for an advanced biology degree and persist in a biology career path, undergraduate students must engage in numerous extracurricular critical experiences such as research or volunteering. However, if a student’s motivations are not aligned with the critical experiences they need, it may affect their engagement in the critical experiences required for persistence. Using Wigfield and Eccles’ (2000) Expectancy-Value Theory (EVT) as a lens for looking at students’ motivations, we aimed to characterize how undergraduate students’ underlying expectations for success, task values, and perceived costs impacted or were impacted by their engagement in critical experiences. We took a phenomenological approach to characterize students’ motivations surrounding critical experiences during their undergraduate tenure. We conducted 40 in-depth, retrospective interviews with undergraduate students that have sought admission to either medical or graduate school. To capture broad perspectives and experiences, we aimed to recruit students of diverse backgrounds (gender, race, ethnicity, socioeconomic status, etc.). We employed an interview technique new to DBER called a LifeGrid, which was validated in medical sociology to reduce recall bias and facilitate a qualitative interview. The LifeGrid was a physical document filled out collaboratively between the interviewer and respondent during the interview, and resulted in detailed timelines rich with students’ descriptions of their engagement in critical experiences. We analyzed the transcribed interviews using a deductive coding scheme based on EVT to elucidate 1) how early and often students who advance to medical and graduate school begin to access critical experiences, 2) how expectations for success, values, and perceived costs impact and are impacted by student engagement in critical experiences, and 3) whether students’ unique identities and backgrounds influence their motivations to engagement in critical experiences. To ensure reliability of our findings, we enacted a team coding protocol in which pairs of coders reached consensus for all coded segments of text and traded a portion of the data with another pair of coders to calculate inter-rater reliability. Substantial reliability was achieved for all EVT codes presented. Preliminary analysis of 30% of the interviews showed that medical school bound students, more often than graduate school bound students, report engaging in critical experiences because they are linked to their identity (attainment value). This often presents as a desire to help people or be someone that serves others. Both medical and graduate school bound students regularly engage in critical experiences because they enjoy them (intrinsic value) or need them to achieve another goal, often this involves the need to list the experience on a resume or application (utility value). Our findings suggest that a critical and holistic look at biology students’ motivations, while also considering their identity, might serve to promote student engagement in the critical experiences that enable persistence along a biology career path.

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

Teaching via highly structured course models, which involves pre-class preparation, in-class active learning, and post-class practice exams, increases student success. Research suggests that more active learning during the first year of classes increases persistence at an institution. Two theories of motivation and learning, interactionalist theory of student departure and self-determination theory, can help explain persistence. Interactionalist theory of student departure suggests that persistence is greater when students are socially integrated. Self-determination theory suggests that persistence is greater when students have autonomous types of motivation and feel like a productive, connected member of their community. Prior research provides evidence that active learning increases both student autonomy and student social integration. Furthermore, active learning, particularly in introductory courses, develops critical thinking skills that are likely to benefit students in future
courses. Despite the extensive data that active learning improves student outcomes in individual courses, there is scant data on the longitudinal outcomes of active learning on persistence in particular majors. In Introductory Biology I at our university, a highly-structured active learning approach significantly improves student success and closes the achievement gap for underrepresented minorities. We hypothesize that active learning in Introductory Biology I also increases success in upper-level classes and persistence in the biology major. Here, we compare data from students in two control semesters with three high structure semesters, all taught by the same instructor. Multiple regression analysis is used to determine the longitudinal effect of active learning in Introductory Biology I on student persistence and final grades in the next two courses in the core sequence for biology majors, Introductory Biology II and Genetics.

Poster #49
“Like a Scientist with Training Wheels:” Students describe their science identities
Cara Gormally (Gallaudet University)*; Rachel Inghram (Gallaudet University); Megan Majocha (Gallaudet University ) Paper ID: 99
For undergraduate students, feeling an affinity with a STEM community is a key factor related to interest and persistence in STEM. Students’ science identities are based on years of patterns of participation, attitudes, expectations toward science learning, and conceptions of science and scientists. In this qualitative study, we interviewed biology majors and non-majors at two institutions, including students who were hearing and Deaf, to better understand the trajectory of science identity development, as well as what factors influence students’ science identity development. The research question and interview guide were used to frame the iterative data analysis process. Following Miles & Huberman (1994), we used comparative tables to analyze interviewees’ responses. During meetings, we discussed coding and classification of responses until reaching agreement. Through this process, patterns and themes emerged. Findings suggest that students’ science identities are strongly related to their conceptions of science and scientists, career goals, and active engagement in doing research, whether in a laboratory class or through a research internship experience. Additionally, students’ personal identities and family backgrounds influence their science identities. Biology majors’ science identities appear to be more cemented toward the end of their undergraduate education. Implications for supporting students’ science identity development in teaching and mentoring are discussed, including challenging stereotypical conceptions of science and scientists and helping students to identify connections with science careers in their communities.

Poster #50
Assessment norms have disparate impacts on under-represented minority and first-generation undergraduates in introductory STEM classes
Shima Salehi (Stanford University), Sehoya Cotner (University of Minnesota), Cissy Ballen (Auburn University)* Paper ID: 7
Despite institutional efforts to promote diversity on college campuses and classrooms, student performance and attrition can still be predicted by categorical descriptors of an individual’s identity in science, technology, engineering, and math (STEM) disciplines. Because college entrance exams (e.g., ACT or SAT) resemble the assessments which determine performance in introductory STEM classes – i.e., multiple choice, high-stakes, timed - and because grades in such classes can be influential in determining students’ educational trajectory, college entrance exams (a coarse proxy for incoming academic preparation) might serve as strong predictors of achievement for students during their first year. This work is embedded in the context of critical pedagogy (CP), an approach to teaching inspired by critical theory. CP relates learning contexts to the social contexts of classrooms, with the ambition of creating more just and equitable classroom environments. While this approach has recently gained momentum, few studies have exclusively pursued research through this lens. We addressed the research question: what variables most strongly explain performance gaps between (1) majority and under-represented minority students (URM), and (2) continuing-college students and first-generation college attendees (FGEN). Our unique dataset spanned two STEM colleges at a large public institution, with disaggregated classroom assessment data (e.g., exam, non-exam, total grade), along with survey data (N = 2,395). The surveys distributed at the end of the semester across introductory courses encompassed psychosocial subscales that were strong candidates likely to impact academic performance in classrooms, such as test anxiety, susceptibility to stereotype
threat, sense of social belonging, and interest in course content. We also possessed students’ incoming entrance exam (ACT) scores, and demographic information. We used mediation analysis to explore the structural relationships between performance, attitudes, and identities among new students in STEM. Our results pointed clearly to incoming preparation (ACT) as the chief culprit in explaining the persistent gaps in performance among those under-represented in STEM. In other words, students’ demographic status (i.e., URM, FGEN) affected exam performance indirectly through incoming preparation. Second, we found that incoming preparation also impacted performance indirectly through its influence on psychosocial factors, which in turn affected performance. Due to the assessment norms of colleges and universities, we show that less academically prepared students were not provided with the opportunity to excel from the very beginning, in introductory science classes. Instead, those who succeeded were students already poised for success because they were more academically prepared. We advocate for increased institutional resources devoted to supplemental instruction, bridge programs, and a reduced reliance on one or few high-stakes exams to assess student performance in large introductory STEM courses. In order to improve persistence in STEM fields it is necessary to track successes and failures at the institutional level and collect data that help explain existing trends.

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

An expanded investment in interdisciplinary research has prompted greater demands to integrate knowledge across disciplinary boundaries, as today’s real-world problems cannot be solved from a single disciplinary perspective. Vision & Change (2011) similarly made interdisciplinary expectations a key competency for undergraduate biology majors by tasking students to “tap” into the interdisciplinary nature of science, including the ability to make connections between social science and STEM fields. However, we are not yet synchronized on the meaning of interdisciplinary science, including the ability to make connections between social science and STEM fields. We are not yet synchronized on the meaning of interdisciplinary science, and it is challenging to assess the level of integration students achieve. Furthermore, there is a gap in knowledge on how best to overcome the sociohistorical and institutional barriers that inhibit integration within STEM and across non-STEM disciplines. These factors collectively make this benchmark difficult to meet and assess. In an effort to forge a unified path forward, we present: (1) a proposed definition of interdisciplinary science derived from the expertise of faculty members and (2) a theoretical framework to guide faculty in designing and assessing curricula that foster students’ interdisciplinary science understanding across all disciplines. We internationally surveyed science faculty (n=184) to construct a working definition of interdisciplinary science. We used thematic analysis to code survey responses into six main themes that faculty identify as intrinsic to interdisciplinary science (IRR>80%): (1) disciplinary knowledge/expertise, (2) different research methods and methodology, (3) integration of two or more disciplines, (4) collaboration, (5) various perspectives and theories, and (6) ability to address problems that cannot be solved by one discipline. We leveraged these proposed elements in conjunction with existing interdisciplinary theoretical constructs from the social sciences and environmental sustainability literature, to build a conceptual model: the Interdisciplinary Science Framework (IDSF). Our framework is comprised of five critical components that can be used to develop and assess interdisciplinary efforts in undergraduate science education: Disciplinary Humility, Disciplinary Grounding, Different Research Methods, Advancement through Integration, and Collaboration across Disciplines. We believe the IDSF will provide a theoretical foundation from which the community can develop learning outcomes, activities, and measurements to help students meet the Vision & Change Core Competency of “tapping into the interdisciplinary nature of science”. On a larger scale, we intend the IDSF to be used as a launch point for educators to begin to address the larger sociohistorical issues impeding integration between STEM and non-STEM disciplines.

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

Understanding evolution is critical to learning biology, but few college instructors take advantage of the body of peer-reviewed literature that can inform evolution teaching and assessment. Here we summarize the peer-reviewed papers on concept inventories – test-based tools to assess student misconceptions and conceptual
learning – focusing on inventories covering evolutionary concepts. We code each instrument based on its format, target audience, and degree of validation, and present an accompanying guide with suggestions for how a college instructor teaching evolution might use these concept inventories in their classroom. In addition, we cross-reference the topics covered in these instruments with a previously published list of the most commonly covered topics in undergraduate evolution classes. This allows us to identify which topics have good coverage across various concept inventories, as well as the areas of evolution that are commonly taught in undergraduate classrooms but do not yet have any relevant published concept inventories. We highlight these topics as areas where future instrument development and research on misconceptions can make a large impact for instructors teaching evolution.

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

In the Fall 2015, I asked a question to my students, whether instead of doing regular lab based activities; they want to do an experiment in the lab. Where we will do the experiments to investigate the effect of a teratogen on the determination and differentiation of the stem cells in to the neurons. We will ask some novel questions and we might be able to present our data in a conference and potentially write a research paper. I also explained to them that if they choose to do so, they will have to spend many extra hours and we will have to come to laboratory at the times not assigned for the lab hours. I provided them the basic information about the embryonic testicular carcinoma cells (P19 cells) and the teratogen –Tributyltin (TBT) that we were going to use for this study. Students were asked to search the relevant literature from about TBT, P19 cells and what is known about the effects of TBT on Neurons. Students were given one week to think about this question. They had to respond to me after a week that if they want to do a research based investigatory lab or they just want to do the regular lab activities. Next week, 92% (11/12) students agreed on participating in the research based laboratory exercise. From the literature survey students found that TBT is as an organotin and consumption of contaminated see food leads to human dietary exposure to Tributyltin. They also discovered that TBT could cross both the blood brain barrier and placenta. After learning the techniques of determination and differentiation of P19 cells in to neurons, students were divided in to four groups. Students were asked to explore the literature to find out the concentration of the TBT to be used, write hypothesis and propose the experiments to test their hypothesis. Oral presentations were also made to discuss their hypothesis and research plans. In the remaining semester, students performed experiments to investigate the effect of lead on the determination and differentiation of P19 cells into neurons. But this was not a smooth process, many students who were athletes could not attend the labs in the evenings and some students had other classes at the time when they were supposed to do the experiments. I had anticipated this is advance, therefore initial grouping was done to make sure that at least one member of the group is there to take care of the experiment at the designated time. Some students did not like this as they had to be there all the time when needed but other students were not present in the lab and also the student who were always present started feeling that they are doing the work for others. The other problem was when everyone in the group was present, because these experiments are conducted under sterile condition in the laminar flow hood, It was not possible to accommodate all the students in the cell culture facility at the same time, therefore at a particular time some students had to wait and watch other students. After completion of the experiments, data were statistically analyzed, interpreted and each group presented their finding in the form of oral presentation. Students also presented their data at college wide research colloquium. Finally every student submitted an individual lab report comprising abstract, introduction, Material methods, results, discussion and reference. After the end of the semester it became very difficult to motivate all the students to participate in writing of the research paper, out of 12 students only 4 students showed interest in writing the research paper and there was a lack of agreement on the sequence of authorship. I repeated the same strategy in the fall of 2016, these students got interested in investigating the teratogenic effects of lead on neuronal development. But this time after showing initial enthusiasm most of the students (54%) did not participate anytime in the lab activities outside the normal laboratory hours. I surveyed these students about their lack of interest, 25% students were engaged in athletics in the evening times and 75% students were not interested in cellular molecular biology experiments. The other major hurdle was scheduling the time for these experiments. I also realized that 100% of the students in the developmental biology class were senior’s and they already had specified their future interests and this was the
main reason for their lack of motivation for doing original course based research. Thus, I decided to introduce the similar experiment to different group of students associated with my Tutorial class of “Proteins structure and function”. We usually have 3-4 students in these tutorials and in the Spring 2017, I had only three students in this class. None of these students were involved in athletics and they were all (100%) motivated to do research in cellular and molecular biology. These students were second year students, and were already exposed to a research-based lab in my introductory cell biology tutorials. Flint water crisis of 2015 made these students interested in investigating the effect of lead toxicity on neuronal development. These students devoted a lot of time in the lab and presented their data in the form of lab report and also presented their data in the college wide science colloquium. In the Spring 2018, I talked to students of new batch about these experiments and research performed by the previous years students. I discussed with these students about the possibilities of further in-depth investigation to understand the mechanism of lead toxicity. After extensive literature review and discussions in the lab these students designed and performed the experiments. These students also presented their data at the college level research colloquium and wrote individual lab reports. Students from both spring 2017 and spring 2018 were highly motivated (100%) to make a carrier in the cellular molecular biology research (40% wanted to pursue MD, Ph.D and 60% wanted to go for Ph.D.). These students coordinated together and were willing to write the research paper based on their results from the lab. These students submitted their research in Journal of Neurotoxicology and Teratology, revised the manuscript and were finally able to publish their research. I surveyed the level of satisfaction from the students of all the four years. From the scale of 1 to 10, average satisfaction for the Fall 2015 was 6.5, Fall 2016 was 4.8 and Spring 2017 was 8.3 and Spring 2018 was 10. Thus the productivity and success of the research-based lab depends on the academic age (First year versus seniors) and the motivation (future plans and research interests) of the students.

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

Calls to transform undergraduate biology education focus on creating authentic learning opportunities that engage students in thinking and reasoning about complex biological systems. Conceptual models are a common tool in science; in undergraduate biology classrooms, these models can promote and reveal students’ understanding of and reasoning about complex biological systems. However, research in chemistry and physics education finds that assessment format can impact the knowledge students retrieve and how they subsequently reason about a problem. We sought to determine if assessment format can impact knowledge retrieval for biology students in the context of evolution by natural selection. Specifically, we characterized the extent to which the knowledge represented in student-generated models was consistent with the knowledge revealed in short essays. We collected data from an introductory biology course for science majors (n=117). Instruction on natural selection included readings, screencasts, and classroom activities; students constructed models and essays throughout the instructional module, receiving peer and instructor-generated feedback. Students completed isomorphic construction tasks at three different times: pre-instructional and post-instructional homework, and the evolution unit exam. Informed by Bishop and Anderson (1990), we coded students’ models and essays for evidence of nine key concepts of natural selection: genetic variation, phenotypic variation, inheritance of genes, genetic control of phenotype, fitness, differential survival, differential reproduction, genotypic changes in a population, and phenotypic population changes. On the post-instructional homework, students included an average of 4.5 key concepts in their models and 4.9 in their essays. Students were more likely to include genetic variation in their models (p=0.05), while genetic inheritance (p=0.001) and phenotypic population change (p=0.01) were more common in essays. Just 8% of students were consistent across the two assessment tasks, including the same core evolutionary ideas in both their model and essay. Analysis of the pre-instructional homework and exam data is ongoing. Students were largely inconsistent in their responses to isomorphic modeling and essay tasks, indicating that assessment format may impact the ideas students retrieve, at least in the context of natural selection. These preliminary results underscore a need to further explore how and to what extent assessment format impacts the knowledge and reasoning students use in undergraduate biology. In addition, as the transformation of undergraduate biology classrooms continues, the nature and format of assessments will also change. It seems
plausible, based on this research and others, that multiple types of assessment are essential to fully capture student understanding of core biological concepts.

**Poster #55**

**Using annotated research articles in the cell biology classroom: increases in scientific literacy, comprehension, and knowledge of scientific techniques**

Mary E Washburn (University of North Georgia)*; Melissa R McCartney (Florida International University); Ryan Shanks (University of North Georgia); Miriam Segura-Totten (University of North Georgia) Paper ID: 54

Reading scientific literature plays a large role in a college student’s education, especially for STEM majors. Scientific literacy skills are integral to students’ ability to read research articles, as these are very technical in nature and introduce unfamiliar methods. Our previous research revealed that, compared to faculty, undergraduates who read an article possess less prior knowledge of scientific methods and experimental design. Additionally, faculty utilize the scientific literacy skills of evaluation and analysis more often than students when reading an article. These results suggest that resources to supplement student knowledge might allow students to better comprehend scientific literature. Based on these findings, we hypothesize that using articles annotated with informational links and videos will lead to increased comprehension of both the data and techniques presented in the article. For this study, we used a suite of four articles annotated through the “Science in the Classroom” initiative. We used a constructivist approach, where students in cell biology classes had to answer a set of thought-provoking questions to build knowledge about the article ahead of time, and they had to analyze and present the article data during the classroom discussion sessions. Students read either the original articles (comparison group, N=71) or annotated versions of those articles (treatment group, N=24). Students then analyzed and discussed these articles in class. We administered quizzes after the discussion of each article to test student knowledge and comprehension. We compared questions that tested student factual and technical knowledge as well as comprehension in the first and final quizzes of the semester. A three-way ANOVA revealed that students in the treatment group had a greater improvement in all categories than students in the comparison group (p = 0.008). Since our work and that of others predicts that analysis of the literature will increase scientific literacy skills, we administered the Test of Scientific Literacy Skills (TOSLS) in a pretest/posttest design to all students. A two-way ANOVA showed a significant increase in scientific literacy of students who had low pretest scores and who used annotated articles compared to low scoring students who used the original articles (p = 0.03). Our results suggest that using annotated articles can improve knowledge, comprehension, and scientific literacy skills in college students.

**Poster #56**

**Data MAKER Biology Framework: Designing across biology, data modeling, and argumentation learning goals**

Anna Grinath (Middle Tennessee State University)*; Seth Jones (Middle Tennessee State University); Casey Whitworth (Middle Tennessee State University); Angela Google (Middle Tennessee State University); Harlee Morphis (Middle Tennessee State University) Paper ID: 63

Problem: Vision and Change inspired deep thinking about how students learn, yet there is a need for researchers to attend to questions of designing for student learning. Our work aims to design undergraduate biology learning experiences that engage students in the conceptual, epistemic, and social domains of science learning. This study addresses the problem of developing and testing a design framework that embodies the multidimensional nature of biological investigation by designing for student learning in three areas: biological concepts, data modeling, and scientific argumentation. Design: In this exploratory design based research project, we developed the first iteration of a design framework, used it to develop a lesson, and studied the lesson in ecologically valid conditions (undergraduate biology classrooms). Data sources included videos and artifacts of student work. Using the analytical approach of conjecture mapping, we developed “humble theories” about context specific relations among designed learning ecologies and changes in student thinking. Analyses: We selected data modeling as the starting point for coordinating these three areas to use literature to sequence increasingly sophisticated data modeling practices. We identified an appropriate data modeling practice for the group of students and then identified a biological context to evoke that practice. The design framework incorporates scientific argumentation.
by designing for students to share, compare, and revise their data modeling approaches and interpretations (arguing to learn) and for students to construct and critique scientific arguments (learning to argue). To test the framework, we designed and studied a lesson in three undergraduate biology lecture classes (300 students total). This lesson focused on the data modeling practice of quantifying biological constructs. We coordinated this practice with the biological context of structure and function relationships by asking: How quickly can a sponge filter seawater? Student groups engaged in argumentation around data collection methods and interpretation and developed scientific arguments to answer the research question. Contribution: This design based research poster presentation contributes our initial conjecture of a design framework that has been tested over three iterations with student artifacts to support its utility to more broadly guide the design of multidimensional student learning opportunities in biology education.

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

Communicating science to a general, non-scientific audience (herein SciComm) is an important scientific skill. Recently, scientific communities have called on scientists across the world to communicate more frequently with the general public across a range of formats and channels. Having students engage in the same practices as scientists is important to foster future generations of scientists and develop a scientifically literate society. Moreover, recent seminal reports have included SciComm as an important scientific practice in which undergraduate students should become competent. Unfortunately, undergraduate science students rarely are provided the opportunity to engage in SciComm. A contributor to the minimal opportunities comes from a lack of a cohesive, theory- and evidence-based framework for guiding students to effectively communicate science to a non-scientific audience and instructors to assess students’ SciComm. We have taken steps to remedy this constraint by synthesizing and adapting relevant frameworks from the literature related to science communication, education, science, and communication. The framework details essential elements (e.g., identification of a suitable and accessible audience) for students to communicate science effectively that are organized into strategic categories that follow the logic of storytelling (i.e., who, why, what, how). We applied this framework in two studies. For the first study, we used the framework to assess how environmental science students engaged in SciComm when given maximum freedom and few instructions on how to do so. The analysis showed that students included on average 8 out of the 13 essential elements of effective SciComm. Themes in how students addressed the elements emerged: the students targeted broad and specific audiences composed of interested adults; most of the students aimed to achieve two communication objectives with increasing knowledge and awareness being the most common; and the students planned and executed remote projects using social media. We used these findings to develop a SciComm project for introductory cell biology students to engage in effective SciComm given specific elements and constraints from the framework. For the second study, we investigated how the SciComm project impacted students’ knowledge and perceptions of SciComm with a post-unit assessment. Students correctly answered 8.8 (SD=2.5) out of 14 questions that applied their knowledge of effective SciComm. Students were better at identifying an appropriate audience than identifying focused and relevant content. Students successfully identified SciComm objectives that were assigned for their projects but not other, equally important, objectives. Students continued to value remote platforms such as social media but many students recognized the value of small, in-person settings. Students reported that the project improved their understanding of the biological content and science communication skills. All students reported that it is important for science to be communicated to a general, non-scientific audience such as the public. This work contributes a novel framework and curricular unit to help undergraduate science students engage in an important scientific practice, communicating science to a non-scientific audience. Furthermore, it provides insight into how students engage in SciComm and the learning outcomes and perceptions of students that result.
Poster #58
Asynchronous Discussions to Engage Students in Scientific Argumentation
Iresha N Jayasinghe (Illinois State University)*; Ranija Turner (Illinois State University); Kristine L Callis-Duehl (East Carolina University); James Wolf (Illinois State University); Rebekka Darner (Illinois State University) Paper ID: 72

Scientific argumentation is a practice of knowledge building which bridges claims and evidence. Online discussion boards are a common way to engage students in scientific argumentation. This study examines scientific argumentation occurring in an asynchronous online discussion board to answer the questions: 1. Does gender composition of discussion groups affect students’ engagement in productive scientific argumentation? 2. To what extent does gender composition of groups engaging in scientific argumentation influence the development of scientific literacy? 3. To what extent does gender composition of discussion groups and the quality of scientific argumentation affect students’ satisfaction with the discussion experience? Participants were recruited from an online introductory biology course taught at a large R2 university in the Midwest United States during the summer of 2018. Assigned discussion groups remained throughout the 6-week course. Groups were assembled according to three gender treatments: all-male (2), all-female (5), mixed-gender (5). Students’ pre-course scientific literacy was measured using 10 items from the Test of Science Literacy Skills (TOSLS). Discussions occurring in week 5 of the course were downloaded, de-identified, and coded using the Assessment of Scientific Argumentation in the Classroom (ASAC) protocol to measure the quality of scientific argumentation. Post-course science literacy was measured using 10 different but matched items from the TOSLS, administered with a survey of students’ satisfaction with their discussion experiences. A one-factor analysis of variance (ANOVA), using group composition to predict ASAC score, was performed to address the first research question. A repeated-measures ANOVA was used to assess the influence of group composition on pre/post-course growth in scientific literacy to answer the second research question. A two-factor ANOVA, using group composition and ASAC scores to predict satisfaction scores, was performed to answer the last research question. Results obtained assist in understanding scientific argumentation in an online environment, particularly how gender composition of groups influences the quality of scientific argumentation and students’ satisfaction with discussion experiences. This study opens doors for novel curricula and improved online science education.

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

Evolution is foundational to biology, yet many college biology students do not accept evolution due to their religious beliefs. More than 60 publications have recommended instructional practices that are considered “culturally competent” to decrease students’ perceived conflict between their religious beliefs and evolution and increase students’ evolution acceptance. However, despite these widespread recommendations for the use of culturally competent practices, almost no studies include pre – post data with comparison groups to isolate the effect of different culturally competent practices on student outcomes. Further, studies have not been conducted beyond single institutions to determine whether any positive effects of culturally competent practices are generalizable. Finally, culturally competent practices and student outcomes such as evolution acceptance are measured differently across studies, making comparisons about the effect of specific instructional practices on evolution education outcomes difficult. In order to fill these gaps in the literature, we have launched a national project to explore the impact of culturally competent evolution education on college biology students. So far we have completed a nationwide pilot study of culturally competent practices on college biology student evolution acceptance, comfort learning evolution, and perceived conflict between religion and evolution. We developed new instruments to measure (1) student comfort while learning evolution, (2) student perceived conflict between their religious beliefs and evolution, and (3) the presence of culturally competent instructional practices in college classrooms where evolution is taught. Instruments were developed and iteratively revised through 25 think aloud interviews. The revised surveys were administered to 2,600 students in 8 college biology courses across the United States as a pilot for a larger study to be conducted in fall 2019 and spring 2020. Preliminary analyses indicated that the new outcome measures perform as expected using both factor and reliability analyses. Descriptive data suggests that the use of culturally competent practices in undergraduate evolution education varied. Surprisingly, ~40% of incoming college biology students did not think all of life shares a common ancestor. Future analyses and
data collections will help to determine if the presence of culturally competent practices leads to better student outcomes in evolution education

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

Recent calls from national organizations emphasize the need to train future scientists in applying discipline-specific knowledge to societal problems. However, evolutionary concepts that are integral in fields at the nexus of biology and design (i.e. biotechnology, agriculture) are often poorly understood by undergraduate students. Of particular difficulty is understanding how evolutionary mechanisms result in adaptive structures with particular functions. A plethora of studies grounded in Self-Determination Theory have demonstrated improved student content knowledge in a variety of STEM classes when learning practices support a person’s psychological need for relatedness (e.g., meaningful student-community connections through service). For example, design-based learning (DBL) utilized in engineering education requires students to develop designs that are relevant to community stakeholders while simultaneously improving student content knowledge. This study leveraged DBL processes to develop novel pedagogical approaches that contextualize evolution in a real-world lens for sustainable design solutions. The goals of this research are to evaluate the extent to which a 1.5 weeklong active learning biomimicry curriculum and paired final project influenced student learning gains when integrated in an undergraduate evolution course. Biomimicry is the emulation of natural adaptive structure-functions to create sustainable human design solutions. While a number of academic articles provide classroom biomimicry activities, this study is one of the first to experimentally investigate differences in student learning utilizing a biomimicry framework. In fall 2018, we employed a pre-, post-test design to assess student responses to open-ended questions within two experimental conditions taught by the same instructor (107 participants). Our control condition was taught species to species comparative analysis while our experimental condition class was taught using a novel biomimicry curricula during classes focused on structure-function. We investigated differences in student learning using two open-ended questions regarding (1) understanding of evolutionary mechanisms’ influencing the structure and function relationships, and (2) understanding of how structure-function information can benefit society. Using open coding to identify students’ correct conceptions and misconceptions, we created rubrics and have graded a subset of student responses. Preliminary analysis based on initial coding of ~20% of responses has revealed improvement in understanding of structure-function relationships for students in both treatments, but slight gains in the treatment condition in the diversity of ways that natural structure-function relationships can benefit society. More analyses are needed to investigate (1) the depth of structure-function understanding based on detailed rubric scores and misconception scores on the Evolution Attitudes and Literacy Survey, and (2) the potential moderating role of science teaching practices that support relatedness (i.e. the biomimicry curricula) on structure-function understanding. Results from this study will elucidate whether biomimicry DBL has the potential to increase students’ understanding of biological structure function relationships while contextualizing biology in a real-world lens for sustainable solutions.

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

Despite over thirty years of research on how to improve evolution acceptance, researchers still do not agree on which variables are important for evolution acceptance. One explanation for the inconsistency in evolution education findings is that researchers measure evolution acceptance differently and this could lead to different research conclusions. Despite widespread concern among researchers about the differential measurement of evolution acceptance, no one has systematically explored how instrument choice can impact research conclusions. In this study, we examined undergraduate evolution acceptance scores from seven different instruments used to measure evolution acceptance. First, we explored the extent to which the evolution acceptance instrument we used determined the relationships we found between evolution acceptance and common predictor variables among 1,526 undergraduates in Arizona. Then we collected data from 102 undergraduates in Colorado and 79
undergraduates in Utah and examined the extent to which evolution acceptance scores were similar across the evolution acceptance instruments in different populations of students and whether the seven evolution acceptance instruments could detect differences in population mean evolution acceptance. Major differences in research findings emerged using different instruments to measure evolution acceptance. Most notably, we found that whether evolution understanding and Nature of Science (NOS) understanding predicted evolution acceptance was dependent on the instrument we used to measure evolution acceptance. Additionally, we found that some instruments detected population mean differences in evolution acceptance while other instruments did not. Given these results, we conclude that the instrument used to measure evolution acceptance leads to different research conclusions. The extent to which variables predicted evolution acceptance and whether mean differences in population level evolution acceptance were detected were dependent on the instrument used to measure acceptance. These results indicate that before researchers are able to determine what predicts evolution acceptance and how to best improve evolution acceptance, researchers must think deeply about how to measure evolution acceptance.

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

An important objective of science classes, which is often left unexplored, is developing students’ ability to successfully navigate scientific obstacles. This vital skill is considered a hallmark of the scientific disposition which has been hypothesized to increase students’ persistence in STEM. Recently, there has been increased interest in investigating how various non-cognitive factors (e.g. fear of failure, coping behaviors, and mindset) affect this ability to navigate scientific obstacles in undergraduate STEM contexts. This proposed research line faces a challenge insomuch as many of the frequently used assessment measures developed for these factors --e.g., the Performance Failure Assessment Inventory (PFAI), the Brief COPE, and the Dweck Mindset Inventory--have been developed or standardized in contexts outside of undergraduate STEM samples. Despite the fact that these measures are based on vetted theoretical frameworks in educational psychology, they might not accurately assess levels of non-cognitive factors in STEM students. In order to reliably and accurately investigate proposed intervention effects, it is critical that researchers use forms of these measures that are valid for the desired undergraduate STEM samples. The purpose of this study was to validate existing measures of fear of failure, coping behaviors, and mindset in a STEM undergraduate sample and to create modified versions of these scales if current models were found to be ill-fitting. 235 students participated in this study over the spring and summer 2018 semesters. All students were enrolled in STEM courses across the United States. 44% of subjects described themselves as Biology majors, with 70% reporting some STEM major. The sample was also majority Caucasian (82%) non-Hispanic/Latinx (86%) females (68%). Students were randomly assigned to complete one of two forms of our questionnaire via Qualtrics. One version of the survey presented items from the non-cognitive assessments as they currently exist. The second form of the online survey included modified versions of the existing measure questions which had been altered to specifically cue students to consider their performance in a STEM context when responding. Patterns of missingness in our data were created as part of our planned missingness design and therefore are missing completely at random (MCAR), as confirmed by Little’s MCAR Test (Little, 1988; \( \chi^2 \) (256) = 127, \( p > .05 \)) Thus, missing values were imputed with five iterations and the imputed dataset was used for all further analyses. This allowed us to analyze responses for both the general and STEM-specific items for all individuals, regardless of which form they had been randomly assigned to answer. Multiple factor analyses conducted in MPlus v. 8.2 investigated the item models proposed by current literature, as well as modified models derived by investigating model fit statistics, Beta weights and factors loadings in MPlus output. Data analysis of results for the PFAI ultimately resulted in the removal of 5 items from Conroy’s model of fear of failure. In addition, we found that the STEM-specific versions of the questions demonstrate a better fit than the more general forms of the questions. Differences on students’ mean PFAI scores using the traditional vs. our modified scale compositions support the idea that researchers may significantly misrepresent levels of noncognitive factors if they use measures which have not been validated in STEM undergraduate samples to assess intervention effects in those samples. Results from this sample on the coping behaviors and mindset measures are currently being analyzed.
and will be discussed as a part of this presentation. Implications for the measurement of non-cognitive factors related to students ability to navigate scientific obstacles will be discussed and broader implications for discipline based education research measurement will be considered.

**Poster #63**
The Five Core Concepts in Biology (5CCs) in the classroom: Developing Assessment Tools for Student Understanding of the 5CCs
Kyriaki Chatzikyriakidou (*); Melissa R McCartney (Florida International University)  
Paper ID: 124
Although college biology students usually excel in knowing facts about different biological principles, they struggle with connecting the various facts to specific principles. A good place to start educating undergraduate students about the holistic picture of biology is the Five Core Concepts in Biology (5CCs) discussed in the Vison and Change report. The 5CCs framework can be used in class as a comprehensive guide of the various biological principles that may relate to a biological phenomenon or process. In other words, the 5CCs can help students perceive five different but interrelated perspectives of the same biological phenomenon or process. In a discussion-based introductory biology course, students were introduced to the 5CCs and the corresponding biological scales as described in Vision and Change. In this particular course, students often read and analyzed the findings of primary scientific literature (PSL) articles. We incorporated the 5CCs into the course syllabus by adding a 5CCs activity to each PSL reading. Students were provided a blank matrix table with each row containing a core concept (abbreviations: EV, IFES, SF, PTEM, SS) and each column containing the biological scales (molecular/cellular, physiology, population/ecology). Each week of the semester, students were asked to break down the findings of the research paper they read in class into the 5CCs and biological scales by filling in the matrix table. This activity was completed both as homework and in-class assignment, depending on available time. To assess student understanding of the 5CCs, the same matrix task was included in the first and final exams of the course, where students had to fill in the matrix table for a given paper in the first exam and for a paper of their choice for the final exam. The first exam also included open-ended questions asking students to define and/or provide examples of each one of the 5CCs. A deductive qualitative analysis was conducted on the first exam (pre-) and final exam (post-) datasets to compare the quality/complexity of student responses. The deductive analysis was based on the Conceptual Elements provided in Cary and Branchaw, 2017 for each core concept, along with the known biological scale(s). Preliminary analysis (n=32) of the definitions of the 5CCs in the pre-dataset showed that student responses often related to the same 2-3 conceptual elements of each core concept and single scale examples (>50% in physiology scale). Students had the greatest difficulty defining the core concept PTEM, followed by SF. Each student response to the 5CCs definition will be compared to his/her profile in the pre- and post-datasets, to investigate whether any improvement is evident. We hypothesize that complexity will increase in the post-dataset, as students were immersed longer in the 5CCs activity and practiced the breakdown of PSL findings multiple times. By incorporating the 5CCs in instruction, students may be able to see biology as a network of connected ideas, rather than a group of unrelated facts. Data from this study could help biology educators interpret how well students understand the main biological concepts inherent in biological phenomena that we want them to understand.

**Poster #64**
Development of an instrument to assess student ability to select and incorporate scientific evidence from the primary literature in their writing
Kate Hill (Florida State University) (*)  
Paper ID: 132
Student-centered learning with a focus on helping students develop core competencies has become a major focus of post-secondary Biology Education. Lab courses offer a unique opportunity to address several core competencies from Vision and Change (2011) including the abilities to apply the process of science, use quantitative reasoning, and communicate and collaborate with other disciplines. Communicating science involves complex skills such as constructing an argument using data from experiments and evidence from the primary literature. These complex skills should be practiced in classroom and laboratory settings, and students should receive feedback on their ability to search for, select, and incorporate primary literature into their writing. The Association of College and Research Libraries (ACRL) provides a set of standards for information literacy in higher education, many of which
Poster #65
From Fruit Flies to Phalaropes: Textbook Examples of Sexual Selection

Linda Fuselier (University of Louisville Biology Department)*; Kasi Jackson (West Virginia University); Perri Eason (University of Louisville) Paper ID: 133

Textbook examples, or species used as case studies, enhance learning, evoke emotion, and influence perspective. It is well known that novices rely on examples more than the rest of the text to learn novel content. Thus, the species that become “textbook examples” of phenomena have lasting influence on the learner’s perception and understanding of what science is, how it is practiced, and how communities of practitioners produce knowledge. Sexual selection theory has been critiqued for its assumptions about sex roles ever since it was first proposed. Recently, debates in the literature have questioned the foundational work of Bateman that provided the central paradigm for sexual selection theory. Bateman asserted that sex roles were fixed: females were choosy, males, competitive. However, work completed since the 1970’s complicates sexual selection and shows that sex roles are less likely to be fixed than to be variable or flexible and that they are dependent upon social and environmental contexts. In this study, we examined examples showcased in college textbook chapters about sexual selection. We examined a series of editions of a textbook and additional, current textbooks from four different publishers. For each chapter, we recorded the species used as examples, counted the number of sentences associated with the examples, and categorized them as either fixed or variable/flexible sex role portrayal. We asked the following research questions: Do textbooks converge on particular taxa as model systems? Which taxa receive the most attention? Do examples primarily represent fixed or flexible roles for the sexes? Textbooks used only a small number of taxa as examples, in strong contrast to the large number of extant animal taxa; craniates were most common, followed by insects, crustaceans and arachnids. The most common species used were crickets, fiddler crabs, fruit flies and peafowl, followed by elephant seals, humans, stalk-eyed flies and sticklebacks. The number of sentences devoted to the description of fixed sex roles was significantly higher than the number discussing variable or flexible behaviors, both overall and in each textbook. Textbooks converged on only a few taxa as model systems even though recent studies have revealed that many of these taxa do not fit Bateman’s principles. There is the danger that an inaccurate understanding of sexual selection may remain in the learner’s mind.

are supported by research in science education. The ACRL standards include the ability to 1) identify valid sources and recognize potential biases, 2) select relevant sources and make connections between the research question and the primary literature, 3) differentiate between valued information and irrelevant information, 4) integrate relevant information to support an argument, and 5) paraphrase information and properly cite the source. While most students have basic proficiency with search tools to access the primary literature, they often struggle to distinguish which search results directly relate to their research focus. The product of this disconnect is the use of valid primary literature sources with information that is irrelevant to the student’s research question and experiment. To address this challenge, I developed and validated a formative assessment tool designed to address the skills of relating experimental findings to scientific literature and evaluating the quality, both in legitimacy and relevance, of sources used in scientific writing. The assessment was designed for and validated in an undergraduate Biology laboratory class with a focus on experimental design and scientific writing. The laboratory course was selected because scientific writing is a major part of its curriculum. The assessment consisted of multiple-choice, short response, and extended response questions. Two-tiered multiple-choice items incorporated common misconceptions, derived from student interviews, as distractors. Short response questions were developed using insights from student interviews about how students identify key words for online searches of primary literature. Extended response questions were designed to assess a student’s ability to make connections between data and information from a primary literature source. A sample of 203 undergraduate biology students (novices) and 10 graduate students (experts) completed the assessment and responses were scored according to a rubric. The assessment effectively discriminated between experts and novices, and experts had significantly higher scores on the source selection assessment (ANOVA, p<.001). This assessment tool effectively diagnoses common student misconceptions about searching for and selecting appropriate scientific evidence and evaluates their ability to integrate relevant information to support their claim. By utilizing this tool as a formative assessment, instructors can better inform and adapt their instruction to improve student use of evidence and reasoning in their scientific writing.
Poster #66
Test Driving the Conclusion Assessment Rubric (CAR)
Tawnya Cary (Beloit College)*; Michelle A Harris (UW - Madison Biocore Program); Seung Hong (University of Delaware); Yue Yin (University of Illinois at Chicago) Paper ID: 137

Instructors frequently require undergraduate students to communicate logical scientific conclusions based on evidence that students have either collected themselves and/or that they have gathered from previous studies. While these conclusion statements offer instructors and education researchers a rich opportunity to deeply assess higher order reasoning skills, few tools exist to assess students’ ability to logical, evidence-based conclusions. Our initial literature review of tools used to assess students’ ability to make appropriate, data-based conclusions found that 50% of studies described assessment tools that directly measured experimentation performance, but only 1/3 of studies examined conclusion-making skills. To fill in the gap, we created a Conclusion Assessment Rubric (CAR), building on the experimentation competency framework developed by biologists and biology educators (ACE-Bio, 2017). The CAR is designed to render a comprehensive evaluation of learning outcomes integrating key aspects of biological experimentation. We expect that the CAR can be applied to biological experimentation artifacts such as lab reports, course term papers, posters, oral presentations, and capstone summary papers/manuscripts that result from research involving various levels of student autonomy and instructor guidance. In this study, we present feedback from several instructors who pilot tested the CAR among students at five institutions varying in demographic and Carnegie classification. In a survey, we asked them how they used the CAR, if/how well the CAR met their assessment needs, if/how they modified the CAR, and if they intended to continue to use the CAR. We also asked pilot testers to share any modified versions of the CAR they had created. Pilot tester feedback along with evidence from inter-rater reliability tests were used to update the CAR, which we present here. Finally, we discuss future plans for collecting evidence of validity and reliability as we prepare to disseminate the CAR as a flexible and effective assessment tool that can be used to capture and compare students’ learning progression in a course or a program. Pelaez, Nancy; Anderson, Trevor; Gardner, Stephanie M; Yin, Yue; Abraham, Joel K.; Bartlett, Edward; Gormally, Cara; Hill, Jeffrey P; Hoover, Mildred; Hurney, Carol; Long, Tammy; Newman, Dina L.; Sirum, Karen; Stevens, Michael. “The Basic Competencies of Biological Experimentation: Concept-Skill Statements” (2017). PIBERG Instructional Innovation Materials. Paper 4. http://docs.lib.purdue.edu/pibergiim/4

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

Despite near-unanimous consensus among climate scientists, the misconception of substantial scientific disagreement over the reality of human-induced global climate change persists among members of the general public. Within the research literature on climate science, there exists robust work which quantifies and reviews the scientific consensus on human-induced climate change. There is also a great deal of literature that suggests that perceived consensus is a gateway belief to other beliefs about climate change and support for public action. This study evaluated the efficacy of using research literature which quantifies and reviews the scientific consensus on human-induced climate change as a tool for consensus messaging among undergraduates (n = 11) taking an introduction to biological research course at a large, private, research-intensive university in the northeastern U.S. using a mixed methods approach. Outcomes investigated were informed by the Gateway Belief Model and include the potential impact that reading and discussing such research literature may have had on students’ perceptions of the scientific consensus on human-induced climate change among climate scientists, key beliefs about climate change, support for threat-reduction actions and climate policy, and confidence in their ability to communicate the degree of scientific consensus on climate change to others. Wilcoxon signed-rank tests revealed that the consensus messaging was effective at aligning participants’ perceptions with the actual level of scientific consensus around climate change (p = .010) as well as their self-reported confidence in communicating the consensus (p = .005). There was also an overall increase in the degree to which participants were worried about climate change (p = .020) and qualitative evidence of increased acceptance of human-induced climate change after reading and discussing these articles. We conclude that even undergraduates who are biology majors have a substantial
misunderstanding of the scientific consensus on human causation of climate change, which is likely to be consequential to other beliefs about climate change given the literature basis of perceived consensus as a gateway belief. Consensus messaging using scholarly literature is an effective way to improve perceptions of the consensus, and this could be a practical tool for biology instructors—particularly those who teach about the biological ramifications of increasing global climate change.

**Poster #68**

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

In the undergraduate science classroom, case study pedagogy is method of teaching that employs rich narratives to engage students with learning scientific content. Case study pedagogy shows promise as an active learning pedagogy to meet the demands of 21st century biology education initiatives; however, there is a dearth of information on how students learn with case studies. The purpose of this study was to investigate the roles of salient variables that are implicated in learning theories (prior knowledge, situational interest) that support similar pedagogies (problem-based learning) in order to create a conceptual framework for how students learn through case study pedagogy in undergraduate biology classrooms. Using a case study about cell division in a general biology course, a mixed-method, sequential explanatory design was employed to capture quantitative relationships (N=22) between prior knowledge, situational interest, student beliefs about case studies (role of the narrative and pedagogical features), and three learning outcomes (content knowledge (meiosis concept inventory), transfer of knowledge, and beliefs about learning) and to provide explanatory evidence (N=8) about the dimensions of these relationships. Results show that a particular pedagogical move, small group work, moderates the relationship between prior content knowledge and situational interest. Along with increasing their knowledge of meiosis, students who had strong beliefs that the narrative was connected to their learning (role of narrative) had higher achievement on a near transfer of knowledge item (learning outcome) after the case study. In addition, students who had strong beliefs that the pedagogical features were connected to their learning maintained situational interest during the case study. In alignment with learning theory that supports the role of prior knowledge and situational interest in learning, significant relationships were found between prior content knowledge and maintaining situational interest and between maintaining situational interest and learning in this specific, case study learning context. These findings present a conceptual framework for how students learn through case study pedagogy in the undergraduate biology classroom that can serve to further research about case study pedagogy in undergraduate science education. These findings also underscore the idea that case studies can be used in classrooms with stratified levels of prior content knowledge when practitioners attend to specific pedagogical features such as small group work. A conceptual framework for case study pedagogy in science biology classrooms serves to facilitate the improvement of case study pedagogy with regard to evidence-based development of case study teaching materials and training of faculty in case study pedagogy, and ultimately the widespread adoption of the practice in undergraduate science curricula.

**Poster #69**

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

When reasoning about biological systems, learners construct and use mental models. Mental models are qualitative cognitive representations that integrate one’s knowledge base in a domain, and that can be used to generate adequate explanations about context-specific phenomena. While mental models are unobservable, they can be reflected in external representations that learners produce. Student-generated conceptual models are artifacts that can be used in the classroom to reveal learners’ mental models and to influence their progression. The purpose of this study is to evaluate model-based tasks as forms of assessment that instructors can incorporate in course exams to generate evidence of student learning. We collected data in two sections of an introductory biology class for majors (n=240) in which modeling is an overt practice and a learning outcome. On 3 of the 4 course exams, students were required to generate a model of gene expression, each time in the context of a different specific case study. On exam 1, students circled the part of their model that represented transcription, and provided a written explanation of this process. On exams 2 and 4, students created models of how gene
expression in a heterozygous organism produces a phenotype and completed two short-answer items about allele transcription and the organism’s phenotype. We developed coding rubrics for student models, short answers, and explanations, and established inter-rater agreement of at least 85% among 2 raters. All data were coded by two raters, and any discrepancies were discussed to consensus. For preliminary analysis of exam 1 models, we used the scores assigned by instructors. Analyses were aimed at establishing to what extent students’ explanations and short answers were conceptually consistent with their models. For all three exams, we observed a significant degree of consistency across assessment types (exam 1: Chi-Squared, p <.01; exam 2 and 4: McNemar’s test, p<.01). However, we detected two interesting patterns: (a) 68-45% of students were consistently accurate across assessments of the same concepts, whereas about 25-41% of the students provided answers that lacked internal coherence; and, (b) patterns of inconsistency varied across different concepts. Our findings indicate that student-generated models, combined with other forms of assessment that target the same concepts, provide a richer and more nuanced picture of students’ understanding than either assessment alone.

**Poster #70**

**Assessment of a Curriculum Redesign Highlighting Development of Experimental Design Skills**

Victoria Fringer (1996)*; Elijah Farley (University of Minnesota Duluth Department of Chemistry); Jacob W Wainman (University of Minnesota Duluth)

Poster ID: 211

The Vision and Change report includes experimental design as an application of the “Ability to apply the process of science” core competency of undergraduate biology degrees. Traditionally introductory laboratory courses in the Chemistry Department at the University of Minnesota Duluth have been taught using descriptive, step-by-step protocols. While this typical technique has proved to be an efficient and effective way of introducing basic laboratory skills, this sort of laboratory curriculum fails to provide student opportunity to learn and develop experimental design skills. Within this study, the curriculum of a year round introductory General Chemistry course has been updated to place a focus on the development of experimental design skills. To analyze the effectiveness of the curriculum redesign, an instrument aimed at assessing gains in experimental design ability was created. Students in the revised curriculum were asked to complete this assessment at the start and end of the academic year, with a control group of students within a traditionally taught general chemistry course. This assessment contains multiple choice questions to quantify gains in student laboratory skills, and an affective domain section to capture the effects the revised curriculum had on students’ feelings and understanding of laboratory practices. Analysis of these results integrates item analysis approaches along with evaluation of affective domain responses based on a Likert scale. A comparison between the pre- and post-test results lead to a robust collection of data identifying the effectiveness of the curriculum redesign in terms of experimental design skills and student attitudes towards scientific laboratories.

**Poster #71**

**The DNA Illustration Spectrum: The Variety of Ways in which DNA is Represented to Biology Learners**

Dina Newman (Rochester Institute of Technology)*; Hannah Spector (Rochester Institute of Technology); Julia Steele (Rochester Institute of Technology); Emalee Wrightstone (Rochester Institute of Technology); Kate Wright (Rochester Institute of Technology)

Poster ID: 217

DNA can be represented in many ways, each of which is useful for focusing on different aspects of its structure and/or function. Experts can move between these representations with ease, for example, having no trouble keeping in mind the level of sequence similarity of homologous chromosomes and the genetic information contained in them, while visualizing how these giant molecules maneuver during cell division. Students, however, are more likely to consider only one level at a time (chromosomal or molecular or informational) and seem to struggle moving from one level to another. Thus, when presented with a drawing of DNA, they do not have the representational competence to visualize what is not shown. As a first step to understanding the processes by which representational competence is built, we examined the features of figures typically shown to undergraduate students. We identified six levels of representation that are commonly used to illustrate concepts related to DNA processes: 1) chemical, 2) sequence, 3) helix, 4) ladder, 5) box-line, and 6) informational. We then examined 12 biology textbooks (6 introductory, 6 mid-level/advanced) for the types of representations used in figures. The vast
majority of figures (83%) use one or two levels to illustrate the concept. Those that do include multiple levels, typically portray closely related forms together (e.g. sequence, helix and ladder) rather than including levels at opposite ends (e.g. sequence and informational). Even when multiple levels are used in a single figure, they often fail to demonstrate the integration of those levels, though. Certain concepts are typically illustrated only at one or two levels: gene expression with boxes and lines, DNA replication using DNA sequence or ladder, mutation and DNA repair at the sequence level, and evolution at the most abstract level. However, it is feasible to draw each process at any level. Future work will investigate whether students recognize the same concept in different representations.

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

Persistence of socially subordinated minorities in science, technology, engineering, and math (STEM) is a pervasive problem in the United States. These students often feel a decreased sense of belonging and display a lack of engagement in traditional courses that are fact-based rather than inquiry-based, Eurocentric, and abstract. Ladson-Billings described a culturally responsive teaching theory focused on 1) students’ conceptions of self and others; 2) the manner of social interactions; and 3) conceptions of knowledge that is shared, recycled, and constructed rather than static. We piloted a Genes and Genealogy curriculum (G&G) grounded in this theory to teach population genetics and evolution in an introductory biology course at a historically black university. A control section (n=20) had no exposure to G&G. In three other sections, students were taught and assessed on the risks, benefits, and ethics of personalized DNA testing, and then given the option to submit DNA for analysis to 23andMe. One group tested their own DNA (Own DNA, n=51) and one group used results from faculty members (Avatar DNA, n=17). Students in the G&G curriculum used this data to 1) explore their ancestry, 2) compare skin color phenotype to skin color alleles and 3) assess the relationship between European ancestry and Neanderthal DNA. In each inquiry-based module, students designed and tested a hypothesis using the population level class data and created a graph and figure legend. These activities challenged students’ conceptions of self and others by introducing socially-defined in contrast to biological definitions of race. Culturally responsive assessments included art as a mechanism for students to share the information that they learned. Initially, >94% of students stated that the G&G course would 1) be more personally applicable, 2) be more interesting), 3) improve their learning experience, and 4) make them study more. These perceptions remained high, with the exception of studying more, which decreased. Pre-post exams related to general content, evolution and population genetics did not differ between the control and the G&G curriculum; however, student grades were higher in Own DNA (p < 0.05). More students who tested their Own DNA (94%) passed the course (Avatar DNA- 74%, Control -80%). While the impact of G&G on persistence is unknown, these results suggest that personalizing the curriculum increases student engagement and overall course performance.

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

The ability to make informed decisions about socio-scientific issues (SSIs), like the use of genomic editing, is a component of scientific literacy. Grappling with SSIs involves moral reasoning, self-reflection about a moral question, deciding what is right or wrong and coming to a resolution of what ought to be done. Previous studies have found that when students use higher levels of moral reasoning, they are better able to devise and defend solutions. It is therefore important to provide students an opportunity to use their moral reasoning skills in the context of SSIs. Use of CRISPR/Cas9 is a timely SSI because the potential for its use raises many ethical questions. These include the use in germline cells and to create somatic cell enhancements and are of particular social importance. We investigated how college students understand CRISPR and how they draw on moral reasoning to
make decisions about SSIs involving genetic enhancement. Our research questions were: 1) What are common misconceptions about the use of CRISPR? 2) Do students employ moral reasoning to address uses of genome editing technology? If so, what types do they use? 3) Is the use of moral reasoning related to a student’s understanding of basic genetics concepts? There were 453 undergraduate students from 7 classes in this exploratory study. We used qualitative methods to analyze essays and quantitative analysis of concept inventory scores. Students completed the Genetics Concept Assessment (GCA), a validated instrument that is used to measure basic genetics understanding. Students experienced an in-class lesson on CRISPR/Cas9 technology and then completed an assignment which involved reading an article and responding to a writing prompt. The writing prompt asked students to discuss what CRISPR/Cas9 is, argue for or against non-medical human enhancement and describe a societal dilemma about the technology’s use. We used descriptive coding to identify misconceptions about CRISPR. Structural and descriptive coding of essays was used to identify areas of moral reasoning and characterize these as either consequence-based or principle-based. The most commonly held misconceptions about CRISPR included the ease of its use in humans and in general, the lack of consideration of environmental contexts and the origin of the process. Over half of the essays employed moral reasoning and among those approximately half used principle and half consequence-based arguments. The most prominent principle-based arguments included references to human rights and diversity. Human rights principles were emphasized when students argued against the production of designer babies. A large proportion of students expressed the importance of diversity of human traits. The most common consequence-based argument was related to socio-economic status. We categorized essays into three groups: no moral reasoning, principle and consequence-based. Using an ANOVA, we found that there were no differences among reasoning groups in students understanding of basic genetics (GCA scores). Our results suggest that students need more exposure to the use of CRISPR in real contexts. The use of moral reasoning was common and provided insights into students’ values (human rights and diversity). This in turn can be used as a way to draw students into science as a social process and encourage their reasoning about complex issues.

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

While some have argued that abandoning religious belief is the only way to help religious individuals accept evolution, we strongly contend that highlighting faith/evolution compatibility is much more effective. In March of 2019, we ran a Professional Development Event for science teachers from surrounding districts where Dr. John Hawks (co-describer of Homo-Naledi) presented methods for how to teach human evolution to religious students using a science based approach. Since many science teachers in Utah face a highly religious student population, are religious themselves, and have religious education integrated into the school system, we decided to invite religious educators to the event. We ran a one-hour reconciliation session prior to the workshop where we discussed how to approach the intersection between science and religion in a more productive, culturally competent manner. We collected data both before and after the intervention. Surveys were designed and gathered to address the following learning outcomes: (1) Help teachers understand the importance of the conflict between evolution and faith. (2) Clearly state the doctrine of the Church of Jesus Christ of Latter-day Saints (or lack thereof) regarding evolution and highlight how it is compatible with evolutionary science. (3) Use tools to address the perceived conflict in a way that is reconciliatory rather than confrontational. (4) Identify and answer common questions about evolution with human examples. (5) Create lesson plans that are interactive in teaching evolution. (6) Find strategies for translating new discoveries into illustrations of evolutionary principles. Our results showed that teachers generally feel that there is a fair amount of conflict surrounding evolution and religion. Additionally, our results showed that after the intervention, both science and religion educators had greater acceptance of evolution and felt significantly more confident in their ability to help students reconcile the conflict. They also increased in their confidence and comfort in their ability to use human examples of evolution, to teach more interactively, and to find strategies for translating new hominin discoveries into examples of evolutionary principles. Overall, we believe this intervention was a successful way to bring science and religion instructors together toward common ground in our efforts to help students reconcile evolution and religion.
Poster #75  
**Investigation of the Relationship between Intuitive Thinking and Reasoning about Vaccines across Levels of Expertise**  
Melinda T Owens (UC San Diego)*; Erin Nale (San Francisco State University); Jonathon Torres (San Francisco State University); Kristin De Nesnera (Utah Valley University); Kimberly Tanner (San Francisco State University)  
Paper ID: 253

Vaccines are a critical healthcare tool, but many people have misconceptions about them. Previous work has studied vaccine misconceptions in parents and the general public, but there is a lack of research on to what extent our college biology students have such misconceptions. Also, many of these misconceptions appear to be consistent with forms of intuitive reasoning that cognitive psychologists have shown to underlie many different individual misconceptions in biology, yet there is also no research on the extent to which students use intuitive reasoning when thinking about vaccines. Intuitive reasoning includes anthropocentric, teleological, and essentialist thinking. Therefore, in our study, we use the framework of intuitive reasoning to study the extent to which college biology students agree with misconceptions about vaccines and how their beliefs change as they gain biology expertise. Specifically, we ask: To what extent do students with different levels of biology expertise endorse misconceptions about vaccines? To what extent do students with different levels of expertise use intuitive thinking? Is the use of intuitive reasoning correlated with agreement with vaccine misconceptions? Our study used misconception statements related to anthropocentrism, teleology, essentialism, and the relationship between vaccines and autism to investigate and detect intuitive reasoning in written responses by non-majors, entering biology majors, and advanced biology majors, as well as biology faculty, at a large urban comprehensive university. Prompts asked students to agree or disagree with each misconception and explain their response. We tallied and compared the proportion of students who agreed with each misconception and then analyzed a subset of student explanations for intuitive reasoning. Preliminary results show that 91% (185/203) of students agreed with at least one of the four vaccine misconceptions compared to 30% (3/10) of faculty. Only agreement with the essentialism prompt dropped significantly in advanced biology majors (7%, 3/46 agreed) compared to non- (25%, 18/71) or entering (30%, 26/86) biology majors (p<.01 by chi square). Also, 95% (76/80) of all students used intuitive thinking in their explanations. By better understanding how students incorporate intuitive reasoning into their ideas about vaccines, our research has the potential to shape the way vaccines are taught in college biology courses to better inform individuals about public health.

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

In recent years, there have been several calls for high-quality learning experiences in undergraduate STEM education. Classroom assessments create opportunities to explore and foster student thinking, as well as to analyze and transform teaching practices to better support student learning. In particular, formative assessment enables instructors to elicit student thinking, make inferences about student understanding, and take actions that foster student learning. When using evidence-based teaching practices in large-enrollment classrooms, instructors face challenges to facilitate and assess students’ understanding. Our project utilizes a specialized role, Learning Researcher (LR), for 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. They generate daily reports that provide feedback to instructors for subsequent planning and instructional decisions. We have worked with 22 different LRs placed in 19 classrooms from a variety of STEM disciplines, including biology, for over two years. In this qualitative study, we primarily analyzed the LRs’ written reports to characterize their noticing, interpretation, and suggestions about student understanding. Data collection included written daily reports, pre-post interviews, focus groups, observations and audio recordings of LR training. Preliminary analysis indicated that the LRs were able to provide valuable feedback on student understanding. Initially, the LRs adopted an evaluative stance in the
assessment of students’ ideas and their initial reports often lacked focus and evidence about student learning challenges. However, with training and experience, most LRs learned to improve their focus on student thinking and to make sense of student understanding. LRs’ suggestions were specific to tasks and reflected students’ learning needs. At the same time, the LRs found that creating productive suggestions to modify instruction is challenging. We found undergraduate LRs showed great potential as effective collaborators in promoting formative assessment practice for instructors. Overall, the aim of this presentation is two-fold: 1) introduce a novel, sustainable role which is that promotes systematic formative assessment in large STEM classrooms; and 2) create opportunities to engage instructors in reflective formative assessment practice with a focus on student thinking and learning.

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

Research Question Recent reports have called for reform of biology education at the K16 levels, shifting away from mere knowledge of facts and ideas, toward concepts and competencies. A focus on concepts has the advantage of linking facts and ideas - a property of disciplinary expertise. There are many concept inventories that have been developed to probe students’ factual knowledge of biological systems and processes, but only one metric of which we are aware to probe connections among facts, or disciplinary expertise (the Biology Card Sorting Task, BCST; Smith et. al 2013). We asked whether existing, published concept inventories could be used to probe biological concept expertise, similarly to the BCST. Having multiple metrics of learning and expertise available to educators and researchers would add credibility to our community’s work, and could offer flexibility to researchers and educators to tailor their approach to their student populations. Research Design and Analysis We administered both the Biology Concept Inventory (BCI; Garvin-Doxas & Klymkowsky 2008) and the BCST to students in their first semester of college biology courses for majors or non-majors. We compared normalized gains in normative responses for each metric. Consistent with other published results, both instruments showed an average decrease in student conceptual understanding: the non-majors course saw an average normalized loss of -4.28% (SE ± 1.6% ; n = 272) using the BCI and a normalized loss of -18.6% (SE ± 3.44%; n = 165) using the BCST. The majors course showed average normalized losses of -2.53% (SE ± 1.50%; n = 484) using the BCI and -9.47% (SE ± 3.07%; n = 196) using the BCST. Using a Student’s t-test, we determined that the mean differences between the majors and non-majors courses were significant (p = 0.00021 for the non-majors course and p = 0.043 for the majors course). In our short talk, we will present further in-depth analyses that will shed light on the differences between these two well-validated instruments at assessing developing student expertise in biology. Contributions Taken together, our work contributes to two major directions in BER and teaching. First, we show that biological expertise may be evaluated in multiple ways. This expands the number of quantitative tools that can be deployed to probe changes in student biological expertise, depending on researchers’ and instructors’ intentions. Second, our investigations into the nature of expertise probed by the BCI and BSCT provide a powerful new perspective on how existing, vetted tools can illuminate gains in expertise.
Test-Enhanced Learning in Biology Education: a Laboratory study
Bryn St Clair (Brigham Young University)*; Jamie L Jensen (Brigham Young University); Sam Millar (Brigham Young University); Max Putnam (Brigham Young University); Haley Michelsen (Brigham Young University) Paper ID: 191

Test-enhanced learning refers to the finding that the retrieval of information from memory creates more durable learning than re-reading, or re-studying that same information. Also described as the testing effect, retrieval practice, or practice quizzing, a large body of research in the cognitive psychology literature has shown it to be a robust and replicable mechanism of learning. Sufficient evidence has been gathered on the benefits of testing in general, yet an application of the testing effect to specific disciplines of education has less presence in the literature. The goal of our study was to demonstrate the testing effect using authentic university level general biology content. Our previous research has traditionally approached our examination of the testing effect in the authentic biology classroom. In this study, we implemented a laboratory study to reduce the classroom variability on the testing effect using students recruited from a general university biology course but placed in a laboratory setting that is more tightly controlled. We prepared and administered a digitally recorded lecture interspersed with an active learning module that highlighted 5 learning outcomes about the gut microbiome. Subjects were randomly assigned to a treatment group or control. At a second lab session one week later, all subjects reviewed all of the learning outcomes. The treatment group was given a quiz on three of the total five learning outcomes. The control group was given a quiz on all five learning outcomes (n=30 for the treatment and n=41 for the control). Both groups were given immediate feedback on performance. In the final session, one week after the treatment, all groups were administered an exam on all 5 learning outcomes. We measured a small difference (.022) between the tested learning outcomes compared with the untested learning outcomes, and the difference was not significant. (p=.70). Thus, it appears, that in a controlled setting, with high-level Bloom’s items, the testing effect was not strong. Reasons for the lack of significance will be discussed.

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

Effective instruction benefits from curriculum focused on core disciplinary principles. However, these principles are complex and are composed of constituent ideas that are complex and often made up of further sub-ideas. Making these constituent and sub-ideas explicit can be valuable for both instructors and students; knowing the conceptual makeup of a core principle enables one to assess whether students have a complete or correct understanding of that principle. However, core principles are rarely explicitly unpacked in this manner. Conceptual frameworks represent one format for unpacking disciplinary principles into their constituent ideas. We present conceptual frameworks for two core disciplinary principles in Evolutionary Medicine (EvMed): Mismatch and Trade-offs. EvMed is a growing disciplinary area that applies evolutionary tools and lenses to understanding health and disease. Our previous work has identified the most important core principles in EvMed, but this work did not unpack these principles into constituent ideas. We have iteratively developed conceptual frameworks for Mismatch and Trade-offs using two separate committees of faculty members who are experts in EvMed. In addition to presenting these frameworks, we will present on the process of developing conceptual frameworks, including the benefits and pitfalls. These frameworks are tools that can aid instructors interested in teaching or developing curriculum in EvMed. The contents of the frameworks provide guidance for potential learning goals, assessments, and class curriculum. These frameworks may also be a useful guide for students. Given the broader applications of Mismatch and Trade-offs as evolutionary concepts, these frameworks may have applications in other disciplines.
Poster #80
Learning Theories Unleash the Power of CUREs (Course-Based Undergraduate Research Experiences) in REIL (Research Experiences in Introductory Lab) Biology Courses and Boost Student Self Efficacy in Scientific Reasoning and Experimental Design
Cheryl L Berry (Saint Leo University)* Paper ID: 29

This study will discuss the benefit of choosing the most effective theoretical learning framework to apply to instructional methods in the introductory biology laboratory setting and the impact on the undergraduate science student’s skills and self-efficacy in performing scientific investigations based on authentic research experiences. The impact of selecting the most effective learning theory to apply to an instructional approach can be powerful and have a lasting effect on a student’s perception of science and their own scientific abilities throughout their college research experiences. This study will discuss various learning theories and provide the benefits and drawbacks of the application of the theories within the context of biology laboratory instruction. The outcome of this discussion will emphasize the true power of these learning theories is wielded when there is selection of the best traits from each of the theories, and in combination, are used in the CURE (Course-Based Undergraduate Research Experience) in transitioning from cookbook to critical thinking laboratory instruction. CUREs increase student learning gains and self-efficacy in scientific reasoning and experimental design. The effectiveness of the CURE in this study was measured through student completion of the online Student Assessment of Learning Gains Survey (SALG) pre and post course surveys in the introductory science laboratory courses, Principles of Biology I & II during the Fall 2018 term and Spring 2019 term. The Principles of Biology I & II laboratory courses were originally cookbook labs and over the last few years have undergone curriculum changes to embed CUREs, transitioning the lab curriculum from cookbook to critical thinking. Students went from having provided research questions with known outcomes to choosing their own research questions, experimental set up, and assessing original results. Student went from lab workbooks to writing lab reports using scientific literature as evidence to support their claims. The outcome of the survey is expected to answer the questions: What are student perceptions of CUREs (the integration of applicable aspects of multiple learning theories) compared to cookbook labs (limited learning theory application)? Does the student’s perception of their self-efficacy and scientific abilities increase when they experience CUREs? The outcome of this study is expected to add to the growing body of knowledge and research to support a systemic change in how undergraduate biology labs are designed and implemented. CUREs designed under theoretical frameworks have the power to shape a student’s perception of their scientific abilities in introductory biology laboratory courses leading to improved self-efficacy and persistence in science throughout their college research experiences.

Poster #81
Linda L Hensel (Mercer University)* Paper ID: 32

Course-based undergraduate research experiences (CUREs) provide students with authentic research experiences that have long-lasting positive effects on their learning and career choices. Only 25% of CUREs in biology are at the introductory level and even fewer are interdisciplinary. This study addresses that gap by comparing students in a control group with a traditional “cookbook” lab experience (CBLE) with students in an interdisciplinary introductory CURE. Only the laboratory experience differed between the CBLE and CURE sections; instructors, exams, and all course materials were identical. CURE students spent 6-7 hours per week with drug design, synthesis, and testing of potential biofilm inhibitors while CBLE students used the traditional departmental lab packets. Over 300 compounds were synthesized via amide coupling between an amino and carboxylic acid. Students were excited to find 2 of the 10 phenylalanine derivatives and 4 of the 11 tyrosine derivatives specifically inhibited biofilm formation in B. subtilis and S. aureus, respectively. Demographic data, course grade data, anonymous student evaluations, pre- and post-test data, and student reflections regarding their experiences in the program were collected. Students enrolled in the CURE sections performed better on exams and overall; moreover, the number of lower-performing students not continuing in science was reduced substantially (by 45 % for Biology and 93 % for Organic Chemistry). Student responses reveal the increased engagement in the course
material may result from understanding the relevance of the material to “real world” applications. Student evaluations also indicate instructor engagement in CBLE sections appears to be less than in the CURE sections. A most impressive outcome is the large numbers of students that gain an understanding of authentic research and build confidence in their own abilities to participate in research. From 2 to 4.5 times more students in CURE versus CBLE participated in post-CURE undergraduate research. Student responses also indicated that over 90% of the participating students gained an understanding of the discovery and applied natures of research, as well as the authentic frustrations present in authentic research. This study supports the idea that a CURE at the introductory level can enhance student learning and give them the confidence to continue in research at an early stage in their academic career. A scaled-up version has just been completed in hopes that the student gains be expanded to a larger population.

**Poster #82**

**Can Students Build Data Analysis Skills Using Course-Based Research in Introductory Biology?**

Marney Pratt (Smith College)*  Paper ID: 35

Building quantitative skills, particularly related to data analysis, is crucial for undergraduate biology majors to prepare them for a wide variety of careers. In our work to integrate and scaffold research into our curriculum, our department identified building quantitative skills as one of our major learning objectives. However, many students report that they do not feel adequately skilled in data analysis by the time they graduate. There are also concerns from some faculty and students that focusing too much on one course-based research project will not give enough breadth of practice to build necessary skills. The purpose of this study was to assess our introductory biology lab course to see how much students learned data analysis skills over the semester while focusing on one large course-based research project. This course focuses on a semester-long research project that monitors the effect of two invasive insects on eastern hemlock trees. The methods of data collection were developed by the instructor, and students helped collect data to contribute to an ever-growing dataset that includes 5 years of data so far. There are no pre-requisites for the course, but all students were introduced to basic methods of data analysis and then in a group of 2-4 students they were expected to choose their own question that they can address with the dataset. After analyzing the data, the student groups then present their results and write up the results in a paper in the style of a journal manuscript. In the spring of 2019, there were 45 students distributed into 3 sections all taught by the same instructor. Students were given a pre-test at the start of the semester to see what data analysis skills they came into the course with. The average score on the pre-test was 60.9% (the students were not given their scores nor were the answers to the questions discussed). The same students will be given the test again at the end of the semester to see if they have made gains in their data analysis skills. I expect that students will make enough gains to show that using course-based research is an effective way to help students learn basic data analysis skills at the introductory level.

**Poster #83**

**Implementation and Refinement of a Full-length Course-Based Undergraduate Research Experience (CURE) in Microbial Ecology and Molecular Evolution**

Blythe E Janowiak (Saint Louis University)*  Paper ID: 52

Increasing data in the literature has shown that students greatly benefit from participating in authentic individual independent research projects, under the supervision of a faculty member. However, often there are not enough available faculty mentors for this one-on-one authentic individual independent research project approach. I developed a course-based undergraduate research experience (CURE) called Microbial Ecology and Molecular Evolution to help to fulfill that need at my university. I have taught the course to four cohorts so far, modifying and changing it each time I teach it. For each cohort, students worked in groups of 4, and each group crafted their biological research question using the scaffold of determining the biodiversity and organismal activity of soil microbiomes obtained from a particular field site, addressing a larger ecological question (comparison between two conditions in a particular niche). Ecological niches used in the previous cohorts were: 1) native vs non-native plants, 2) well-maintained vs not well-maintained city parks, 3) clay run-off exposed mine tailings vs not exposed, and 4) man-made closed ecosystems made to mimic landfills vs pristine conservation area. Students were given an experimental framework to answer the scaffold questions based on their hypotheses, but then had
to use external resources to design their detailed experimental methods to address their specific hypotheses. Students were allowed to pool data from other students in the course, using the same niche, as needed, to help add support to their hypotheses. As datasets were collected, I guided the students in the analysis and interpretation of those datasets. The students presented their results of the group project as a poster presentation research symposium, that was publically held in our department on the last day of the class. Students presented their work in pairs, while the other pair of the group participated in peer-review, and then the pairs switched roles. I will present summaries of the scaffolds and niches used for each cohort, along with sample student-derived hypotheses that were successfully tested in the CUREs. I will also discuss pre- and post-class surveys that were used to assess the CURE with respect to student perceptions (scientific identity, motivation to continue in biology, scientific skills).

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

Course-based undergraduate research experiences (CUREs) are a pedagogical approach of integrating authentic research experiences into the classroom to engage students while reaching a broad and diverse cohort of students often absent within the traditional apprenticeship model. Although, widely adopted by faculty in the life sciences, reports indicate existing barriers for implementation include necessary technical training, fiscal limitations, time associated with curriculum development, lack of a supportive community, and the ability to dedicate a large percentage of course time to a single project. The Assessing the Prevalence of Antibiotic-Resistance in the Environment (PARE) CURE consortium is designed to address these barriers by providing faculty with a low-cost short-duration authentic research core module based on standard microbiology techniques. Additionally, the PARE community encourages instructors to develop and disseminate expansion modules for the greater PARE community for adoption in classrooms when modules meet course-specific learning objectives. The goal of this study was to test the feasibility of a progressive scale-up model for the development of PARE research expansion modules at a liberal arts college. To achieve this aim, a progressive three-step model was established to develop and pilot novel CURE research modules. (1) Undergraduates, in an independent research setting under the mentorship of a faculty member, developed the conceptual basis for and piloted a preliminary protocol for a novel module, (2) in its second iteration, the module was then tested for the ability to be scaled up in the classroom setting, and (3) the module along with two rounds of pilot data were presented to a group of PARE faculty for further development and packaging using a standardized PARE format prior to distribution to the broader PARE community. Between each progressive segment of the three-step model, the faculty member led a voluntary student focus group to obtain feedback for refining and improving the module prior to further iterations. Student comments and PARE faculty feedback support the notion that a progressive three-step model for module development is a viable means for CURE curriculum development at a liberal arts college. This process could also serve as a prototype for other consortium-based CUREs looking to harness the collective knowledge and resources of diverse communities for rapid module development and dissemination.

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

Research Question: Does inclusion of a new CURE in introductory biology affect students’ understanding and ownership of experimental design and data analysis and/or enhance students’ comfort with complex scientific ideas.  
Introduction: General Biology for Majors students’ lab experiences at St. Philip’s College are a mix of memorization of plant and animal anatomical structures, dissection of specimens, research and presentations of taxa and a few brief student designed activities. To enhance the student designed experiment content, we added a “Bean Beetle Project”, an 8-week project with experiments designed and conducted entirely by the students.  
Research Design: St. Philip’s College has a Student Engagement Grant (SEG) program that is available for faculty to provide funds for students who participate in activities on campus. In Fall 2018 SEG students initiated the ‘Bean
Beetle Project by researching and developing protocols for Callosobruchus maculatus. They replicated experiments then designed and performed their own experiments. They presented posters at the STEM symposium. In Spring 2019, the SEG students described their research to two sections of Biology. The 45 Biology students researched the organism, background materials, designed experiments, and are currently conducting experiments. They will continue to their research as dictated by their findings and curiosity until the end of April. The students will analyze the data. The analysis will vary dependent upon the type of data collected. Students in statistics classes will help the Biology students determine which statistical tests are appropriate. Biology students will prepare posters for presentation. Assessment of the students will be done using a pre and post Student Assessment of Learning Gains (SALG). Analyses/Interpretations: We do not yet have data to analyze or interpret. The SEG students have become more engaged in STEM activities; all are seeking Research Experiences for Undergraduates (REU) this summer. Contribution: Our college is both an Historically Black College and an Hispanic Serving Institution, so one of our contribution is to expand research experiences in introductory laboratory classes is to include diverse student populations as well as dual credit students. Plans are being made to implement the CURE in a high school, as well as the other 2 sections of Biology. A similar CURE will be implemented in Biology, Part 1 in Fall 2019.

Poster #86
From rigid syllabi to democratic CELLS (Civically Engaged Lectures and Labs): an attempt to boost science literacy among non-majors
Robert D Sieg (Truman State University)*; Jennifer Schroeder (Young Harris College) Paper ID: 123
Numerous studies have highlighted the benefits of active learning, authentic research, and non-traditional course delivery as alternatives to traditional lecture. At small, private liberal arts colleges, a primary need for promoting biological literacy is at the non-majors level, as these students are generally disinterested in or distrustful of science, even when active-learning pedagogies are used. To address this issue, a non-majors course that had been taught using an active approach with a traditional content-heavy syllabus was rebuilt with a modular design framed around critical biological issues such as food security, antibiotic resistance, or GMO safety. Students were presented with six modules called “CELLs” (Civically Engaged Lectures and Labs) at the onset of the semester. The three CELLS earning the most votes from students were used to construct the syllabus, following a “boot camp” on chemical principles and evolution. Each CELL addressed learning objectives on data analysis, molecular biology, evolution, and ecology, assuring that concepts were covered regardless of which CELLS were selected. CELLS were framed as globally-relevant challenges to provide an interdisciplinary context and promote the civic value of biology. Labs used an inquiry-based approach; some were based off of established CURES, while others were developed following workshops with REIL-Biology and SENCER. Final student projects for each unit generated products that promoted civic outreach to non-scientists. To compare student gains in science literacy, content mastery, and interest in science before and after the redesign, we conducted pre/post surveys using published instruments (including the CLASS-BIO, TOSLS, and SALG). We detected a more bimodal response for several survey metrics in the redesigned course compared to the traditional delivery, suggesting that the modular approach was polarizing for non-majors. We also present how learning gains differed when the redesign was piloted by instructors who employ distinct pedagogical approaches. We provide a framework for developing new CELLS and suspect that our design is best suited for multi-section introductory courses, as it provides greater flexibility for individual instructors and grants the option to develop new modules to build up a CELL portfolio.

Poster #87
Student perceptions of iteration and collaboration in research during a laboratory course
Caroline L Dahlberg (Western Washington University)*; Suzanne Lee (Western Washington University); Benjamin Wiggins (University of Washington); Leah Lily (Western Washington University) Paper ID: 198
Two important aspects of Course-based Research Experiences (CUREs) are the opportunities to collaborate and opportunities to iterate in the laboratory. Our preliminary results from a CURE at a primarily undergraduate institution (PUI) suggest that collaboration may change how students strategize about problem solving. However, iteration and productive failure may be more immediately important to students’ approaches to research projects. As part of a techniques-based course (Molecular Biology Laboratory), undergraduate students run quality control
genotyping on samples provided by a large research-oriented (R1) university. The CURE module is embedded within existing course content, which includes principles of gene expression and genetic modification. At the end of the quarter, students had the opportunity to re-run an experiment of their choice, including the collaborative CURE experiment. Preliminary analysis of focus group interviews suggests that the CURE itself, and its focus on collaboration, was less salient to students than the opportunity to revisit experiments or protocols. In a task-based qualitative question that probed troubleshooting skills, many students expressed an understanding of the power of collaboration for gaining insight towards solving a problem in a Biology laboratory. We hope to learn what students value in realistic scientific collaboration, as well as to learn how students’ perceptions of collaboration influence their understanding of authentic scientific research.

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

Exposure to compounds found in personal care products, such as phthalates, is common (Silva et al., 2004) and an emerging public health concern. We are beginning implementation of an intervention-based project focused on reducing exposure to potentially harmful chemicals contained in these products. In this set of laboratory modules, course-based undergraduate research experience (CURE) participants assess exposure to phthalates due to personal care product use. They begin by performing cookbook-style laboratory exercises focused on development of laboratory skills. They then propose methods of analysis for human urine samples based on the faculty-designed intervention study in which participants abstained from product use. Afterwards they extract samples, detect analytes, and analyze data. They complete the semester-long CURE by presenting their results and proposing another iteration of the intervention study. For example, students can propose to change personal care product(s) of interest, mode(s) of intervention, analyte(s) of interest, etc. It is the intention of this project to maintain an initially consistent intervention study design for two years to obtain data to judge the effectiveness of this set of modules in meeting the proposed learning outcomes. Student-designed intervention studies will be used in subsequent years. Key questions addressed by this CURE include: whether participation in this CURE improves learning over cookbook-style exercises; whether this comprehensive, term-long CURE enhances students’ skills in experimental design, analysis, and scientific communication; and whether student attitudes towards science improve through completing this CURE. Student learning is being assessed by rubrics for proposals and lab reports, and pre-, mid-, and post-CURE content exams; while students’ scientific attitudes (self-efficacy, project ownership, science identity, networking, and community values) are being assessed using the PITs survey (Hanauer et al., 2016) at the beginning and end of the CURE. The laboratory module is being implemented within Organic Chemistry II laboratory course which is for biology majors only. There is a maximum student impact of forty students each academic year. While the population of students participating in this CURE is relatively small, we suggest this set of modules will be engaging to a large proportion of biology majors, given the number of students with interest in health-related professions.

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

Lack of financial support for research and many contact hours for faculty are common features of majors biology programs at most community colleges. In an attempt to overcome the financial and temporal hurdles at my school, I have integrated authentic research experiences across multiple courses by embedding parts of a continuing research project in each course. The research goal across these courses is testing species hypotheses in dusky salamanders. In the fall and spring, I teach a 100-level (no perquisites) Regional Natural History and Field Biology courses. The objectives in both of these courses puts students into a position to make field collections of samples which are then prepared and archived. During the lab of my Introduction To Biology (BIO 111) course students perform DNA extractions with the material collected by students (sometimes collected themselves) from the Regional Natural History or Field Biology courses. In the second Introduction To Biology (BIO 112) course labs students study these same specimens as part of learning to identify and classify various kingdoms and phyla across...
the tree of life. This lab is followed by a field lab aimed at studying different ecosystems and microhabitats which provides an opportunity to talk about natural selection and adaptation in the context of the specimens examined previously or that are observed during the field lab. The DNA extractions are then followed by PCR, sequencing, various cleanups and bioinformatics during my 200-level Biotechnology course. Since this process results in original data it provides an opportunity for students to present posters on their finding at our state academy of science meeting and other various local meetings. With the availability of thermalcycler loan programs and PCR and/or sequencing services this approach should be amenable even to smaller colleges. This approach should prove adaptable to all manner of living things and terrestrial arthropods in particular could result in some important contributions to efforts to document biodiversity.

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

Many students who begin their college journey majoring in a STEM field do not continue through to graduation, opting instead to change their major. However, when a student is given the opportunity to develop an identity as a scientist, they tend to persist in the field. Thus, the development of a science identity is key to student retention in the sciences. While there are a number of factors that influence science identity, one area that has been less studied is the impact of Course-Based Undergraduate Research Experiences (CUREs) on students’ science identity. The purpose of this research is to use a qualitative approach to examine motivation, self-efficacy, and the development of scientific identity in introductory biology students participating in a CURE. To address this, semi-structured interviews were conducted at the beginning and end of the semester, questioning students about their perceptions of themselves as scientists, their motivation in taking the course, and how they measure their own success in the CURE and in science in general. The data were analyzed for themes to determine the relationship CUREs play in students’ perceptions of themselves as scientists and the common themes that exist among students entering a STEM field. The participating students indicated that their experiences performing the CURE helped them to see the intersection between science and their daily lives, inspiring them to continue in the field. They additionally indicated that the iterative nature of the CURE helped them to envision themselves as scientists. Future research is planned with a larger number of students and a more refined set of interview questions to delve deeper into the impact of the CURE on students’ science identity.

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

Science can be thought of as a culture with its own values, beliefs, norms, expectations, and actions. This definition of the culture of science ranges from broad, big picture ideas that define the field of science, to the day-to-day practices that occur within science. Work done by philosophers and historians of science led to the development of a consensus on the values/beliefs of science called the Nature of Science. A framework for the actions of science research has also been defined in the Next Generation Science Standards. However, there is currently no framework in place for understanding the norms/expectations of working in a specific field of science such as biology. Therefore, we aimed to develop a consensus on the norms/expectations of biological research. We also explored how undergraduates perceive the culture of biological research after participation in a Course-based Undergraduate Research Experience (CURE). CUREs have been developed and implemented to broaden authentic research experiences to a larger population of undergraduates. However, student perceptions, including gendered perceptions, of the culture of biological research have not been explored in this context. A preliminary framework that includes nine norms/expectations of biological research was developed following a focus group with biological researchers. This framework was used to gain an understanding of how students perceive the culture of biological research following their participation in a CURE. Informal interviews were held with students during poster sessions at the end of an introductory laboratory CURE course. Students presented their research projects and were asked three broad questions about what they liked, found challenging, and took away from their
experiences in the course. Responses from 135 students were coded based on the culture framework. Norms/expectations were mentioned most often as challenging or valued aspects. Females enjoyed the practice of Planning & Running Experiments, whereas males found this practice challenging. Males more frequently mentioned Persistence & Resilience as valuable while females found this expectation challenging. Our results suggest that the norms/expectations of biological research are important aspects of students’ experiences, and differences in the experiences of males and females may impact their perceptions of biological research.

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

Course-based undergraduate research experiences (CUREs) expose entire course populations to the practices of authentic research that is usually lacking in other lab formats (i.e., traditional labs and inquiry lab). CUREs have been shown to increase retention in science and may have their largest impact through large enrollment introductory courses. Our objective has been to determine the benefits and drawbacks of CURE implementation to the largest audience at SIUE – the introductory biology laboratory course for biology majors. A significant obstacle to curriculum developers of an introductory level CURE is selecting a CURE topic that fits several criteria: affordable resources, lab techniques that can be quickly mastered, time for multiple research iterations within one semester, and the opportunity to generate new knowledge. The SIUE CURE focuses on the multidisciplinary process of converting microalgae lipids into biodiesel. We initiated the CURE in Spring 2016 with 3 lab sections assigned as CURE labs and twelve lab sections assigned to the traditional lab format. Students had no knowledge of lab format when registering and were unable to change lab sections once the semester started. CURE participants in the Spring 2016 pilot phase reported increased positive responses to project ownership, collaboration, discovery and relevance, iteration, and science identity, all factors proposed to increase persistence in STEM.

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

Within the last decade, course-based undergraduate research experiences (CUREs) have become increasingly common at many institutions as a platform for promoting student access to authentic scientific opportunities. Numerous national CUREs now exist, including the Science Education Alliance-Phage Hunters (SEA-PHAGES) program, the Genomics Education Partnership (GEP), and the Small World Initiative (SWI). In addition, course-specific CUREs have been created by instructors at individual institutions to serve the needs of their students in a particular laboratory class. While the impacts of enacting national CUREs have been relatively well documented, little has been done to determine if course-specific CUREs can be effectively implemented at multiple diverse institutions and what outcomes are associated with such implementation. We sought to address this need by examining the effectiveness of the Tigriopus CURE, a course-specific CURE, at three institutions. These institutions included a women’s college, a liberal arts college, and a Hispanic-Serving Institution (HSI). At each institution, a quasi-experimental, pre-/post-test design was used to assess CURE students’ (N = 234) development of experimental design skills [as measured via the Expanded Experimental Design Ability Tool], motivation [as measured via the Biology Motivation Questionnaire], and science identity [as measured via Estrada’s Science Identity Scale] relative to a matched comparison group. Exemplar data from the liberal arts college revealed, for instance, a statistically significant shift in CURE students’ intrinsic motivation, career motivation, self-efficacy, and science identity development as compared to their non-CURE counterparts (p ≤ 0.044 for all analyses, as determined via a series of Analysis of Covariance procedures). Similar outcomes were observed at both the women’s college and HSI, including statistically significant gains in experimental design skills among CURE students (p ≤ 0.036 at both institutions) as compared to their non-CURE counterparts. Collectively, these results suggest that the Tigriopus CURE provides a flexible yet effective course-specific model to advance student growth and success in the biological sciences.
Poster #94
Interviews reveal perceptions of students participating in a series of conceptually-linked Course-based Undergraduate Research Experiences
Kelly McDonald (California State University, Sacramento)*; Allison Martin (California State University, Sacramento); Salem Bitwoded (California State University, Sacramento); Heather Fletcher (California State University, Sacramento); Navneet Singh (California State University, Sacramento); Thomas Landerholm (California State University, Sacramento) Paper ID: 203

A number of studies report a range of benefits for students participating in single Course-based Undergraduate Research Experiences (CUREs), including increased self-efficacy, project ownership and career clarification. However, few studies explore the impacts on students participating in multiple CUREs coordinated around a common scientific theme or problem. In the fifth year of the Sustainable Interdisciplinary Research to Inspire Undergraduate Success (SIRIUS) Project, research-based curricula focused on the human impacts on the river system running through our campus has been implemented in 16 courses spanning four science departments. Roughly 3,500 students at our comprehensive teaching institution have had the opportunity to conduct locally-relevant research through courses designed using the CURE framework and situated learning theory as a guide. To date, student outcomes related to self-efficacy, future academic/career goals and science identity have been evaluated at the course-level with initial comparisons across lower-division, intermediate and capstone biology courses. Here, we describe early results from a semi-structured interview protocol designed to explore the awareness, understanding and perceptions that students have about the SIRIUS courses and overarching program goals: to provide more students with research experiences and to collectively study an important local problem. Study participants are graduating seniors majoring in biology, but are otherwise randomly selected to ensure representation from all biological concentrations. The SIRIUS project is not mentioned in recruitment communications; instead, students are told that the goal of the interview is to learn about their academic experiences and career goals. The interview protocol consists of five sections: 1) career goals, 2) skills development, 3) research opportunities, 4) a card sort activity to identify impactful courses, and 5) knowledge and perceptions of the SIRIUS project. While this study is largely exploratory, we hypothesize that 1) the number and combination of SIRIUS courses taken will influence the benefits recognized by students, and 2) students’ perceptions of the value of the SIRIUS project will be influenced by their career goals. Twelve (12) students (of the 30 intended for the study) have been interviewed to date. Interviews were audio recorded, transcribed and analyzed using question items within each interview section as units of analysis for code and theme development. All 12 students demonstrated an awareness of the SIRIUS project, and over half mentioned it prior to being prompted in section 5. Furthermore, all students were able to describe at least one of the two major goals of the project. Students also unanimously agreed that their SIRIUS courses offered authentic research experiences and recognized the importance of studying the river, but students expressed different degrees of ownership and personal investment. All students reported benefits to participating, but specific benefits differed and were influenced by career plans. Students offered insightful feedback regarding weaknesses of the program, including dissatisfaction with failed experiments and a lack of communication of the impacts that their research is having on the American River. While additional interviews are necessary, data collected thus far are already shedding light on the impact of SIRIUS and providing ideas for curricular and programmatic improvements.

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

Multi-day summer faculty development workshops are a common place in the field of biology education. However, there are few published recommendations on the best practices for organizing these dynamic events to enhance participant learning and the skills needed to plan and manage intensive workshops fall outside the scope of traditional academic training. This case study investigates and reports on the features that make a biology education workshop valuable to attendees and describes the challenges, and learnings that will inform future iterations of this training. The objective of the case study workshop is to provide faculty participants with the resources, skills, and confidence to successfully implement a protein modeling and characterization Course-based
Undergraduate Research Experience (CURE) that aims to engage machine learning to better predict successful enzyme design. To accomplish this, the workshop integrates (1) CURE pedagogy, (2) computational protein design, and (3) a wet-lab molecular biology workflow. In Summer 2019, five faculty attended this workshop; this group represents a range of institution types from community college to R1 universities. We hypothesize that both the content-centered components and the event-planning logistical factors are essential to the success of the workshop. The most direct measure of success would be of a count of CUREs taught in the subsequent academic year. However, to predict this outcome we asked faculty participants to self-report their intent to teach the CURE in the coming academic year. We also investigated faculty perspectives more broadly; faculty were asked to respond pre- and post- workshop Likert-scale survey modeled after questions on the Student Assessment of their Learning Gains (SALG) website and were asked to provide written feedback through a post- workshop questionnaire. In addition to the assessment of the content-centered components, participants were also asked to share their perspectives on the logistical elements of the workshop; we used a modified version of the Craig et al., 2017 survey on faculty perspective on transitioning to a CURE, which outlines a program with a similar objective but different training process. The preliminary data that we gathered in this pilot group informs the second-year iteration of the workshop and in analyzing the successes and hurdles, we aim to provide a useful example and model for other faculty-led, professional development workshops.

**Poster #96**

**Describing instructor decisions around student ownership and collaboration in CUREs**

Kelly Hogan (UNC Chapel Hill)*; John Bruno (University of North Carolina, Chapel Hill); Blaire Steinwand (University of North Carolina, Chapel Hill); Sabrina Robertson (UNC Chapel Hill); Bryant Hutson (UNC Chapel Hill)  

Research question: Course-based undergraduate research experiences (CUREs) are being utilized across biology and other disciplines to achieve many positive student learning outcomes. When faculty first develop a CURE, they make decisions about implementing the CURE model. For example, if an instructor gives students ownership in devising their own novel question (requiring much time and iteration), it might be at the expense of ownership over other aspects of the project, such as gathering data. We are interested in understanding what decisions are made as instructors develop and teach CUREs, specifically regarding student ownership and collaboration. Research Design: As part of an institutional program, we developed a year-long faculty learning community related to the CURE model. Over three consecutive years, 31 faculty from the sciences, social sciences, and humanities have participated in our program. Most have taught their CURE at least once. In addition to collecting LCAS survey data from students in each CURE, we have developed a new instrument that asks faculty to reflect upon the specific points of the research project in which students engage in ownership and collaboration. We have constructed a congruent student survey as well. Our study will show the degree to which a course adheres to the CURE model based on LCAS comparisons, and if faculty and students agree on questions of ownership and collaboration in these courses. Analyses and Interpretation: Across the courses in our program, we see scores between 65.17 and 84.72 on the LCAS, demonstrating that these courses qualify as CUREs and can be useful for further investigation. We are now piloting our instruments with faculty and students and will complete the data collection and analysis within two months of end of the semester. Contribution: CURE instructors make decisions they wouldn’t be required to make if time was not limited to a semester. By comparing issues of ownership and collaboration, our study will provide new information about instructor decision points, as well as the rationale for their decisions. Through a similar line of questions, we will learn if students perceive ownership and collaboration the way an instructor intended. We anticipate the survey instrument will be useful as an evaluation/reflection tool for a single instructor of a CURE or across a larger CURE program, like ours.

**Poster #97**

**The Benefits of Iteration in a Sequence of Course-based Undergraduate Research Experiences**

Caitlin Light (Binghamton University)*; Megan Fegley (Binghamton University); Nancy Stamp (Binghamton University)  

The Freshman Research Immersion (FRI) program is a 3-semester course-based undergraduate research experience (CURE) focused on student understanding and application of the process of science and professional skill development. A key learning outcome, related to a larger goal to increase STEM retention, is to help students
understand the value of iteration. Iteration is defined as one of five key features distinguishing CUREs from traditional lab courses. Iterative research tasks include skill development (lab, analytical, writing) and experimental optimization or replication. Unfortunately, students often view such repetitive tasks as boring or evidence of failure. This study focused on the microbial biofilms research track of the FRI program and the impact of emphasis on iteration. We hypothesized that high levels of iteration in the CURE sequence and incorporation of learning activities illustrating the value of iteration in research would result in improved student-reported learning gains using the Laboratory Course Assessment Survey (LCAS) and the CURE Survey. Such learning activities included reliance on accuracy in lab notebook records, iterative data analysis to direct research progress, and science writing and presentation with peer, mentor, and instructor feedback to illustrate the value of refinement. Results from the surveys, administered to four FRI biofilms cohorts, demonstrated gains for tasks where iterative practices were implemented instructionally and framed as important to the process of research. In the LCAS, cohorts 3 and 4 exhibited iteration scores of over 85% compared to published results for a traditional biology lab course (72%) and a reference CURE (80%). The CURE Survey identified strong, student-reported learning gains in areas where iterative strategies were used, including mastery of laboratory techniques, ability to analyze data, understanding the research process, tolerance for obstacles in the research process, and skill in science writing and presentation. Additionally, qualitative analyses of student’s course reflection essays showed common themes about perceived gains in understanding the process of science, importance of practice, development of persistence, and importance of feedback and critique in research. These results demonstrate that emphasis on iteration in CUREs and addressing students’ misconceptions about the value of iteration in research can enhance student learning gains and perceptions about research.

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

Previous studies have shown that students who perform experimental research are more likely to: 1) improve their understanding of how science is conducted, 2) feel they belong in the scientific community, and 3) pursue science-related careers. To enhance equity of access to research opportunities, we created a course-based undergraduate research experience (CURE) in 2 quarters of introductory biology (Bio 1 and Bio 2) at X. CURE students engage in authentic research investigating evolution of antibiotic resistance. In Bio 1, students select antibiotic-resistant E. coli strains bearing different mutations, conduct a long-term evolution experiment, and characterize changes in the strains’ fitness and resistance levels. In Bio 2, students analyze molecular and structural data to propose explanations for their strains’ fitness- and resistance profiles. To investigate how CURE participation influences students’ abilities and attitudes, we measured CURE students’ learning outcomes versus those of students in the same lecture who attended non-CURE laboratory sections (~72-96 students per condition). At the beginning, middle, and end of the Bio 1/Bio 2 series, we administered a survey to assess students’ 1) understanding of natural selection, 2) ability to design experiments, and 3) attitudes towards science and themselves. To evaluate students’ ability to draw connections amongst genotype, phenotype and fitness, we prompted them to consider molecular- and organismic-level factors. Categorical ordinal modeling indicated that CURE students were 86% more likely to score at least 1 point higher on experimental design (E-EDAT, 11-point rubric) and 6.3-fold more likely to score at least 1 point higher on explaining trait-gain (E-ACORNs, 13-point rubric). Initial qualitative data indicate that CURE students consider their research relevant for society and their future careers. Furthermore, Peer Facilitators (CURE alumni who mentor current students) describe the CURE as a research gateway that fosters inclusivity. The X Introductory Biology CURE provides students with an authentic research experience over 2 quarters. Unique features of this CURE include the quantitative nature of students’ research and its scale and context: X CURE will serve 1000’s of students per quarter at a large research-based
university. Therefore, our findings may set a precedent and help inform the design and implementation of future high-enrollment CUREs at other higher education institutions.

**Poster #99**

**An Epistemic Perspective on Student Argumentation in a CURE**

Dennis M Lee (Clemson University)*; Cazembe Kennedy (Clemson University); Jason Tedstone (Clemson University); Dylan Dittrich-Reed (Clemson University); Lisa Benson (Clemson University)  
Paper ID: 245

Biology education has seen a shift from teaching students what they need to know to teaching students what they need to do. Course-based Undergraduate Research Experiences (CUREs) focus on building science process skills, such as argumentation, through practice. Participation in CUREs has led to positive outcomes such as increased analytical and technical skills. However, focusing solely on skills as outcomes may lead students to memorize routines, rather than understand how these skills help us learn what we want to know in biology; i.e., biology epistemology. Therefore, we asked “What are the different epistemic practices that students use to build arguments in an introductory biology CURE?” Research in argumentation has found that students often provide evidence for claims, but rarely connect evidence to the claim through a warrant. However, it is impossible to infer if a student’s argument-building practices align with biology epistemology if the warrant is absent. Thus we analyzed student arguments and the reasoning they used to build the argument. We used a phenomenographic approach to answer this research question. Phenomenography assumes that there is a finite number of ways to conceptualize a phenomenon, and seeks to find the different ways of conceptualization. We operationalized the “phenomenon” as building an argument. We describe the diverse ways in which students build arguments in the context of an introductory biology CURE where students complete three scaffolded inquiry projects at a large Midwestern university. Participants (n=21) were selected for maximum variation in the quality of their first research proposal. We analyzed arguments in participants’ second research proposal, initially using the lens of Toulmin’s Argument Pattern (TAP). Guided by this initial analysis, we interviewed participants about how their evidence warranted their claims. Analysis of proposals and interviews was guided by the AIR model for Epistemic Cognition. We identified salient epistemic passages through participant use of epistemic Aims, Ideals, and Reliable processes for achieving epistemic goals. Each of the three team members coded proposals and interviews separately before coming to a consensus of participant epistemic practices. The analysis team then sorted participant argument-building practices, which facilitated the construction of 6 categories: 1) Searching for information, 2) Meaning making, 3) Checking information credibility, 4) Including argument components, 5) Connecting to prior knowledge, and 6) Justifying actions. From this analysis, we found that while most participant arguments were scientifically sound, they did not align with the norms of biology epistemology. Instead, a majority showed a variation of epistemic practices, ranging from rote instruction following to synthesis of claims sourced from established biological theory and peer-reviewed literature. These variations will be discussed during the talk. Based on our results, we suggest that explicit discussion of biology epistemology could narrow this variation. These results also lead to new questions such as, why do some participants’ argument practices align with biology epistemology while others do not? This work, along with Duschl’s (2008) hypothesis that what is “missing from our pedagogical conversation is how we know what we know and why we believe it” (pg. 269) supports epistemology as an important part of assessing CURE outcomes.

**Poster #100**

**The Elephant in the CURE Classroom: What Do We know About CUREs Taught by Graduate Teaching Assistants?**

Emma C Goodwin (Portland State University)*; Kelly McDonald (California State University, Sacramento); ERIN E SHORTLIDGE (PORTLAND STATE UNIVERSITY)  
Paper ID: 252

Evidence of positive outcomes from course-based undergraduate research experiences (CUREs) has prompted increased use of CUREs in introductory biology labs. In CUREs, numerous students collaborate on scientific research within a structured course, guided by an instructor who often acts as a research mentor. As CURE implementation increases, graduate teaching assistants (TAs) inevitably are or will be responsible for teaching CUREs. The implications of TA-taught CUREs are completely undetermined—both for undergraduates, and for the TAs themselves. We predict that TAs experience CURE-specific challenges and benefits, and that a TA’s perspective
on CUREs will impact their student’s outcomes. To gain a baseline understanding of the CURE TA experience, we interviewed veteran CURE TAs to explore how they perceive their instructional role. Second, through an in-depth case study, we will assess the alignment between the perceptions, experiences, and outcomes of CURE TAs and their students. We first recruited 22 TAs from 15 institutions for semi-structured interviews. Questions included: Why do you think your institution uses CUREs? Has TAing helped you develop useful skills? Through open-coding, we identified that participants felt their experience teaching CUREs developed their skills as a teacher (68%) and as a researcher (45%). They enjoyed a better relationship with students (68%) and found teaching CUREs to be exciting (63%). For some, the experience clarified their own career goals. Challenges included a larger time investment compared to other classes (64%), the lack of predictability in research (55%), and a lack of research expertise hindering their role as a CURE research mentor (18%). We are now conducting our first case study on eight TAs and their students at a single comprehensive institution with an extensive biology CURE program. TAs and students will be observed in-class, answer reflection questions, and participate in interviews/focus groups. We will use the Laboratory Classroom Assessment Survey (LCAS) to measure if students experienced CURE elements. The TAs will take a modified LCAS, measuring if TAs identify facilitating the same CURE elements. Student grades and quantifiable course outcomes will be correlated to their LCAS scores and interviews. Student data will then be matched to their TA’s LCAS results and CURE perceptions. Our analyses will triangulate student and TA outcomes, resulting in evidence-based recommendations for best practices in implementing TA-led CUREs.

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

Participation in authentic research experiences has been shown to have many positive outcomes for students. As a result, a number of institutions are implementing course-based undergraduate research experiences (CURE’s) in which all students enrolled in a given course conduct research under the guidance of the instructor. While data in the literature highlight the benefits of CURE’s for students at 4-year colleges and universities, there is much less published data describing the impact of CURE’s on community college students. Therefore, our goal is to study the effect of a CURE on our community college students enrolled in our introductory biology course for non-majors. Over the course of a five-week lab module, students work in teams to develop and test their hypotheses using DNA barcoding. Examples of student projects include investigating potential seafood fraud, studying the prevalence of invasive plants on campus, assessing the biodiversity of benthic macroinvertebrates in local waterways, etc. The culmination of the CURE is a scientific poster session in which the student teams present their findings and the relevance of their work. Students enrolled in both the CURE and traditional lab sections of the same course taught by the same instructor are assessed with the CURE pre-course and post-course online surveys to measure the effect on science attitudes, career aspirations, and learning gains from the CURE. Preliminary results indicate that the greatest benefits that students in the CURE lab sections gained over students in the traditional lab sections include the ability to analyze data, learning laboratory techniques, oral presentation skills, and self-confidence. Students who participated in the CURE said, “I liked that the professor did not know what the outcome would be, which made it seem more ‘real-world’ research experience. Activities like these are not usually done in science classes.” and “it made me put myself in the position to be a biologist and think like one.” Moreover, the percentage of students considering declaring a major in the sciences increased after participating in the CURE labs section while the percentage of students who did traditional biology labs did not. Our future directions include conducting longitudinal studies on CURE vs. traditional lab students to determine if there are any lasting effects, such as whether or not students who participate in the CURE have higher persistence and transfer/graduation rates.
**Poster #102**  
Mine! Microbe ownership as a gateway for project ownership and positive affect in an introductory biology CURE  
Pamela Hanson (Birmingham-Southern College)*; Kevin Drace (Birmingham-Southern College)  
Social science research defines ownership as a sense of possession or “mineness”. In educational settings, ownership can positively impact student engagement and persistence in STEM. The collaboration, discovery, and iteration in course-based undergraduate research experiences (CUREs) have been shown to contribute to the positive affect that correlates with project ownership. However, the instruments used to measure these contributions do not directly measure a sense of mineness and only assess a subset of factors that can contribute to it. For example, Pierce et al. (2001) identified multiple routes to ownership. These routes, or how feelings of ownership develop, include controlling the target, knowing the target, and investing one’s time and energy into the target. Here we describe a semester-long, introductory-level CURE in which students characterize soil microbes. Although this CURE features discovery and iteration, students do not design their own experiments or hypotheses. Consistent with this design, students (n=79) reported significantly greater (p<0.05) ownership of their microbe relative to the hypotheses they tested. It has been hypothesized that student-driven development of research questions facilitates a sense of project ownership, yet one of the most successful and widely adopted CUREs – HHMI SEA-PHAGES – as well as the project we describe here focus more on descriptive characterization of an object (a phage or bacterium) than student-driven hypothesis development. Yet significant ownership has been observed in both cases. To identify the routes to microbe ownership, we administered a survey featuring a combination of novel questions and questions from existing instruments. The Cronbach’s alpha for the first semester of data was 0.91, suggesting the survey is internally consistent. In agreement with prior research on CUREs, a correlation matrix revealed that possession/mineness correlates with positive affect. With respect to the routes to ownership, preliminary data analysis suggests that coming to know the target and controlling the target were the greatest contributors. Once additional data is collected this spring, structured equation modeling will be used to determine whether these factors make independent contributions to ownership. Though preliminary, these findings suggest that ownership of a biological object (a microbe) as opposed to an idea (a hypothesis) can contribute significantly to the positive affective impacts of CUREs.

**Poster #103**  
Does a CURE Improve Students’ Scientific Literacy?  
Brian P Teague (University of Wisconsin -- Stout)*  
Why do we require students in the arts and humanities to take science courses? A common rationale for including science courses in a liberal arts curriculum is to increase students’ science literacy: as the importance of science and technology in our everyday lives increases, we want our students to be better-prepared to make informed decisions in these spaces. Unfortunately, research has demonstrated little if any improvement in science literacy for students taking introductory and general-education science classes. In this study, I asked if a course-based undergraduate research experience (CURE) could contribute to students’ development of scientific literacy. Science literacy is a practical manifestation of a student’s fluency with the nature of science, and I hypothesized that an authentic research experience could help students understand science as a process that (a) is based on observation and inference, (b) involves human creativity and subjectivity, (c) happens in a broader cultural context, and (d) is forever uncertain. This improved understanding of the nature of science should then translate to improved science literacy. I am measuring students’ scientific literacy using Nuhfer et al’s science literacy concept inventory (SLCI). The SLCI is a short survey instrument that assesses 13 concepts relating to science as a “way of knowing,” and its validity and reliability have been demonstrated on a sample of over 17,000 undergraduate students. I am administering the SLCI to students at the beginning and end of two introductory courses: an introductory cell and molecular biology course, whose lab is taught in the style of a CURE, and a general-education course in human biology, whose labs are more traditional “cookbook”-style active learning experiences. By using a pre/post study design, I can study whether students’ understanding of the nature of science improved over the course of the semester, and whether the magnitude of that improvement differed between the two course designs. This poster will present preliminary data and analyses, which I hope will spark discussion about the direction of the project moving forward.
**Poster #104**

*Comparing learning and attitudes between introductory CURE and traditional lab sections over different instructors and semesters by both quantitative and qualitative measures*

Iglika V Pavlova (UNC Greensboro) * Paper ID: 285

As part of a wider reform to scaffold quantitative and research skills throughout the biology major, we introduced lab sections where students work in teams to design, implement, analyze, improve, write and present for two CURE experiments. To probe whether a research focused design will improve statistical and scientific reasoning, we compared student learning outcomes and science attitudes through validated instruments and written reflection questions over two semesters of CURE sections taught by three different instructors with a propensity score-matched cohort from the traditional sections (n=83 for each group). Written responses were coded by two researchers blinded to student and group identity. In the intervention, but not in the traditional sections, students significantly improved pre-to-post semester on both the difficult Statistical Reasoning in Biology Concept Inventory test (SRBCI, p<0.001) and the Expanded Experimental Design Ability Tool (E-EDAT) (p<0.05). Lab report analysis in the CURE sections is consistent with the instrument scores, with 77% of students scoring over 90% using criteria for experimental design, statistical analysis, and evidence-based conclusions. In open-ended reflection answers that were coded for themes, CURE section students most often reported designing experiments (38%), statistics (32%), lab reports (27%), and analysis (20%) as the most valuable experiences for the lab (with 2.4%, 0, 0, 3% in the matched control, which does not have statistics or lab reports), while also noting statistics (32%) and lab reports (20%) as the most difficult aspects of the lab. The CURE sections showed a significant positive change in science attitudes compared to the matched control on the BioCLASS instrument (p<0.05). The reflections testify to a spirit of independence and inquiry in CURE section students who identify as most interesting designing their own experiment (49%), being hands-on (46%), and exploring (19%), compared to the matched control (0, 24, 7%). This study adds to the literature demonstrating learning gains on knowledge tests in CURE sections that can be reproduced over several instructors and semesters in the diverse student body of a large public institution (63% of students in this study are identified as non-white). With students finding value in learning statistics when they apply it to their own experiments, it also supports the use of statistical instruction in inquiry-based introductory biology labs.

**Poster #105**

*Classroom Undergraduate Research Experiences (CUREs) do no harm, and show statistically significant benefits for females.*

Alaron Lewis (UW Bothell School of STEM) *; Irene Shaver (Rise Institute, Bellevue College ); Gita Bangera (Bellevue College); Thelma Madzima (University of Washington, Bothell) Paper ID: 295

There has been a strong push recently to create Classroom Undergraduate Research Experiences (CUREs) that can be used as replacements for traditional lab activities. CURE’s have a variety of potential learning goals and benefits for students above and beyond the traditional “cookbook” labs of introductory science courses. More specifically, this model deemphasizes the lab as a subject matter tool, and puts the emphasis on understanding the role of experimentation in scientific discovery and on the student’s role as a scientist. These labs give students an experience that more accurately reflects the scientific method, and the challenges of research science. Instructors who are interested in adopting CURE’s are often confronted by colleges and students who argue that lecture-focused active learning labs are vital for student success in the course, and make a significant contribution to student learning of the basic material. In this study we set out to try to document that the adoption of CURE did no harm to the students, and to try to quantify the advantages of the CURE methodology.

Over the course of two years we taught the 2nd class of introductory biology as a split course. All students shared the lecture portion, while the five lab sections were divided into “traditional” and “CURE” labs. Students were not informed of differences ahead of time and signed up for labs according to their schedules. Exams focusing on course material were administered to the joint lecture class, and the assessment of lab learning was done primarily through a likert style pre-post survey with several open ended questions given to all students at the end of the course.
Over this two year period 149 students took the course, with 73 students in the CURE labs. Analysis of the data for shared exams showed no significant difference between the two student groups. Indicating that there was no detriment to students in the CURE labs when it came to understanding course material. We saw relatively few statistically significant gains in those students. The data suggests that students from both labs groups reported increases in understanding, and the increases for CURE students where often slightly larger then traditional students, but were not statistically significant. However, when we analyzed only the Female data from these labs, the majority of the questions showed significant gains for this population. These data suggest that females respond more strongly to these types of pedagogical changes.

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

In addition to human, close reading of student text with rubrics for assessment, educators use nonhuman, distant computer-assisted tools to help quantitatively measure otherwise qualitative keywords to prevent bias in grading and help read beyond the sentence for underlying cognition. The Linguistic Inquiry and Word Count (LIWC) software tool can be applied to analyze different forms of student writing in STEM education and research. LIWC measures four summary variables, Analytical Thinking, Clout, Authentic, and Emotional Tone, to provide outputs as raw word counts, as percentages of words used relative to the text compared with a dictionary of words in categories and sub-dictionaries, and as scores correlating these words algorithmically based on a dictionary of terms associated with underlying meanings. While LIWC use for other genres is well established, less validation has been done for use with scientific writing. Previous studies suggest that patterns can be detected as indicators in scientific writing for potential use as a heuristic model to prevent bias in graded sections by different teaching assistant graders and in different semesters. Here, from two semesters of biochemistry writing-intensive lab courses, we examined de-identified student reflective writing samples for underlying psycho-social indicators and student scientific writing for detection of cognitive and analytical processes by selecting key variables in the LIWC software. We followed the recommended steps in LIWC analysis, downloaded electronic copies of both genres, and compared LIWC computer-analyzed codes with our own hand-coded measures to determine reliability and validity. Scientific writing samples from large lab report manuscript discussion sections showed patterns. From a representative sample, Cronbach's alpha for the internal consistency between these two different scores was found to be 0.98 demonstrating that some variable choices could be used. Further, we compared our scores to graded scores given by the graduate teaching assistants to test if patterns could be used to prevent bias. These hand-graded results were more subjective; whereas, LIWC yielded algorithmically generated scores suggesting the potential for using LIWC measures of cognitive processes for different measures of student writing in science courses.

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

Project EDDIE (Environmental Data Driven Inquiry and Exploration) aims to create curricular modules that engage students with large datasets that are freely available online, such as from the USGS or NASA, to foster students’ quantitative reasoning (QR). We define QR as the combination of skills needed to: 1. Perform directed mathematical computations during data analysis, 2. Make sense of mathematical output derived from analyses to answer research questions, and 3. Contextualize the analysis is the larger disciplinary framework. For example, in Project EDDIE’s Climate Change module, students generate best-fit-lines and run regression analyses for atmospheric CO2 and temperature data, use slope or R-squared (depending on the research question), and then apply their newly developed statistical skills to explore Vostok ice core data to answer the question: Is the current global warming trend human-induced or resulting from Earth’s natural cycling? Project EDDIE modules cover a range of ecological, environmental science, and geoscience content areas. All modules contain multiple phases in
which scaffolding is gradually removed, and students become progressively more independent throughout the phases. Students answer genuine research questions during the modules, in that the questions are unanswered, from the student’s perspective, and students, rather than instructor, explain answers to research questions based on data analyses. Modules are written for undergraduate science majors or graduate students, although they have been used with non-science majors and students as young as middle school. Students who have been engaged in Project EDDIE modules have demonstrated increased comfort using spreadsheet software, increased content knowledge, and greater likelihood in using big data to answer research questions in the future. Students also report positive experiences using large data sets to explore open-ended questions. Project EDDIE is entering a new phase involving additional module development, deeper explorations of QR, and investigations of how participation in Project EDDIE influences instructors’ teaching, generally. The purpose of this poster will be to share data on Project EDDIE’s influence on several student outcomes, elicit ideas on how incremental changes in QR might be documented or measured, and invite the SABER community to participate in upcoming Project EDDIE workshops in which new modules will be developed.

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

Socioscientific issues (SSIs) are scientific issues with social implications and, therefore, affect all students regardless of major. Students must think critically when making and justifying a decision about an SSI, weighing information from a variety of beliefs and knowledge that they have learned throughout their academic careers. This study explores the process of epistemic cognition when supporting SSI decisions in undergraduate students. Epistemic cognition can be described as a context-based process of thinking that draws upon epistemic beliefs when supporting decisions and opinions. Although it is challenging to measure epistemic cognition, the AIR model provides a framework for examining how individuals determine if an information source is accurate and how they utilize that information when making a decision. Through 30-minute semi-structured interviews, this study probes 20 non-science majors’ and 20 science majors’ thought processes about the vaccination controversy through the AIR model. Each interview is thematically coded through an interpretive phenomenological analysis. Preliminary results (6 science majors, 6 non-science majors) suggest that undergraduate students often base their opinions and decisions about vaccinations off of their personal beliefs regardless of the scientific information that they may know or that they learn within their courses. Supporting this finding, a major theme that has emerged from the data is that there is a disconnect between science in the classroom and SSIs within society. This is reflected through the contradictory responses when asked what information sources students would utilize when supporting an SSI decision compared to the information that they actually utilized when supporting their SSI decision. Additionally, several students were more inclined to deem an information source about SSIs reliable if they could understand the content. If the content was too complex, students described these sources as unrelated to the decision that they would make about the SSI. The results of this study will contribute to an understanding of how epistemological mechanisms contribute to the ways in which students are thinking and learning about science. Additionally, these results may inform the development of required science courses through encouraging the inclusion of SSI discourse within the classroom as an exercise to promote development of students’ scientific literacy skills.

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

Undergraduate biology majors typically require mathematics courses as prerequisites, yet students are often unable to use mathematics concepts in biology or make connections from mathematics to science courses across disciplines. For example, rate of change is a crosscutting concept that causes widespread difficulty among
students. From population growth in biology to reaction kinetics in chemistry and kinematics in physics, students struggle with a plethora of well-documented misconceptions even after instruction, e.g., explaining the meaning of terms in differential equations, making sense of rates of change in graphical representations, distinguishing between instantaneous and average rates of change, and working with both constant and variable functions. Instructors isolated in disciplinary silos cannot effectively address these challenges. Funded by an NSF Improving Undergraduate STEM Education grant, we have curated an interdisciplinary team consisting of biologists, chemists, physicists, and mathematicians to develop 20 short instructional videos informed by the research on students’ understanding of mathematics in science. The videos address subtopics within rates of change. Individual videos explore each subtopic across foundational biology, chemistry, physics, and mathematics; a fifth video on each subtopic provides an example of its relevance in current research in one of these disciplines. This poster will describe the activities of the interdisciplinary team to develop the videos. Of particular interest is the development of a community of practice within the interdisciplinary team, with the goal of better understanding one another’s disciplinary traditions and the different ways we think about and teach foundational concepts. As a result, we have developed an evidence-based checklist for instructional video production that operationalizes the relevant education literature, covering content and sequencing, as well as cognitive supports and affective considerations.

**Poster #110**

**Weekly e-learning journals as a tool to promote and improve metacognition in undergraduate life science majors**

Seth W Hunt (University of Delaware)*; Alenka Hlousek-Radojcic (University of Delaware)  Paper ID: 117

Improving metacognition has been advocated across multiple disciplines in the field of education as those tools are shown often to be used frequently by experts in the field and are strongly correlated with future learning success. Like other hard and soft skills that undergraduate STEM educators wish to instill in their students, opportunities must be given to students to develop and demonstrate their metacognitive abilities but implementing activities and opportunities that promote and improve metacognitive skills within students can be a significant time commitment and often falls outside of typical college STEM course learning objectives. We implemented weekly surveys as well as exam reflections in an integrated introductory biology and introductory chemistry course taken by freshmen life science majors in an effort to provide the opportunities for the development of metacognition. Data from the weekly surveys were aggregated and trends in studying methods and reflection were presented to the students for further reflection at several times during the semester as a means of showing how this information is used by the instructors to inform themselves on the status of the students as a whole. While the questions being asked in the reflective journals varies from the week to week some patterns have arisen. In general, study methods and types by reported by the students change over the course of the semester in relation to proximity of the nearest exam. In addition, there appears to be differences in the manner in which students rate their performance on exams by course. Further analysis needs to occur to ascertain the relationships between student responses and performance within the course as well as the development of a tool that measures students’ metacognitive abilities.

**Poster #111**

**Biofilms as a Context for Understanding Mechanistic Reasoning by Undergraduates**

Sharleen Flowers (Purdue University)*  Paper ID: 143

In recent years, science has shifted from a focus on reductionist explanations of biological phenomena to a more integrated, systems approach. This shift has made its way into curricular recommendations for undergraduate education (AAAS, 2011). To understand complex biological phenomena such as biofilms, it has been argued that students employ mechanistic reasoning, in which one describes a mechanism by identifying the activities that produce change, the entities which engage in activities, and the conditions of time and space (Machamer et al., 2000). Students’ use of mechanistic reasoning requires engaging in the complex task of simultaneously integrating and coordinating multiple elements across space and time. In addition, students must link and organize their scientific ideas and then structure their thoughts into a network of knowledge, as described by Knowledge Integration Theory (Clark & Linn, 2003). Previous studies that have explored students’ understanding of scientific concepts using knowledge-integration as a lens found that students’ nonmechanistic ideas prevented them from
Identifying gaps in the connections between their ideas and from forming normative knowledge (Haskel-Ittah et al., 2018). Thus, this study seeks to investigate the features of students’ mechanistic reasoning in the context of biofilm development and explore the different types of connections between ideas in their molecular mechanisms. Using a semi-structured interview, five junior undergraduate biology students were asked to answer general questions about biofilms and produce a mechanistic explanation describing the transition point between initial attachment and irreversible attachment during biofilm development. Preliminary inductive and deductive coding analysis of interview transcripts indicates that students struggle to incorporate the causes and role of gene expression in their mechanistic explanations of phenotypic change. Further analyses will draw on the theoretical model of knowledge integration in undergraduate molecular and cellular biology which groups student knowledge on a continuum of fragmented to integrated biological ideas (Southard et al., 2015). This will enable us to examine how students define and group entities within their mental categories and explore the kinds of connections students make between molecular events to construct mechanistic explanations of biofilms, providing insights for the teaching and curriculum development on this topic.

Poster #112
Characterizing instructional approaches to mathematics in the undergraduate biology
Fangfang Zhao (University of Minnesota)*; Linh Chau (University of Minnesota); Anita Schuchardt (University of Minnesota)  Paper ID: 158
The increasingly quantitative nature of biological research has prompted calls for greater integration of mathematics in biology courses. However, there has been little research examining how biology instructors are teaching mathematics. Different instructional approaches to mathematics probably have different affordances and constraints for students’ quantitative skill development. Algorithmic instruction might promote quick and accurate problem solving on familiar problems, while mathematical modeling approaches might promote increased ability to connect mathematics and the biological phenomenon. This study aims to characterize instructional patterns used by 3 biology instructors teaching mathematical expressions. Three instructors were observed and audio-recorded during lessons including mathematical expressions. Using the grounded approach of Glaser and Strauss (1967) and following best practices outlined in Miles & Huberman (1994), transcripts were qualitatively analyzed in their entirety. Three teachers with distinct instructional patterns were chosen for further analysis in 6 areas: 1) Treatment of Mathematical Expression, 2) Framing of Purpose of Mathematics, 3) Expectations of Students, 4) Attitude about Student Competence 5) Student or Teacher-centeredness 6) Questioning Discourse. Instructional artefacts were used to support findings. A comparison of the 3 instructors across all 6 areas will be presented. Only a few areas (identified by numbers in parentheses) for 2 instructors are presented here as an example. Amanda expected students to be able to read the equation (3). She treated the mathematical expression as an object to be decoded (1), telling students (5) what the variables meant; and framed it as a tool (2), showing students (5) how to perform calculations. In contrast, Tina expected students to be able to interpret the meaning of the equation with respect to the biological phenomenon (3). She presented students (5) with the equation as a representation of the biological phenomenon (2), asking students questions to lead them (5, 6) to conclusions about relationships between variables as a way of understanding the biological phenomenon (1). These six areas for characterizing teaching will be applied to more instructors in different contexts to test for generalizability and validity with the ultimate goal of developing a framework that can be broadly applied in order to test for interactions between instruction and student learning.

Poster #113
Combating cognitive load with metacognition to improve student performance in introductory genetics
Gretchen Wettstein (University of Colorado Boulder)*; Jenny Knight (University of Colorado, Boulder)  Paper ID: 160
In the past several decades, cognitive load theory has become increasingly important in science education. This theory suggests that students’ working memory capacity is limited, and that this limited memory is best allocated towards constructing meaningful relationships between concepts. To date, most research has focused on instructional design to optimize cognitive load, but little work has been done to connect cognitive load to
One of the features of successful biology students is the ability to apply concepts across varied biological phenomena. If students have a sophisticated understanding of general quantitative relationships, they can use them as a heuristic to predict outcomes in novel situations. However, transferring knowledge across situations is often a challenge for biology students. Previous research suggests that instructing students to invent a general explanation for a series of contrasting cases helps students identify the deep structure of the question and increases transfer. We wanted to investigate if inventing leads to more effective transfer than practicing with a known relationship. To do this, we developed two parallel versions of an in-class worksheet with different pedagogical approaches: inductive or deductive reasoning. In the inductive reasoning worksheet (“invent”), students were asked to invent a general relationship based on data from a series of cases, whereas the deductive reasoning worksheet (“worked example”) provided the general relationship and data from the same cases and then asked students to use the relationship to predict the outcome in each case. Students were reasoning about flux, or movement of different molecules by inventing or applying the general relationship that flux is related to the gradient (driving force) and the resistance to movement. Each worksheet presented three tasks addressing varied examples of flux including oxygen diffusion, glucose diffusion, ion movement, and osmosis. We led think-aloud interviews with ten undergraduate biology students. Students worked in pairs to complete the invent worksheet before doing the worked example. They were able to invent a general relationship in each task.
engaged readily with the tasks, and stated that they found the invent worksheet interesting and more helpful for understanding the topic than the worked example. To test impacts on student learning between the two reasoning conditions, we will implement these worksheets in laboratory sections of an introductory biology course. We will measure transfer on related items at multiple times during the course, and determine how incoming GPA and demographic factors impact learning in the two reasoning conditions. We propose that understanding the impacts of this teaching intervention on student learning will inform future teaching innovations and promote better student understanding of general quantitative relationships in biology.

**Poster #115**  
**Persistent Insect Misconceptions**  
Emma Wester (East Carolina University)*  
People begin to learn from a very young age how to catalog the natural world, absorbing criteria for classification through media, social interactions and formal and informal education. In the case of insects, these classifications are often formed with misconceptions gleaned from children’s books that contain erroneous information. We theorize that the earlier a misconception is formed, the harder it is to overturn and thus persist through adulthood even when the adult learns and uses information counter to the misconception. In this case, we are examining how the types of misconceptions children have formed about insects through their interaction with erroneous media persists through adulthood (undergraduates). To analyze adult misconceptions about insects, we tested misconceptions of insects among undergraduates in an entry level biology class, both before and after they are taught the correct criteria for classification. To assess which errors about insects to which children are commonly exposed, we rated trade books, for number and egregiousness of the errors. The significance of this study is to improve our ways of addressing these misconceptions in the classroom by creating activities that truly overturn the misinformation learned in childhood and to create a framework for providing young children with media that does not create these misconceptions from the beginning.

**Poster #116**  
**A collaborative digital approach to building primary paper literacy within a framework that fosters critical high-level skills in data analysis and interpretation**  
Revati Masilamani (Tufts University)*  
Primary literature reading is a key predictor of success in graduate school [Urquhart et al. 2016]. PhD programs often erroneously assume that primary paper literacy is acquired at the undergraduate level. Instead, when undergraduates do get exposed to primary literature it is often adapted for ease of comprehension to provide students with an appreciation for authentic scientific inquiry. However true paper reading mastery requires higher-level data analysis and interpretation skills, the ability to identify limitations in the study to come up with alternative conclusions, and most importantly the ability to situate one’s own research in the context of the field. Students who lack these skills fall behind in graduate school and often drop out of research. It is therefore vitally important for retention of diversity in the scientific arena, that this skill gap be closed early in graduate school. We decided to ask whether primary literature reading skills could be developed in a rigorous and systematic manner by implementing a structured approach to decoding papers using collaborative digital annotation. We modeled our approach on ‘online collaborative learning theory’ [Harasim et al. 2012], which is a form of constructivist learning that posits three phases of knowledge construction through group online discourse- 1. Idea generating-brainstorming 2. Idea organizing- discussion and argument 3. Intellectual convergence- synthesis The online discussion format holds students accountable for participation and allows for formative assessment by the instructor. Areas of misconception can then be addressed, either online or in an in-person session. The structured approach to annotation- QMDC (Question, Method, Data, Conclusion), uses the canonical format of biology papers to assist students in distinguishing between describing experimental data from the act of deriving conclusions from that data. This pilot study was carried out with 8 graduate students and their instructor in a first-year journal club course that met once a week for 6 weeks. The students were assigned a paper at the start of each week. They had asynchronous online discussions structured by the QMDC approach through the week. They then met for an in-person session at the end of the week, and critically argued for and against the claims of the paper, and its contribution to the field. The students were assigned an anonymous pre-post survey [Lie et al. 2016] to measure
their self-efficacy in skills related to paper reading, as well as to identify aspects that they found most challenging. The pre-post responses as well as the online discussions were coded for Bloom’s level. We wanted to assess whether the Bloom’s level changed through the different phases of discourse in the model above, and whether instructor or peer comments influenced that change. We conducted semi-structured interviews with students after the course, to assess changes in self-efficacy towards primary literature specifically and research in general. The key findings of this study are that 1) The online collaborative component of the journal club holds all students accountable to participate, in contrast to most in-person journal clubs 2) The written format of the online discussions forced students to communicate clearly and facilitated peer-teaching 4) The increase in frequency of high-level Bloom’s annotations in all students, through the course, suggests that progression in the continuum from novice to mastery is occurring. 5) Findings suggest that increased confidence with paper reading correlates with a gain in self-efficacy towards research skills, as has been posited. The data suggest that structured annotation in a collaborative digital space can facilitate student mastery over primary literature early on in graduate school. This approach could be standardized for use in graduate as well as undergraduate programs across the country to address the problem of retention in research.

**Poster #117**

**Students’ Mechanistic Explanations Across Undergraduate Chemistry and Biology Courses**

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

Prerequisite or corequisite requirements link many college and university courses implying that students should be transferring and applying ideas between their 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 STEM courses, chemistry (Chem1) and cell and molecular biology (Bio1). Mechanistic explanation involves identifying underlying factors, unpacking what those factors do, and systematically linking these factors into causal chains that explain how and why the phenomena occurs. 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 general phenomenon. 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. 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 describe the development of three prompts to elicit diagrammatic, model-based explanations of the general phenomena of protein structure and function using three specific contexts. We developed these prompts 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. Analysis of explanations generated using these prompts reveals prompt specific explanation patterns as well as common gaps and shortcomings in how students incorporate ideas from chemistry into mechanistic explanations of protein structure and function. Future plans include expanding the prompts to include ideas from a third linked course, organismal biology (Bio2), conducting a cross-sectional study to establish if and how students use mechanistic explanation at different time points in an introductory STEM curriculum, and exploring connections in explanation sophistication across related phenomena. This work advances knowledge of how students use science practices and core ideas across an introductory STEM curriculum and will provide a framework for aligning the science practice of mechanistic explanation across disciplines.
**Poster #118**

**Comparison of Analytic and Holistic Coding Approaches and Machine Learning Performances Across A Flux Learning Progression**  
Lauren N Jescovitch (Michigan State University)*; Emily Scott (Univ. Washington); Jack Cerchiara (University of Washington); Mark Urban-Lurain (Michigan State University); John Merrill (Michigan State University); Jennifer H Doherty (University of Washington); Kevin Haudek (Michigan State University)  
Paper ID: 194

Flux is a core concept and principle in undergraduate physiology that describes passive flow of substances and heat down gradients. Student thinking about flux can be characterized using a learning progression (LP) framework. LPs are frameworks which outline cognitive paths of student learning in a domain and can provide reference points of student progress. We are developing LPs in undergraduate physiology focusing on how undergraduates use principle-based reasoning in ion flux constructed response assessments. Constructed responses can assess student thinking and can be evaluated using rubrics. LPs use holistic rubrics that assign responses to a single, mutually exclusive bin based on reasoning. Another approach to coding is analytic. We define an analytic rubric as evaluating material by the use of multiple coding bins which are not mutually exclusive. Unlike holistic rubrics which can categorize multiple concepts within a single rubric bin, each analytic bin represents a single concept. We use machine learning (ML) to develop scoring models based on these rubrics in order to score large number of responses. In preliminary work, we found that an analytic rubric reduces coding complexity, which may improve model development. The objective of this current study is to empirically compare results of two coding approaches, analytic and holistic rubrics, using outcomes of human-human inter-rater reliability (IRR) and outcomes of two, automated ML scoring models (i.e. human-machine IRR). We are systematically comparing two approaches of rubric development and coding: i) holistic approach based on LP levels, and ii) analytic approach based on multiple subscores of student reasoning, that can be subsequently combined to generate a holistic code. Responses to four different assessment items about flux were coded (two experts coded ~700 responses) using both holistic and analytic coding approaches. We then used the codes to train two different ML models: i) an 8 classification algorithm ensemble, and ii) LightSide Researcher’s Workbench. Time and effort of coding and model building were recorded and used in a cost-benefit evaluation of approaches. Coding and ML results varied across items and rubric type. As an example, human coding for a 13-bin analytic rubric had an IRR range, measured by Cohen kappas (K), from 0.80-0.97 for 12 bins with the 13th at 0.59. We condensed the 13 bins to 12 for ML. ML had K ranges from 0.67-0.99 and 0.54-0.99 for ensemble and LightSide, respectively. In comparison, coding of a holistic approach for another item had human K of 0.87. ML had Ks of 0.73 and 0.72 for ensemble and LightSide, respectively. Results show coders achieved sufficiently high IRR between both rubric approaches. Also, both ML approaches have similar performance metrics for predicting holistic and analytic codes in these rubrics; although, the ensemble approach may have some benefit by improved performance on analytic bins that are more difficult to model. Metrics for model performance across items will be examined. Findings from this work will inform rubric development, coding and ML approach best suited to score short, content-rich, constructed response assessments; especially those associated with complex constructs such as a LP. Findings from this study may be of interest to researchers who employ qualitative coding methods or are interested in ML approaches.

**Poster #119**

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

Even though substantial evidence shows that active learning strategies result in enhanced student learning in undergraduate biology, most lectures are still taught using traditional strategies. However, students enrolled in introductory biology courses at primarily undergraduate institutions (PUI) are often required to co-enroll in lab sections. The design of lab activities varies, but all emphasize the process of science in the context of lecture content. Thus, although most introductory lectures are traditionally taught, the associated labs provide an aligned active learning experience that focuses on both the process of science and course content. Our hypothesis is that students who have a traditional lecture, but an active learning laboratory experience aligned with lecture, will
demonstrate better mastery of concepts that are used in lab compared to those taught only in lecture. To test this hypothesis, we have enrolled 6 biology instructors and 158 undergraduates at a single PUI. Prior to the study, the instructors reviewed the Introductory Molecular and Cellular Biology (IMCA) or the Ecology and Evolution-Measuring Achievement and Progression in Science (EcoEvo-MAPS) concept tools and indicated which topics on each assessment were learned in (1) lecture only, (2) lecture and lab, or (3) neither lecture nor lab. Enrolled students completed these assessments at the beginning (pre-test) and end (post-test) of the course. Post-test performance will be correlated with pre-test performance to document the change in mastery. To control for confounding influences due to differential instruction, we characterizing the level of active learning and engagement in each classroom using the Classroom Observation Protocol for Undergraduate STEM (COPUS) tool. Each instructor was observed at least three times over the course of the semester. At the end of each semester, instructors will complete the Teaching Practice Inventory (TPI) to generate an “extant of use of research-based teaching practices” (ETP) score. Hierarchical linear modeling will be used to “nest” student data within instructor and within course type. The significance of this study is that it will provide some much needed information about the role of course-associated labs at PUI in helping students master content that is still mostly delivered as lecture. If our hypothesis is correct, this has implications for the intentional design of course-associated labs to maximize content mastery.

Poster #120
Exploring the role of motivation on retention of conceptual knowledge and model-based competencies.
Bethany J Gettings (Michigan State University)*; tammy m long (Michigan State University) Paper ID: 135
Fewer than 40% of students who begin college with an interest in science ultimately attain a STEM degree; a majority abandoning this goal after enrolling in their introductory STEM courses. Increasingly, research is focusing on the role of motivation in STEM persistence, but few have examined its relationship to measures of performance, particularly over time spans longer than the duration of tough, introductory classes. For my dissertation, I propose research that asks, “Is there a relationship between motivation and long-term retention of conceptual knowledge and skills?” My study focuses on students in a practice-based introductory biology course that relies extensively on model-based instruction. To assess motivation, I will use surveys based on two theoretical frameworks: (1) Achievement goal theory explains three underlying purposes for engaging in achievement-related behaviors: mastery focuses on acquiring new information to develop competence, performance-approach relates to outperforming their peers and appearing competent, and performance-avoidance indicates a desire to avoid appearing incompetent. (2) Expectancy-value theory suggests the most direct predictors of achievement are students’ expectations for success (perceived competence) and value they attribute to the task (task value). Hierarchical cluster analyses of survey data will identify motivational profiles. Performance will be assessed by analyzing classroom artifacts and conducting interviews with a subset of students during and 1-year post course. Interviews will engage students in model-based tasks similar or identical to ones experienced during instruction. An emergent coding scheme will identify and classify behaviors and utterances indicative of modeling competencies and conceptual understanding. Holistic rubrics will be used to evaluate overall interview performance as well as quality of model-based artifacts. MANOVA analyses will indicate whether motivational profiles are predictors of short- and/or long-term model-based performance. While motivation is thought to be just one of myriad factors that predict students’ long-term academic success, it is under explored in terms of its relation to specific performance measures. Gaining a better understanding of motivation during the early college science experiences may be a critical factor in supporting motivation, retention, and achievement for all students in STEM.

Poster #121
The effectiveness of virtual labs in introductory Biology course in promoting basic laboratory techniques.
Douglas Ayega (University of North Texas)* Paper ID: 34
The advent of information technology has created an array of pedagogical applications which have sustained unique learning environments characterized by computer simulations and virtual realities. These artificial forms of
learning environment display exceptional modes of learner/learner and learner/instructor interaction. Introductory biology classes are designed to enhance learning of scientific skills through hands-on experiences to promote mastery of biology laboratory techniques in subsequent higher level biology courses. Numerous studies on pedagogical approaches that have integrated virtual labs in teaching introductory biology classes have depicted an increase in learning, engagement, and improved outcomes. However, most of these studies have not analyzed how basic lab techniques learned through virtual labs can enhance future performance in biology courses. Some of these basic laboratory tenets include: Understanding course content Experimental design Collecting and analyzing scientific data Applying science in answering questions Apply scientific knowledge to create a theory

This study investigated the learner’s perceptions and their achievements based on the above objectives on both live and virtual lab. Students investigated the effect of enzyme catalase on hydrogen peroxide to demonstrate their conceptualization of the basic skills. They were taught on properties of enzymes, mechanisms of enzyme function, and factors affecting enzymes. The lab created a traditional live lab and a student designed virtual lab. The live lab comprised of denatured (control) catalase enzyme (boiled at \(100^\circ C\)) and two experimental catalase enzymes: deactivated frozen (\(0^\circ C\)) and active (\(37^\circ C\)). Students were anonymously surveyed before and after both lab activities. A chi-square revealed that a significant number of students reported increased knowledge, confidence, and experience on lab techniques from virtual labs. The importance of this article is to ensure that best pedagogical approaches are used to provide learners with a solid foundation for academic success in subsequent biology courses. This study observed that the integration of virtual labs in introductory biology courses is significant in standardizing techniques and promoting successful experimental outcomes in subsequent biology courses. However, limited studies are still at initial stages to reveal how students can apply scientific knowledge through virtual labs to create theories.

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

Two of the essential practices of science are the analysis of data and the creation of visual representations for exploration, interpretation, and communication to a broader audience. This requires that students create and use graphs to explore and summarize their data in a way that is aligned with their research question, hypothesis, and/or predictions. As part of a bigger NSF-funded project where we are designing a digital graphing assessment tool, we explored 43 undergraduate biology students’ graph constructions in two different formats: pen-and-paper and digital. Participants from two different Midwestern universities made a graph testing a hypothesis/prediction in the context of conservation biology. 21 students were assigned to the pen-and-paper format, and 22 to the digital; both participant groups had a similar representation of class standing and ethnicity. Participants’ graphs were analyzed to identify the graph types used, variables plotted, and the form of the data plotted (i.e., aggregated versus raw). Constant comparative analysis (Strauss & Corbin, 1994) was used to analyze participants’ verbal justifications for graph types and variable selection. The most popular types of graphs were bar and scatter, and raw data was plotted more frequently than aggregated data in both graph types. Preliminary results of the analysis of participants’ justifications for their selection of graph types illustrate that they mostly referred to characteristics of the data, visualization affordances, data exploration, and consideration of other graph types. Participants mostly justified their selection of variables referring to the hypothesis, prediction, contextual information, and/or personal reasons. Participants’ justifications differed by graphing format. They were more likely to refer to data visualization reasons for selecting a graph type when graphing in the digital format, and through a comparison of graph types when graphing in pen-and-paper. This study contributes to our understanding of the affordances and limitations of working in different formats when graphing, which provides us with potential instructional targets and insights into the potential impact of the graphing formats for student learning.
Poster #123
Exploring Student Self-Efficacy Through Quantitative Biology Group Work
Alexander Kulacki (University of New Hampshire)*; Melissa L Aikens (University of New Hampshire) Paper ID: 107

As the field of biology becomes increasingly quantitative, there is a growing need for better integration of quantitative skills into the biology curriculum, but these efforts can be hampered by low student engagement. Self-efficacy theory posits that student engagement and performance on a task is influenced by their beliefs about their ability to succeed at that task. Students build self-efficacy through experiencing success on the task (mastery experiences), comparing their ability to their peers (vicarious experiences), or receiving feedback from others (social persuasions). Self-efficacy is also influenced by a student’s physiological state towards the task, such as fear or anxiety. Group work is one instructional strategy with the potential to increase students’ self-efficacy, but how students experience the sources of self-efficacy through group work and how different sources affect their overall self-efficacy is unclear. This exploratory qualitative study examines how group work affects the quantitative biology self-efficacy beliefs of introductory biology students, specifically those who report low math self-concept. Students worked in small (4-5 student) groups to complete in-class quantitative biology assignments. Upon completion of an assignment, low self-concept students were invited to participate in a short semi-structured interview which asked about their experiences working with their group on the assignment. Preliminary analysis of four interviews suggests that students became more confident in solving quantitative biology tasks upon given opportunities to master them (“Really just being able to do them out [helped], because I didn’t know how [at first]... Once I’m able to answer the first [few], I feel pretty good.”). This mastery is reinforced by the collaborative aspect of group work through vicarious experiences (“I thought when I was doing it I... shouldn’t have [the answer]. But... I was more confident because everyone else did.”) and social persuasions (“I think it’s helpful when we can just talk to each other...”). However, students also experienced negative social persuasions when conflicts arose (“It's difficult for me because I don't feel as confident in what I think is correct as they do so it's kind of easy for me to back off or just agree with them.”). This study will provide useful insight into how educators can structure group work to promote the development of self-efficacy, especially within the context of quantitative tasks.

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

The University of Minnesota Duluth’s Introductory Chemistry Laboratory Series has previously been revised in to include more experimental design elements in each lab period to enhance student learning and prepare students for greater challenges in their upper division courses. Assessing the effectiveness of this new curriculum is necessary, and we developed an instrument to do this based on previous research. We adapted the Experimental Design Ability Test (EDAT), replacing the biology-specific prompt with a more chemistry-specific prompt. This test was given to both the lab for chemistry and biochemistry majors only, where the new curriculum has been implemented for the 2018/2019 academic year, as well as to the lab for non-majors, who were enrolled in the original lab curriculum. The pre-test was given at the beginning of the first semester before students began any labs, and the post-test was administered at the end of the second semester. Learning gains between these pre- and post-tests will be compared to assess their learning over the two semesters of lab. The student responses were scored using a ten point rubric. The ten criteria in this rubric, based on the original EDAT rubric with some modifications, advance in difficulty to achieve and use higher level chemical reasoning to discriminate between the higher points. Multiple raters have score the student responses. To ensure reliability between graders, analysis using Cohen’s Kappa was utilized for each criterion, giving an average of around 0.76. This project aims to increase student abilities to independently plan and execute experiments. In the future, we aim to introduce this curriculum for all students in the Introductory General Chemistry Laboratories, including students majoring in other STEM disciplines.
**Poster #125**  
**Where to sit? Student seating preference, motivation, and performance in introductory biology.**  
Chloe Wasendorf (Iowa State University)*; Nancy Boury (Iowa State University)  

While there have been studies examining the correlation between student position in the classroom and their educational outcomes, most have been in smaller (under 40 student) classrooms (1), in non-STEM fields (2), or experimentally manipulated where students are sitting (3, 4). In this study we examined the relationship between student choice of seat and their performance as measured by daily work, unit exams, final exams, and final grade. We also looked at differences in student attendance, student motivation (5) and self-assessment of understanding (6) to determine possible correlations between self-regulated learning practices, time spent in class, course performance, and seating preference. The data gathered from two different semesters with approximately 250 students each semester in an introductory biology class indicate that students choosing to sit in the back of a large lecture hall have significantly lower performance on unit exams, in-class work (clicker points), and a comprehensive final exam. They also have significantly lower attendance. Deeper analysis of the student motivation data, showed lower grade-based motivation and self-determination (study strategies) in the middle section when compared to both the front and the back. The evidence suggests that while students choosing to sit in the back do tend to perform worse overall, they also differ significantly on other variables, such as attendance, self-determination, and grade motivation, suggesting that lower performance might be about more than just the choice of seat location. In this session we will discuss both the research findings and discuss teaching strategies based on this data. References 1. Kaya N, Burgess B. 2007. Territoriality: Seat preferences in different types of classroom arrangements. Environment and Behavior 39:859-876. 2. Pichierri M, Guido G. 2016. When the row predicts the grade: Differences in marketing students’ performance as a function of seating location. Learning and Individual Differences 49:437-441. 3. Kalinowski S, Toper ML. 2007. The Effect of Seat Location on Exam Grades and Student Perceptions in an Introductory Biology Class. Journal of College Science Teaching 36. 4. Armstrong N, Chang S-M. 2007. Location, location, location: does seat location affect performance in large classes? Journal of College Science Teaching 37:54. 5. Glynn, Shawn M., et al. "Science motivation questionnaire II: Validation with science majors and nonscience majors." Journal of research in science teaching 48.10 (2011): 1159-1176. 6. Dunning, David. "The Dunning–Kruger effect: On being ignorant of one's own ignorance." Advances in experimental social psychology. Vol. 44. Academic Press, 2011. 247-296.

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

Introductory level courses play an important role in STEM students’ retention. Interestingly, prior research indicates that the first day of class alone can impact students’ course grades. The first day of class can vary in content and aims dependent on the instructor and, while there are many recommendations for best practices in popular press articles, there is little research on what actually takes place on that day in STEM courses. Our work aims to address this gap by cataloging how time is spent during that day (e.g., going over the syllabus, diving into content, introductions between students) and identify the kinds and abundance of noncontent instructor talk. We leveraged the noncontent instructor talk framework described by Seidel et al. to inform our analysis. This framework encapsulates everything an instructor says that is not focused on delivering content to students, such as pre-framing classroom activities, empathizing with student struggles, and explaining the nature of the field. Seidels’s original noncontent instructor talk research analyzed two biology courses throughout the entire semester and found that the first day of class contained the greatest abundance of noncontent instructor talk. However, additional courses have not been studied using this lens or focusing on the first day of class. Our sample included 23 videos of the first day of class in introductory STEM courses from across three research-intensive universities. By focusing only on the first day of class, we are able to diversify the number and field of courses analyzed with
this framework with the aim of capturing variation in instructor approaches to the first day. We used deductive coding to analyze the videos for noncontent instructor talk and also cataloged the topics covered on those first days. Our coding captured both the frequency and length of instances of noncontent instructor talk by coding occurrences of different types of talk (e.g., relating to student experiences and boosting self-efficacy) in one-minute windows of class time. This analysis indicates that each faculty member focused on a different subset of aims on the first day, which ranged from outlining the activities that would occur throughout the semester to establishing classroom culture and norms. Therefore, students may begin STEM courses with various understanding about classroom expectations and differing preparation of what to expect in these courses. Each topic that may be covered on the first day of class expresses different priorities and expectations to students through noncontent instructor talk. Identification of the relationship between topics and noncontent instructor talk can promote deep reflection of what the first day of class imparts to students.

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

The research on argumentation in science is vast, examining diverse settings, educational levels, and interventions. Students learn best when their ideas are challenged and when they challenge other’s ideas. When data is the focus of argumentation, close examination of ideas encourages students to develop relationships among science concepts and practices, strengthening the cognitive pathways by which students draw on that knowledge. Empirical studies of undergraduates in argument-based laboratory courses and controlled, lab-base psychology studies support this assertion. Notably, research conducted in large-lecture undergraduate courses is largely missing. While there is sufficient evidence to suggest that argumentation-to-learn pedagogies can increase student learning and reduce achievement gaps observed for traditionally underrepresented groups, most studies have been conducted in smaller classes or laboratory sections. Little is known about how to scale argumentation-to-learn for large-lecture environments. For example, what pre-class activities will support students for in-class argumentation sessions? What instructor scaffolding must occur in real time to engage all students in argumentation? What data are most fruitful to ask students to discuss in an argumentation session? In the work presented here, we investigate the pre-class supports necessary for in-class argumentation in large-lecture biology. Prior to an argumentation session designed to teach students about the role of alternative splicing in cancer, we provided students lecture notes and a pre-class assignment which included (a) an application question about alternative splicing and (b) the first set of data that would be used during the in-class argumentation session. We compare student performance across two sections of large-lecture biology to determine (a) the efficacy of these activities in preparing students and (b) whether or not there is benefit to students seeing the data prior to class. Through this poster, we hope to both share and gain insight from other large-lecture biology instructors and biology education researchers about how to leverage pre-class activities to prepare and engage students in active, constructive activities during class.

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

Our students spend a substantial amount of time working in their laboratory groups, and we as instructors want to make evidence-based decisions on how to best form these groups. Despite several studies on group composition, the evidence appears to be quite context-specific, and very little has been published about lab groups. Further, many studies focus on conceptual learning, while the lab is an important venue for also supporting non-content outcomes such as confidence, process skills, team skills, and attitudes. Thus, we are interested in the impact of group composition, and group formation process, on a spread of student outcomes.
We have collected pre/post data from >800 students over 3 semesters; our measures assess conceptual knowledge, confidence in lab skills, attitudes toward group learning, lab grades, some demographics, and student perspectives (open-ended questions). Using a multiple regression approach, we have established a model that predicts student outcomes depending on their individual and their lab group attributes. Surprisingly, several variables in the model were unimportant: most notably homo/heterogeneity of the initial group attributes, and whether the groups were student- or instructor-selected. Further MANCOVA analysis demonstrated that student interactions outside of the lab were the strongest predictors of positive student attitudes toward group learning. These findings have clear implications for our course design and instructional choices; this poster will describe how we can focus our efforts to promote positive student outcomes in our lab courses.

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

In response to the 2010 NSF and AAAS appeal for biology departments to evaluate how their teaching practices reflected current “real world” biology scientific endeavors, our public university, open access, multi-campus biology department conducted an extensive curriculum review and revamped our approach to introductory biology. This research explores student learning for Vision and Change outcomes in online and traditional course delivery modes. Aligned with core competencies the introductory biology course was redesigned into a 6-credit, one-semester intensive, with current best teaching practices to immerse students in the scientific method. After 7 semesters, the redesigned course success rate is ~87%. A challenge for this design model has been to help students with a wide variety of backgrounds, many of whom have work and family commitments that make a 6-credit face to face course particularly challenging. Therefore a blended version of introductory biology with lecture material provided online, while the lab remains face to face, was created. A 5-week unit/module with identical materials and assessments across the delivery modes allowed for evaluation of student performance. Concept quiz 7 and 8 scores were significantly lower (p=0.02, p=0.002, respectively) for the hybrid cohort as compared to the face to face cohort. Concept quiz 7 average score for hybrid was 70.2% ± 5.29% (CI 95%, n=12) while face to face was 82.3% ± 1.99% (CI 95%, n=83). Concept quiz 8 average score for hybrid was 67.3% ± 9.16% (CI 95%, n=12) while face to face was 76.5% ± 3.28% (CI 95%, n=87). Because the course focuses on scientific practice and exploration, not just rote knowledge, quantitative quiz results only assess one aspect of learning. The analysis of this course will be continued to determine break downs in student learning and reasons for reduced success in biological concepts. It is necessary to attain success with this hybrid module to include remote site labs that increase students’ success in STEM fields and begin their scientific method training at an earlier point in their scientific careers. Implications for these data could help expand student learning beyond traditional course settings, it is critical that we find innovative ways to deliver high quality scientific method development courses to STEM eager students.

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

Fostered by reports such as Vision and Change, changes in the way colleges are teaching their biology courses can be observed nationwide. Change has come in the form of initiatives dedicated to advancing evidence-based science education practices, including active learning. One stumbling block in the process of this transformation is the time and energy commitment, which can be substantial, needed to produce the learning materials. In response to this need, the journal CourseSource was created. Here, we will familiarize the audience with CourseSource, show how this journal has grown in recent years, and describe how this journal provides authors with the opportunity to publish teaching materials. CourseSource publishes undergraduate biology teaching materials that implement approaches already shown to be effective. It is not an attempt to reinvent or compete with existing repositories or publication routes. Rather, CourseSource fills the previously unmet need for a peer-reviewed journal that captures and shares high quality, evidence-based teaching methods. Most importantly, this format
means that adopters of active learning have a place they can go to obtain teaching materials that have been vetted by experts. Thus, it is appropriate to think of CourseSource as a methods journal for teaching, with articles that provide specific field-tested implementations of evidence-based practice in a variety of undergraduate classroom contexts. CourseSource contributors describe how they have developed and implemented evidence-based approaches to meet specific learning objectives established by scientific societies. The opportunity to publish in CourseSource incentivizes instructors to share their materials publicly, thus promoting scholarly teaching in a format that intentionally supports use by others. Recently, there have been several movements to rethink the way teaching effectiveness is evaluated. Notably, there are generally agreed upon metrics for evaluating research success, but evaluating teaching expertise using only student evaluations can be subject to bias and not necessarily tied to student learning. However, if faculty publish their activities in peer-reviewed journals like CourseSource, these publications can be used as evidence for effective teaching. By publishing in CourseSource, authors can amplify the impact of their work, promote course transformation, and help students learn—all at once.

**Poster #131**

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

STEM graduate students are the future and will serve as science ambassadors throughout their careers. Increasingly, communicating science to the public is recognized as the responsibility of professional scientists; however, these skills are not always included in graduate training. Not providing science communication training limits access to those students with external resources, such as time and money, to attend additional workshops. When the availability of science communication becomes limited, science communication is not democratic. This study provides a comprehensive analysis of what science communication training is like from the point of view of today’s STEM graduate students. A survey was distributed using social media and relevant list-serves across the US in the summer of 2018. We received 143 complete responses from STEM graduate students in 24 states, two US territories, and three international locations. We have a gender ratio of 70:30 female to male and a demographic spread of 69% white, 12% Hispanic, 1% black or African American, 14% Asian, and 2% multiracial. We have a broad distribution of time in graduate school, with the majority of students responding being in the middle of their graduate careers and working towards a PhD degree. Half of our respondents are in the biological/health sciences (52%), 36% are in mathematics/physical sciences, 7% in the social sciences/humanities, 3% in computer sciences, and 2% in engineering. We are confident that our data represents the average graduate student. We investigated where graduate students are receiving science communication training (if at all), what this training looks like from the student’s point of view, and, for graduate students that are engaging in science communication, what do these experiences look like. Quantitative data indicates that 74% of respondents received no formal training in science communication from their graduate institutions. There is approximately an even spread in where the students who do receive training (26%) actually get their training: within their institution, at an extracurricular workshop, or other. This suggests that the average graduate student is most likely not receiving science communication training, and, if they are, they are most likely going outside of their institution to find opportunities. We also explore, using qualitative data, how graduate students define science communication and how they describe their previous opportunities, if any, to communicate science. Respondents shared their thoughts on the intersection of teaching and science communication in order to determine if graduate students would be interested in using teaching opportunities, which are often built into doctoral programs, as an avenue to improve their science communication. Taken together, these results will provide a starting point for designing science communication training modules that can better integrate into existing graduate programs.

**Poster #132**

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

Research Question and Problem Despite recommendations to implement evidence-based instructional strategies (EBIS) (e.g., Freeman et al., 2014), many post-secondary STEM classrooms still tend to exhibit traditional
methods of instruction (Stains et al., 2018). STEM faculty perceptions of the relationship between research and teaching may offer insight for why they may revert to traditional teaching methods in light of evidence. For example, institutional and departmental guidelines for promotion and tenure are oftentimes perceived to prioritize successful research over effective teaching (Dennin et al., 2017). Neumann (1992) found that academics can perceive the research-teaching relationship (RTL) at various systemic levels. This could be in terms of an individual’s research influencing their teaching practices, as well as the hiring decisions at the departmental level influencing the courses that are offered to students. Faculty begin their development of these perceptions as graduate students. Therefore, using ecological systems theory (Bronfenbrenner, 1978) this study explored the systemic levels that may influence biology graduate students’ perceptions of the relationship between research and teaching. This presentation will disseminate findings pertaining to how biology graduate students perceive the relationship between research and teaching. Two research questions guided this work: (1) Do biology graduate students perceive a relationship between research and teaching as synergistic, antagonistic, neutral, or nonexistent and (2) what ecological systems shape biology graduate students’ perceptions of the relationship between research and teaching? Research Design Using a convergent-parallel mixed methods research approach, data was collected using a cross-sectional survey that was distributed to biology graduate students (n = 317) across the United States. The survey included both open and close-ended questions about perceptions of the RTL as well as norms and social relations experienced related to RTL. Analyses and Interpretations This study was descriptive in nature. Frequency counts of respondent perceptions of the RTL were generated. The survey had three multiple choice items that asked participants to select the response they most agree with. Each response was coded as either -1 (antagonistic), 0 (neutral), or +1 (synergistic). For each respondent, an additive score was generated for the three questions and coded on a scale from antagonistic (more negative) to synergistic (more positive). The second research question was answered by generating frequency counts of responses to Likert-scale “agreement” items. These questions were designed to ask participants whether they perceived certain norms about research and teaching at different ecological systems levels. Preliminary results revealed biology graduate students hold primarily synergistic perceptions of the RTL. This is congruent with the scholarship on faculty perceptions of the RTL. However, graduate students seem to be experiencing mixed norms and messages about the prioritization of research and teaching. Contribution This work contributes to the growing literature on the professional development of biology graduate students and their experiences in graduate school. Future work will take a more in-depth approaches to understanding how these perceptions are developed and how they may affect other professional development processes during graduate school.

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

Scientists communicate their work to the public in order to increase public scientific literacy and increase transparency about tax-funded projects. Some faculty and graduate students in academia perform outreach because it is congruent with their personal identity or values, despite the fact that it may be in conflict with academic environments that focus on research or teaching accomplishments. For graduate students, there can be mentor, departmental, or even disciplinary discouragement from performing outreach. This can put the identity of the graduate student in conflict with aspects of their research context in ways that impact outreach. This research explores this “cost” aspect of outreach, as per the expectancy-value theory. Specifically, this research asks, “Does conflict between outreach identity and academic context impact outreach participation at one institution?” In Spring 2019, a survey was sent to all Science, Technology, Engineering, and Mathematics (STEM) graduate students at a large Southeastern public research university (N=2,300). The survey included a variety of closed- and open-ended questions, of which this study analyzed their participation in outreach and any conflict they felt in pursuing outreach. About half of the participants to date (N=119 students; N=21 departments) had performed outreach (54%). Outreach was selected more often as an extremely integral part of their identity for those who performed outreach versus those who did not (33% versus 4%). Although the majority of students reported “no conflict” between outreach and research in their STEM fields, departments, lab mentors, and themselves (66%, 71%, 72%, and 57%, respectively), those who conducted outreach reported “some conflict” more often than those who did
not conduct outreach (yes= 46%; 38%; 25%; 44%; no=32%; 24%; 15%; 33%). When asked why they felt conflict, many students said there was a lack of time considering that research was their main priority, and publishing versus participating in research is how they will attain a job. These results suggest that although most STEM graduate students saw no conflict between outreach and research, those performing outreach had identities more aligned with outreach and reported slightly more research-outreach conflicts (i.e."I see conflict between the time you need to spend doing research and the free time to do outreach" and "... time spent conducting research is generally valued higher and has more direct and measurable benefits"). Exploring the conflict that students face can give insight into how perceptions of outreach and research may be impacting students who wish to reach out to the community as part of their identity.

Poster #134
The effects of a semester-long pedagogical training on the teaching knowledge and mentoring relationships of graduate and undergraduate teaching assistants
Mitra Asgari (Cornell University)*; Frank R. Castelli (Cornell University); Mark A. Sarvary (Cornell University) Paper ID: 81
The pedagogy training provided to Graduate Teaching Assistants (GTAs) at different colleges if available varies in terms of content, duration, and extent, while often no or very limited training is offered for Undergraduate Teaching Assistants (UTAs). However, in a course where the Graduate and Undergraduate Teaching Assistants work together to foster students’ learning, a concurrent pedagogy training can benefit both groups of Teaching Assistants as well as the students taking the course. Here, we investigated if teaching perspective and knowledge of GTAs and UTAs change before and after participating in a semester-long pedagogy training while teaching an undergraduate biology laboratory course at a research-focused institution. Also, we investigated whether this pedagogy training improved the mentor-mentee interactions between the GTAs and UTAs. To answer these questions, a group of GTAs and UTAs assisting with the laboratory sections of an introductory biology course participated in a developed pedagogy training and assessment processes. We have used pre/post survey questions and weekly reflection paragraphs to assess the effectiveness of the designed pedagogy training. Results from the first semester of this study (Spring 2019) will be presented. Because the participated GTAs have a more diverse teaching and mentorship background (novice vs. experienced GTAs), we expect to see more variation in the way the pedagogy training impacts their teaching perspective and performance compared to the UTAs which have a more similar prior teaching experience (mostly novice). With the design and assessment of such pedagogy training, we hope to help GTAs shape and improve their student-centered teaching skills and mentoring expertise of undergraduate assistants in teaching environments. In addition, such training can provide valuable instruction and support for UTAs to have valuable experience in transitioning from a student to an educator role. Finally, such training could indirectly improve the quality of teaching and learning environments provided to the undergraduate students taking a course.

Poster #135
Detecting the Winds of Change: Classroom Observations and Syllabi as independent indicators of instructor transition
Rebecca S Reichenbach (North Dakota State University)*; Madison Milbrath (North Dakota State University); Lisa M Montplaisir (North Dakota State University) Paper ID: 138
Billions of dollars have been poured into professional development programs in hope that faculty would embrace and implement evidence-based practices. Research has shown the opposite still holds sway as traditional lecture continues to dominate undergraduate classrooms. Extant studies have examined results of professional development using pre/post indicators leaving the transition process itself an enigmatic area. This study begins to blow aside some of the curtains shrouding the process of instructional change. Instructional change was examined in the context of a professional development program at a doctoral granting institution that runs two years with periodic workshops and on-going support in the form of Faculty Learning Communities. This has allowed us to address the question: When does the largest proportion of instructional change occur? Nine participating STEM faculty met the selection criteria: instruction of the same course across multiple Fall semesters, attendance at the majority of the training workshops, and self-identified as transitioning their courses. Data was collected in the form...
of classroom observations and participant submitted course syllabi. Unannounced classroom observations were conducted at least twice during each semester of participation. They were documented using the Classroom Observation Protocol for Undergraduate Stem (COPUS). COPUS data were averaged for each semester to generate an instructional profile for each participant. Codes of specific interest for the study were those aligning with active instruction (e.g. Students doing: group work; Instructor doing: moving among groups). Syllabi were examined using two rubrics. The first rubric checks compliance with university requirements. It was developed and refined through an iterative process. The learner-centered rubric is an existing validated rubric. All syllabi were rated on both rubrics by teams who came to agreement on final scores. All data indicate the same semester for greatest change: the Fall semester following the third workshop of the program. This may be due to amount of cognitive processing time after first training, time over the summer semester for instructors to plan, or the number of training workshops. The time-point where instructors are attempting to implement the greatest amount of change is when they need the most support. Revealing this critical period allows future professional development programs to target extra support.

Poster #136
Survey data support international graduate students as biology instructors
Lisa L Walsh (University of Michigan)* Paper ID: 141
In most American universities, undergraduate students are largely introduced to college-level science by graduate student instructors (GSIs). Undergraduate student performance in early courses affects their decision to ultimately pursue a STEM degree, situating GSIs in a potentially impactful role in STEM retention (Seymour and Hewitt, 1997). First-time GSIs express concerns including feeling unprepared for the job at hand and receiving limited support (Smollin and Arluke, 2014), and this anxiety can be amplified if the GSI is an international student (Moussu, 2006). One study evaluating GSIs in a large psychology class found that students with an international GSI received a slightly, but statistically significant, lower grade (Borjas, 2000). Recently, students expressed that their higher education is negatively affected by language barriers in the classroom (Finder, 2005). To better understand how domestic and international GSIs impact undergraduate students in science, I surveyed 1474 students and their 37 GSIs at an R1 institution across three semesters in a gateway biology course. Undergraduate surveys evaluated interest in a STEM major and course grades because higher grades in gateway courses increase the likelihood of majoring in STEM (Seymour and Hewitt, 1997). GSIs identified their previous academic institution, and all GSIs originating from international institutions were confirmed as English language learners. Student overall grades, paper grades, and interest in majoring in STEM were compared between domestic and international GSIs, using a two-tailed unpaired t-test. Overall grade and change (after — before) in STEM interest across the semester did not differ between students taught by domestic and international GSIs (all p > 0.498). Students taught by international GSIs received significantly higher paper grades than those taught by domestic GSIs (all p < 0.001). This difference in paper grading might be due to the time and effort required to grade as an English language learner. My results indicate that paper grading techniques are an important topic to cover for international GSIs when designing professional development. International GSIs showed no negative impacts on overall grades or student interest in STEM. Empirical data such as these are vital for promoting and sustaining diversity in academic institutions, especially given the current political climate, in which many foreign GSIs feel less welcome and supported in American academia (Gewin, 2017).

Poster #137
Graduate Teaching Assistants’ Cognition Related to Teaching: A Comparison of STEM and Non-STEM Groups
Dirhat M Mohammed (MTSU)*; Grant E Gardner (Middle Tennessee State University) Paper ID: 183
STEM Graduate teaching assistants (GTAs) teach a large number of undergraduate students in many university departments, yet receive few opportunities for teaching professional development (Gardner & Jones, 2011; Schussler et al., 2015). Understanding how to design effective professional development requires scholars to first elicit pre-established cognitive variables that GTAs bring to the classroom. There is very little research dedicated to measuring these variables related to effective teaching in GTAs (Reeves et al., 2016). It is also unclear if STEM GTAs are in a unique position due to the fact that they commonly teach laboratories. We operationalize “cognition
related to teaching” as GTAs’ beliefs and opinions with regard to their teaching. Understanding GTAs cognition related to teaching, requires valid and reliable instruments; to this extent it is necessary to investigate known instruments measuring such criteria to effectively corroborate the results that those instruments might provide and deem them as reliable. Five instruments were validated with a sample of n = 52 graduate teaching assistants from various departments at a large southeastern university. The data that will be presented in this poster are the results of a confirmatory factor analysis of the pre-data from five instruments: Teacher Beliefs Instrument (Luft & Roehrig, 2007), Pedagogical Discontentment Inventory (Southerland et al., 2011), Teaching Self-Efficacy Beliefs (DeChenne, 2012), Goal Orientations Toward Teaching (Kucsera et al., 2011), and the Instructional Practices (Walter et al., 2017). We also compare the results of these measures for STEM and non-STEM graduate students. By interpreting the results of this study, we hope to translate them into concrete goals to design and construct effective teaching professional development programs for STEM graduate students. This talk will be interesting to both undergraduate educators as well as education researchers.

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

Teaching assistants (TAs) often lead biology laboratory classes. The training that these TAs receive is highly variable, and the effectiveness of training is rarely assessed. Additionally, course administrators often have a limited amount of resources available to implement a training program. As a result, TA training often focuses on either pedagogical techniques that are broadly useful to a variety of TAs teaching myriad courses, or course-specific procedural content related to curricular activities. We aim to investigate if training that incorporates both pedagogical techniques and content knowledge is effective in preparing TAs to create a student-centered classroom. We trained TAs to enact a series of activities designed to incorporate student-centered learning techniques. The trainings and activities were implemented in a quasi-experimental design; all of the TAs received procedural training on the lab exercises (Traditional), and half of the TAs participated in additional trainings that explored teaching techniques and content that can be used to facilitate student-centered learning (Intervention). The training sessions and associated activities occurred early in the course, during which time all TAs were observed. Intervention TAs were observed teaching one of the new activities for which they had received training incorporating pedagogical content knowledge, while traditional TAs were observed teaching an original lab exercise. TAs were also observed a second time, when all TAs were teaching lab exercises for which they had received traditional training. Observations were analyzed using the Reformed Teaching Observation Protocol (RTOP). Preliminary data shows that intervention TAs had significantly higher RTOP scores than TAs teaching the traditional curriculum, suggesting that the design of the lesson is an important factor that impacts how TAs teach. To investigate if pedagogical training early in the semester impacted how TAs later taught, we explored the impact of lesson design and training experience on TA RTOP scores at timepoint two using a linear model. Our initial analysis suggests that both lesson design and prior training significantly impact TA RTOP scores at timepoint two. Future work will expand our findings to a larger group of TAs and characterize the teaching moves that TAs are using in their classrooms after undergoing training.

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

No matter their level of education or preferred title, many university-level STEM instructors experience variability in how their students address them. This variability could be due to a student’s lack of knowledge of appropriate titles, their means of expressing respect or disrespect based on personal attitudes towards a particular professor, or even just conforming to contemporary vernacular that students are accustomed to using in their everyday language. Physical attributes such as race, attractiveness, age, and gender may also affect student
attitudes. Our study focuses on the impact of instructor gender and age, and whether or not these factors significantly affect the titles students use to talk about their instructors. As a first step to answer this question, we used www.ratemyprofessors.com, a popular teacher-rating website utilized among college students. Rate My Professors currently includes over 6000 colleges and universities and nearly 800,000 instructors. This public forum gives students an opportunity to express feelings and opinions about instructors on an anonymous platform with a high level of openness and immunity. In the context of this freedom, students are able to refer to their professors in whatever way is most comfortable or suitable for them personally. While data from this website have limitations (selection bias, inadequate information about student rater identity, etc.), the amount of data and the opportunity to easily compare different institutions make it a valuable resource. By evaluating the frequency of titles used (i.e. Doctor, Professor, first name only, last name only, etc.) for instructors with at least five reviews on Rate My Professors, we hope to see if instructor gender and age play a significant role in how students address their professors. Preliminary analysis of ratings for life science instructors at a large, private university suggests that male instructors are more likely to be called by their last name only and called a “teacher” while female instructors are more likely to only be referred to by pronouns rather than a title. Older instructors were more likely to be called by terms such as “this guy” or “lady.” Once our dataset is greatly expanded, multiple regression will be used to better capture the complex relationships between various instructor characteristics and how they predict wording in student comments. Results at different institutions will also be compared.

Poster #140
An exploration of the benefits of the undergraduate teaching assistant (UTA) experience across biology courses and other STEM courses at an R1 research-focused university.
Frank R. Castelli (Cornell University)*; Mark A. Sarvary (Cornell University) Paper ID: 200
Opportunities for undergraduate students to take on an official role of a teacher are widespread at colleges and universities. We refer to students with such roles as “Undergraduate Teaching Assistants” (UTAs), although they are sometimes given different titles (e.g., “undergraduate learning assistant” or “tutor”). Regardless of their title, the responsibilities of these teaching roles presumably vary widely across courses and disciplines leading to differences in experience. Several studies have examined how students benefit from having a UTA in their course, but few have examined how the UTAs benefit from the experience of being a UTA and we are not aware of any that have examined how benefits vary across disciplines. Using a longitudinal survey of undergraduates in official teaching roles at an R1 research-focused university, we explored the potential benefits of the UTA experience across several STEM courses in biology, chemistry, physics, and computer science. First, we describe the variation we found in responsibilities and experiences between courses and disciplines. Then, we summarize UTAs’ perceived benefits of the UTA experience gathered from open-ended questions and how these perceived benefits changed between two administrations of the survey given early and late in the semester. We also report on questions that were intended to measure specific benefits to UTAs that we hypothesized a priori, including improving metacognition of their own study habits, gaining clarity in whether or not to pursue a career in teaching, and increasing confidence in several areas such as public speaking, explaining concepts, and resolving conflicts. Results from the first semester of this study will be presented and discussed. We suggest that these results be used to highlight the potential benefits of the UTA experience and influence institutional curriculum development across disciplines.

Poster #141
Anchoring the Adrift: Developing an instructional training program for our teaching assistants
Elizabeth MY Steves (Simon Fraser University)*; Megan Barker (Simon Fraser University) Paper ID: 201
Teaching assistants (TAs) support almost all aspects of our biology courses: they run labs and teach tutorials, support students in lecture, communicate with students, and grade assessments. Students may view TAs as more accessible and approachable than course instructors, looking to them for mentorship as for a guide to the course or university as a whole. However, at our institution, the role of a TA is often unstructured within a course, and support can vary from course to course. Our graduate students often receive no formal instructional training, and many are new graduate students with no previous teaching experience. Therefore, we are planning to create a TA training and development component, integrated into our large introductory courses, to support TA skill
development and confidence. As a first step, we took a TA-centred approach to understand their experiences and goals. We have used a mixed design, including quantitative (pre/post surveys, COPUS-style tutorial/lab/meeting observations) and qualitative (focus groups, open-ended survey questions) data collection. We have analyzed data from over 25 TAs in three courses over two semesters. Pre-post analysis of surveys from TAs at different stages in their career show changes in their perspectives about their role and their students. We see a wide spread in TA instructional practices in labs and tutorials; we also see a variety of practices in how TA-instructor meetings are carried out. Our interview findings indicate that TAs struggle with preparing and running tutorials in the absence of training, and that if a TA feels underprepared, they feel as if they are doing a disservice to their students. It is also unclear to our graduate students how any training in the TA role is applicable outside the classroom, particularly for those not interested in pursuing teaching careers. This poster will include our study design, data collection strategies, and major findings useful for developing a semi-structured TA pedagogical training program.

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

Effective mentoring during STEM graduate education has been identified as a catalyst for higher rates of scholarly productivity, academic performance, career advancement, and overall well-being. However, there is little research on the problematic experiences graduate students can have with their mentors. To address this knowledge gap, we are conducting a study aimed at identifying and characterizing the negative elements of mentoring that doctoral students experience during their graduate research. Specifically, we conducted a phenomenological study of the negative mentoring experienced by life science doctoral students (n=30). We identified potential participants by distributing a screening survey by email to life science graduate students at universities across the U.S. This allowed us to identify individuals who experienced problematic mentoring and to ensure the sample represented diverse institutions, socio-demographics, subfields of the life sciences, and program timepoints (e.g., pre and post candidacy). We interviewed participants about their negative experiences with research mentors. We then analyzed their qualitative accounts using standard deductive and inductive content analysis, drawing from frameworks of negative mentoring in workplace settings and from research describing constructs of abusive supervision, harassment, and incivility in the workplace. We identified six broad dimensions of negative mentoring that students reported during various stages of their graduate education: mentor mismatch, lack of psychosocial support, insufficient career-related guidance, professional misconduct, harassment, and abuse of power. Graduate students in our study reported that these behaviors had significant impacts on their personal and professional growth, development, and future goals. Some of our findings echo the negative mentoring behaviors reported by individuals in workplace and undergraduate research settings, but other results indicate that graduate students experience unique forms of negative mentoring that directly harm their training, well-being, and career development. This work begins to provide an evidence base for responding to recent calls from the National Academies to improve graduate STEM education, including the mentoring graduate STEM students experience. The next step for this research is to use these qualitative results as a foundation for developing a quantitative measure to study the prevalence and impacts of negative mentoring in graduate education.

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

Research over the last decade has indicated that a diverse student population can positively contribute to better learning outcomes in undergraduate biology courses. Transforming the instructional methods at the undergraduate level to specifically incorporate diversity and inclusion is vital for promoting an inclusive culture of student learning. This is particularly true in science laboratory courses, where there is often an emphasis on collaborative group work. Many universities rely heavily on graduate teaching assistants (GTAs) to facilitate these laboratory courses. These novice instructors often lack the pedagogical knowledge and experience to effectively
implement inclusive instructional practices and may require targeted support to develop the knowledge and skills needed to promote an inclusive classroom environment. Given this reliance on GTAs, providing them with opportunities for inclusive teaching-centered professional development is imperative for improving student learning. This project describes a professional development series for GTAs that focuses on diversity and inclusion in the science classroom and laboratory. Initially, we offered three consecutive iterations of a semester-long program resulting in 50 trained teaching assistants. Assessment included both qualitative and quantitative metrics. Quantitatively, we measured changes in teaching assistants’ knowledge and confidence with respect to inclusive teaching practices using a locally designed pre- and post-survey. During the programming, teaching assistants submitted several reflective writings that we qualitatively analyzed using grounded-theory framework to describe how their understanding of inclusive teaching changed over the course of their experience. Data analysis demonstrated that teaching assistants reported an increase in their knowledge of strategies for creating an inclusive classroom, minimizing the impact of implicit bias, minimizing stereotype threat in the classroom, and issues associated with bias in the sciences. Teaching assistants also reported increased confidence in implementing strategies to achieve more inclusive classrooms. On average, gains in knowledge were larger than gains in confidence, which prompted the development of a second semester-long program for previous GTA participants based on a professional learning community (PLC) framework that focused more on the implementation of inclusive teaching strategies. Over two consecutive semesters, 18 GTAs opted to participate in the PLC program and their experiences were examined through both quantitative survey metrics and open-ended writing. Overall, GTAs found the PLC program supportive of their development as teachers and felt that the structure of this second experience better allowed them to set goals and take action around implementing inclusive teaching strategies in their classrooms and labs. Due to the small number of total participants, we were unable to meaningfully determine quantitative changes in knowledge or confidence of GTAs resulting solely from the PLC program. Thus, we plan to conduct a retrospective assessment with the 18 GTAs to determine their growth in knowledge and confidence with inclusive teaching practices over their time in both the initial program and the PLC program.

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

Nearly 50% of college students in STEM majors have interest in teaching as a career, yet science courses are usually not designed to meet the specific needs of future teachers. This largely reflects a separation between science and education departments, and a failure to move beyond traditional teaching approaches in college science courses. As a result, many teachers struggle to meet federal and state standards for use of authentic science in all classrooms (such as asking questions, designing experiments and interpreting data). Improving how we educate future science teachers is a critical national goal, and we believe addressing this challenge will also bring active student-centered learning to undergraduate and graduate science courses. How can we improve science learning environments to better educate future science teachers? A potential solution is focusing on simultaneously teaching biology and evidence-based pedagogical approaches. This accomplishes two important goals: 1) modeling student centered teaching approaches for future science teachers and 2) moving beyond traditional route teaching approaches that we know to be less effective. To accomplish this, we have taken a hybrid online/in-person approach that allows class time to focus on showcasing a range of pedagogical techniques. Students complete an online course that teaches in-depth biology content. During in-person sessions, students participate in student-centered pedagogical activities shown to be effective in teaching biology content to younger students (labs, games, case studies, experimental design, etc). This gives students a model of how to teach, and offers rich opportunities for learning science content. In this poster we will show student outcomes (knowledge and attitudinal) from a neuroscience course offered to pre-service and in-service teachers. Preliminary data show students make significant gains in content knowledge and incorporate the teaching techniques into their own teaching practice. Despite this success, we acknowledge that in-person classes are only accessible to students within a geographic space and are time intensive – both major challenges for working teachers. Moving to a fully online model may address this challenge, but how can evidence-based teaching practices be modeled in an online setting? We are currently working to adapt our hybrid courses into fully online courses with this goal: simultaneously teach biology and evidence-based pedagogical approaches.
Poster #145
Modeling the effect of social interactions on the instructional decisions of biology faculty
Melody McConnell (North Dakota State University)*; Lisa M Montplaisir (North Dakota State University); Erika Offerdahl (Washington State University)  Paper ID: 237

Adoption of instructional innovations such as evidence-based instructional practices (EBIPs) by faculty is an essential step toward improving undergraduate STEM education. Instructors’ choices about whether and how to implement innovations are complex and can be thought of as an innovation decision process. Each individual instructor’s innovation decision process is likely affected by interactions with departmental colleagues, who can provide ideas, support, and influence. In turn, an instructor who makes a decision for or against using an innovation may affect peers the same way. Instructors’ interconnected innovation decision processes can then lead to diffusion of teaching innovations throughout an academic department. The overarching goal of this research is to understand the ways in which social interactions influence university instructors’ teaching decisions. To do so, we have 1) synthesized prior models of innovation decision and innovation diffusion to hypothesize how social interactions affect the innovation decision process, and 2) gathered empirical data to test and refine the model. Data collected to inform the model include social network, survey, and interview data of instructors within a research-intensive biology department. In this poster, we present the initial results of one of these data streams (interviews) and reflect on elements of the model that may need further revision. Semi-structured interviews were conducted with eleven instructors (33% of the department). Interviewees were asked about their teaching practices, where teaching ideas came from, the process of changing (or not) their practices, and interactions with peers. Interviews were transcribed and subsequently coded for two main aspects: process of change/decision and effect of social interactions. Codes were refined through iterative review of the interviews, and novel constructs and negative examples were actively searched for. Finally, the coded interview data allowed us to refine and modify the model of innovation decision to incorporate the role of social interaction. This research provides insights into how and under what conditions instructional innovations are adopted and spread through research-intensive biology departments. Understanding the role of social interactions in adoption of instructional innovations will inform administrators, change agents, and instructors about high-impact strategies to spread instructional change and support instructors in using EBIPs.

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

The Scientific Teaching (ST) pedagogy includes many of the research-based instructional strategies recommended in science education literature, and is promoted in national calls such as Vision and Change. These practices include curricular alignment, active learning, science process skills, responsiveness, and inclusion. Recently, a series of measurement instruments was developed to enable users to gauge the frequency of ST practices occurring in undergraduate classrooms. These instruments include a student and instructor survey called MIST (Measurement Instrument for Scientific Teaching) and an aligned observation tool called MISTO (MIST- Observable), which observers use to track occurrences of ST practices across video-recorded class sessions. While MISTO is user-friendly, its comprehensiveness can be daunting and precision in observer scoring may improve with standardized training. In this study, we developed a training guide to introduce potential MISTO users to the instrument, communicate detailed criteria for ST practices and timing, and standardize the training experience for MISTO users. The training guide details how to use MISTO and includes follow-along videos that track the novice observer’s reliability over seven sample courses. The training guide utilizes publicly available college course videos through Open Course programs and includes classes with varying frequency of ST usage. Each video used from seven courses was scored by two reliable observers, and after deliberation between the two observers, master keys were created for each class session. An introduction video orientating the user to the tool, a detailed MISTO description sheet explaining the ST practices, and three example videos that score classes in real time are used to acclimate a novice observer to the MISTO tool. For each class session, annotated sheets are provided that explain when and why a ST practice occurred and how to record the occurrence in the tool. The training guide is freely
available to interested users by request. The suite of MIST instruments allow users to quantify ST usage in undergraduate science classrooms, and MISTO is the first tool that compares the perspectives of students, instructors, and observers using the same set of questions. While these tools are likely to be quite useful in DBER studies, the availability of this in-depth MISTO training guide will increase accessibility to non-expert users and potentially maximize reliability across studies from various research groups or practitioners. This can reduce error among users and help reduce findings of spurious associations between practices and student outcomes, especially among those less-studied ST practices such as inclusion, responsiveness, and science process skills.

**Poster #147**

**How teaching experience and professional development impacts GTA approaches, self-efficacy, and knowledge of student-centered learning at two universities**

Heather D. Vance-Chalcraft (East Carolina University)*; Kari Nelson (University of Nebraska Medical Center)  
**Paper ID:** 244

Graduate teaching assistants (GTAs) play a pivotal role in the introductory biology experiences of many undergraduate students. Thus, it is important for us to consider the roles of GTAs in discussions of professional development to increase the use of evidence-based teaching practices such as student-centered learning. While a limited number of studies have examined the impacts of professional development opportunities on GTAs, a detailed understanding of how GTAs of varying levels of teaching experience respond to professional development is lacking. We conducted professional development with GTAs at two universities, ranging from 20-minute devoted professional development sessions during weekly planning meetings to an intensive multi-day summer workshop. Consenting GTAs attending these various professional development experiences completed multiple published, validated surveys before and after GTA training to assess changes in teaching approaches, knowledge, and self-efficacy. The Approaches to Teaching Inventory (ATI) was used to measure GTA intentions to use a conceptual change/student-focused approach versus an information transfer/teacher-focused approach. The STEM GTA Teachers’ Sense of Efficacy Scale (STEM-GTA TSES) was used to assess GTA self-efficacy about teaching since self-efficacy has been shown to be one of the best predictors of teaching practices. Finally, the subset of questions designated as inquiry-focused from the Knowledge Survey was used to assess GTA perceptions of their understanding of concepts and topics related to inquiry instruction. Results of paired t-tests showed that GTAs, on average, intended to use more conceptual-change/student-focused approaches and were more knowledgeable about some aspects of inquiry instruction after attending professional development. GTA self-efficacy, however, was not significantly impacted. We ran linear regressions to determine if the amount of teaching experience or professional development the GTAs had attended influenced the GTA’s approach to teaching, self-efficacy, or knowledge about inquiry instruction. Many of the models showed a significant interaction between teaching experience and professional development, indicating a complex relationship between these two variables. Teaching experience decreases the strength of the impact of professional development in many, but not all, models. The results were similar between the two institutions, despite differences in the professional development opportunities provided. This work highlights how different professional development opportunities may be needed for GTAs based on the amount of teaching experience they have. Quality experiences tailored to different GTA career stages may be a particularly efficient way to increase the use of evidence-based approaches since prior research has shown that instructional styles are largely established within a year or two of leaving graduate school.

**Poster #148**

**Professional Development for All: Practices to Broaden Participation in Education Reform**

Christopher Beck (Emory University)*; Rachelle Spell (Emory University); Lawrence Blumer (Morehouse College); Pamela Hanson (Birmingham-Southern College); Joanna Vondrasek (Piedmont Virginia Community College)  
**Paper ID:** 257

We aspire to make education innovation available to all students and professional development (PD) possible for all faculty. Yet, lack of time and resources are often barriers for faculty participating in PD, especially those from under-resourced institutions. In addition, conflicts between perceptions of professional identity as scientists or as teachers may limit faculty participation. Here, we examine attempts to overcome these barriers by partnering with both disciplinary societies and education-focused professional societies to run pre-conference PD
workshops. To determine the impact of this approach, we addressed the following research questions: 1) Who attends (research faculty or education specialists), giving insight into whether we are bridging the perceived divide between research and teaching? 2) Are the workshops expanding access to professional society meetings? 3) Do the workshops attract faculty from typically underserved institutions thereby broadening the impact of professional society meetings? We have facilitated eight workshops in conjunction with the annual meetings of professional societies: three associated with disciplinary society meetings and five with education-focused conferences. We evaluated the impact of this workshop model using end-of-workshop surveys and a summative project survey. One hundred thirty-one faculty from seventy institutions participated. The majority of participants (65%) self-identified as both science researchers and educators, 11% as science researchers, 17% as educators, and 7% as both discipline-based education researchers and educators. Thus, our workshops attract faculty already interested in the intersection between their scientific research and education. Almost all of respondents to our summative survey (97%) agreed that holding our professional development workshops in association with professional conferences was worthwhile with the majority suggesting that it alleviated funding and time constraints. While 79% of participants reported that they had not typically attended the workshop-associated conference, 87% of participants stayed for the associated conference, suggesting that our project expanded access to professional society meetings. Almost 25% of participants have returned to the same conference since the workshop. Faculty from ten two-year colleges and three HBCUs (19% of institutions) participated, suggesting expanded opportunities for their attendance at professional meetings.

**Poster #149**

Are PIs’ supervisory responsibilities impacting the power dynamics with their trainees, and trainees’ ability to attain their training goals?

Laurence Clement (University of California, San Francisco)*; Karen Leung (City College of San Francisco); James Lewis (City College of San Francisco); Naledi Saul (University of California, San Francisco) Paper ID: 275

Although the R1 PI (Principal Investigator)-trainee (i.e. graduate students and postdoctoral scholars) relationship is often referred to as that of a mentor-mentee relationship, to sustain their expensive and complex research, life science PIs must take on an additional, “supervisory managerial” role with their trainees. In the first part of this study, previously presented at SABER WEST, we found that trainees were more likely to agree that their PI had supervisory responsibilities than traditional mentor responsibilities towards them. We hypothesized that this supervisory role comes with power, beyond the type of power that a traditional mentor would have over a mentee, and that mentor and supervisory types of powers may impact trainees’ ability to attain their training goals. We surveyed R1 trainees who participated in a mentoring workshop at our institution (n=43) using the Rahim Leader Power Inventory, as well as Likert-type items relating to the supervisory responsibilities of PIs. We also asked trainees to score how the PI’s actions impacted their ability to achieve seven research training goals identified in a prior study. Using ordinal regression, we tested the fit of the model: supervisory item score ~ position power score + personal power score + fellowship status + visa status. We found that the five supervisory responsibilities of PIs were positively correlated with the PI’s position power, but were not correlated with the PI’s personal power, supporting the hypothesis that the supervisory responsibilities of PIs towards trainees are correlated with the type of power usually held by supervisors towards subordinates. Not surprisingly, we found a negative correlation between fellowship status and financial responsibilities of PIs. To determine if the PI’s personal and position powers were related to the trainees’ ability to achieve their training goals, we used the model: training impact score ~ position power score + personal power score + fellowship status + visa status. We found no correlation between position power and trainees’ ability to attain training goals. We did find positive relationships between PIs’ personal power and 6 out of 7 of the training goals, excluding trainees’ ability to learn to write an R01 grant. We also found a positive correlation between visa status and two training goals: a) the ability to identify gaps that need to be addressed in an area of research, and b) the ability to identify collaborators, which was also positively correlated to fellowship status. These results confirm that the supervisory responsibilities of PIs provide them with position power, which does not fit with the concept of traditional mentorship, but that this type of power does not support the trainees’ ability to achieve their training goals. We believe that this particular power differential between PIs and trainees created by the supervisory role of PIs should be considered when addressing issues of equity and social justice in research environments, as it may have important
implications when it comes to the retention and success of undergraduate students and future faculty in the academic pipeline.

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

Learning Assistants (LAs) are undergraduate students who serve as peer tutors in lectures, discussion sections, and lab sections. LA programs usually consist of 3 interconnected components: content, pedagogy and practice. Unlike the few institutions where the experiences of LAs have been explored, our institution has an “informal” learning assistant program, where the level of mentoring, the LA experience and the pedagogical training varies with instructor and class. This project studies the experiences, gains and benefits of being a LA at our institution. In particular, we are interested in how being a learning assistant can help increase students’ self-efficacy, science identity, and metacognition. Students who have been LAs for one Quarter were invited to complete a survey combining likert-scale and open ended questions at the beginning and end of the first LA experience. Currently, over 100 students have completed the surveys and we have followed up with semi-structured interviews for a subset of students (n=15). Analysis of student survey responses has shown consistent increases in science identity as well as shifts in the perceptions of scientists as a whole. We have also observed changes in the understanding of what makes for an effective student, suggesting higher metacognition, though these changes have not been paralleled by changes in metacognition as assessed by the metacognitive awareness inventory. Using the SURE survey, LAs reported large gains in many of the items that mirror the gains observed in students after an undergraduate research experience. All of these findings highlight the potential of the LA experience to increase science identity and science self-efficacy in undergraduate students (even in the absence of a strong LA program structure); factors that have been linked to increased retention of students in STEM.

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

Research skills, and specifically experimental design, are considered essential for success in doctoral training. Yet, bioscience students enter doctoral programs with varying levels of training in these skills. We anticipated that this heterogeneity in training would not only affect students’ aptitude in experimental design, but also their perception of their own ability to perform research skills. In addition to measuring students’ experimental design performance, our study sought to address students’ research skills self-efficacy and self-reported experience and comfort with experimental design because of their influence on students’ levels of aspiration, motivation, and persistence. These factors of student affect are particularly important during early doctoral training considering that attrition rates from doctoral science programs are estimated to be 25-40% and that the highest rates of attrition occur during the first 2 years. Given the heterogeneous experiences of incoming students, we sought to understand whether the amount of time that students’ had spent doing pre-doctoral research influenced their experimental design aptitude, research skills self-efficacy, and self-reported experience and comfort with experimental design. Given the importance of early stages of doctoral training in laying the foundation for the rest of a student’s graduate trajectory, we also sought to measure changes in students’ experimental design performance and research skills self-efficacy during the first semester of doctoral training.

Lastly, we investigated what training experiences students cited as the primary contributors to their levels of experience and comfort with experimental design. For this study, we administered a survey and the Biological Experimental Design Concept Inventory (BEDCI) at both the beginning and end of the semester to obtain matched pre- and post-test data for each study participant. The pre- and post-semester surveys included a previously published research skills self-efficacy instrument in addition to questions about experience and comfort with experimental design. Our results showed a wide variability of aptitude and self-perception with experimental design at the beginning of the semester; surprisingly, Spearman correlations revealed that these measures were not correlated with the length of pre-doctoral research experience. Using a Wilcoxon signed-rank test, we found
that our students improved significantly over the course of the semester on their experimental design performance, as measured by the BEDCI. Furthermore, use of the same statistical test on the data from the self-efficacy instrument revealed significant improvements on 11 of the 14 Likert scale items, with the largest increases in items explicitly addressed in coursework such as statistics and formulating, testing, and reformulating hypotheses. Finally, we found that students cited a variety of factors including laboratory research, coursework, mentoring, and interaction with colleagues as the primary contributors to their experience and comfort with experimental design. This study adds to the literature as the first use of the BEDCI as a pre-/post-assessment for a doctoral student population. The mean scores on the assessment suggest that many doctoral programs have gaps in their understanding of experimental design. Additionally, the correlation of the largest self-efficacy gains in research skills with explicit objectives in students’ first-year coursework emphasizes that explicit training in these skills can significantly improve self-efficacy. This is further underscored by the fact that 25% of our students cited coursework as the primary contributing factor for their comfort with experimental design. While there are multiple other factors that play an important role in students’ training, these results demonstrate the importance of explicit training in experimental design and other research skills early in doctoral training.

**Poster #152**

**Increasing retention by involving students in an undergraduate research program during their introductory experience: Results of matched-pairs and mixed methods analyses.**

Edward A Leone (Oklahoma State University)*; John Stewart (Oklahoma State University); Lucy Bailey (Oklahoma State University); Coral Rewasiewicz (Oklahoma State University); Donald French (Oklahoma State University)

Paper ID: 122

Undergraduate research experiences (UREs) have many positive outcomes for students including social connections to faculty and professional networks, strengthened science identities, and academic preparation for post-baccalaureate studies. In this presentation, we describe an undergraduate research program that provides research opportunities for first-year students in the life sciences and has a high retention rate. Few studies compare URE participant outcomes to those of non-participating students with similar academic backgrounds. We compare academic outcomes between freshmen who completed the program to similar students who did not enroll in said program. In the program, students participate in a 12-week science communication seminar, find faculty research mentors, and craft a research proposal in the fall semester. In the spring semester, they conduct their proposed research and present posters and author manuscripts about their work. We collected high school GPA, ACT/SAT scores, enrollment status, major status, and cumulative GPA from participants who started as freshman in the Fall 2014 semester and created matched sample pairs (n=98) between program participants and non-participants. To assess the effect of program participation, we performed multiple, paired-sample t-tests and X2 tests on university GPA, persistence within target major, and retention at the university. Program participants had significantly higher GPAs their sophomore year and persisted in their major and at the university at higher rates during their sophomore and junior years than their matched non-participant counterparts. Our findings suggest student participation in UREs yields higher returning university enrollment and retention in their target major. Students who completed the program describe its catalytic effect on the development of their research skills and the pathway it opens to additional research opportunities. For example, one student continued working for several years in the lab where she completed her program research, awakening her appreciation of fieldwork – experiences that also shaped her decision to pursue field-based biodiversity research in graduate school. Additionally, others noted the “advantage” and “value” of learning how to write scientific proposals and manuscripts during their introductory year, working with graduate students and faculty in their research, and developing communication skills with faculty. As one student noted, “It was scary at first, but it turned out great”!

We recommend continued encouragement for both first-year students to participate in research opportunities and faculty to mentor undergraduates through discipline-specific introductory research programs. Our quantitative and qualitative data provide evidence of the mutual benefits the program offers students, faculty, and university through professional development, research productivity, and retention simultaneously. Some faculty are reluctant to take on additional responsibilities to mentor undergraduates in research - preferring to work with graduate students that have a greater skill base, commitment to research, and experience with nuanced and costly projects. Yet, our research suggests the institutional value, student satisfaction, and potential long-term benefit for STEM disciplines to participate in structured research programs early in students’ college programs.
Poster #153

**Expert and novice conceptions of the biotic impacts of climate change** paper ID 26

*Emily Holt*, Julie Sexton, Alicia Romano (University of Northern Colorado), Krystal Hinerman (Lamar University)

Research Problem: Climate change is one of the most important environmental, social, and economic issues of our time. The documented impacts of climate change are extensive. Climate change education can help students link this global issue to students’ everyday lives, foster a climate-literate public, and serve as motivation for action. Yet prior to instructional interventions, the first step in promoting conceptual change is to describe expert and novice conceptions or mental models of the topic (Tregast and Duit 2009). Published studies about students’ climate change knowledge primarily stem from the earth and atmospheric sciences, and focus on students’ knowledge of the mechanisms causing global warming and of the abiotic systems important to climate change. Limited research has documented undergraduate students’ knowledge about the biotic impacts of climate change. Our goal was to describe student/novice and instructor/expert conceptual knowledge of the biotic impacts of climate change. Research Design: We conducted interviews with 30 undergraduates and 10 instructors who are students or teaching in Introductory Biology or Ecology classes. Our semi-structured interview protocol probed participants’ conceptions of the mechanisms, outcomes and levels of impact that climate change has on the biological world. Participants were taken from varying institutions across the US (Baccalaureate, Master’s, and Doctoral). Analyses: Following transcription of all interviews, we used thematic coding analysis to describe novice and expert conceptions of the biotic impacts to climate change. We also compared across interview populations to describe how novice and expert conceptions compare. Contribution: Our findings contribute understanding of biology student and expert knowledge of the biotic impacts of climate change and contribute more broadly to the field of climate science where research on understanding of the biotic impacts of climate change is minimal. Our work will represent a novel perspective because most climate education research at the university-level has focused on earth and atmospheric science students. Further, this work is the first step in a larger project that aims to develop valid and reliable concept inventory related to biotic impacts of climate change – an instrument sorely needed to properly address improvements to climate change education.

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Poster #154

**Novice and expert: what happens when students interview a scientist about their research?**

*Kyriaki Chtzikyriakidou* (Florida International University); Cynthia Cabrera (Florida International University); Melissa R McCartney (Florida International University)*

**Paper ID 28**

Engaging students in the process of research has become a key emphasis in science education. Undergraduate research experiences (UREs), including course-based undergraduate research experiences (CUREs), are one way to actively engage students in the scientific process and have been shown to increase retention and academic achievement. However, not all institutions have the resources to provide these experiences, and, even when they do, the demand far exceeds supply. How can we expand opportunities in scientific research to include a wider and more diverse array of students? We describe a novel method for student engagement in research. “Undergraduates as Annotators” (UAA) aims to emulate the more traditional URE and CURE models by engaging students with research taking place within their own department. First, students deconstruct a research paper connected to the biological concepts taught in their course and published by a faculty member. Next, students meet with the authors of the research paper to have conversations within the traditional scientific discourse, a practice that further develops students’ understanding of the scientific community. Taken together, the two phases of UAA place students in a research mindset: first by having students work through the data and results of a research project, and then by engaging students in an authentic conversation with a member of the scientific community. By engaging students in these two types of scientific discourse, UAA provides learning about research through participation in the context of course content. Specifically, each group of students (4-5) visited the author on campus and engaged in a ~1 hour long interview. There was no particular set of questions that students were required to ask: questions vary from content-based to career-based to personal interest. Over the course of two semesters (Fall 2017 and Fall 2018), we recorded 36 student-author interviews and are currently conducting inductive thematic analysis on this data set. We are examining interview transcripts and are uncovering common themes that take place across each interview, including descriptions of the nature of science, examples of the 5 core concepts of biology being discussed, and career advice being provided. Taken together, our data set will provide insight into how expert and novice scientists can better discuss research findings.

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