Poster Abstracts

Posters 1-77 presented on Saturday

Posters 78-152 presented on Sunday

Poster #1 Online with Career Goals? Exploring student decisions to enroll in online biology degree programs and online lab courses Logan Gin*, Arizona State University; Evan Brus, Arizona State University; Sara Brownell, Arizona State University [abstract #90]

As a way to increase access to higher education, institutions are increasingly implementing online course offerings. Recently, fully online degree programs have been developed at public non-profit institutions, although few online science degree programs have been developed, largely because of concerns about laboratory instruction. However, our institution has launched an entirely online degree program in biology. As a substitute for the traditional in-person laboratory experience, some institutions have students participate in a simulated virtual lab experience. However, student decisions about enrolling in an online biology degree program and taking an online laboratory course have largely been unexplored. We set out to explore the following research questions: (1) What are student perceptions of possible costs and benefits from an online laboratory experience compared to an in-person laboratory experience in the short-term as well as for long-term career goals and (2) Why are students enrolling in an online degree program compared to an in-person degree program, and what do they perceive are the costs and benefits? Using pre- and post-course open-ended surveys and semi-structured interviews, we investigated these research questions in an online introductory biology course with 170 students, 85% of whom were enrolled in the online biology degree program. We used constant comparison methods to analyze the open-ended data to develop a rubric of themes and achieved sufficient inter-rater reliability. We found that 33% of students enrolled in the course thought they would gain greater flexibility in terms of course pace, and 27% would gain convenience of access. Students realized that the online simulation would lack some aspects of a typical lab course: 64% of students thought they would miss out on the hands-on element of laboratory instruction and 51% of students thought that they would miss out on social interactions among students and between instructors and students by taking an online lab course. Of the students surveyed, 53% are interested in pursuing a healthcare career, and 30% hope to attend medical school. Given those career goals, 37% thought taking an online lab course as opposed to an in-person lab course would have a positive impact on their career goals, 22% thought it would have a negative impact on career goals, 25% thought it would be neutral, and 14% thought it would have both positive and negative impacts. Interviews with students have corroborated these results; students are enrolling in online degree programs because of convenience and flexibility, preferences for online instruction, and some perceived positive career benefits. This work suggests that students who enroll in online biology degree programs and online laboratory experiences may not have considered some of the limitations of their experiences, particularly as it may impact their future career opportunities.

Poster #2 Preliminary assessment of the use of out-of-class video presentations for content review in an allied health pathophysiology course Kristen Walton*, Missouri Western State University [abstract #171]

The flipped classroom technique has continued to gain popularity in undergraduate and postgraduate biology and medical education in recent years. This technique generally involves delivery of lecture or other methods of content coverage assigned before class, while class time is instead spent on discussion or other, more active approaches to learning. This technique was implemented for a specific set of content in an upper division undergraduate pathophysiology course. 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 this prerequisite A&P in order to enroll in the pathophysiology, many students continue to struggle with some major topics in A&P, such as cardiovascular physiology. This makes it difficult to have meaningful discussion of the related pathophysiology without first reviewing content from the prerequisite course. This project aimed to assess the use of pre-class 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 preliminary 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 #3 The LEARNTM Consortium: A three-tiered research-mentoring model to impact retention of STEM freshmen and transfer students at three institutions Evelyn Frazier*, Florida Atlantic UNiversity [abstract #12]

Declining numbers of STEM professionals in the USA has made it imperative to increase the retention rates of students in Science, Technology, Engineering, and Mathematics (STEM). Students who are the first in their families to attend college, under-represented minorities or those that transfer from community colleges to complete a four-year degree are particularly prone to leave the STEM fields. There remains a need to establish retention models that are adaptable and can serve a variety of students and institutions. Through National Science Foundation (NSF) funding, faculty have created the LEARN Consortium, a three-institution initiative focusing on developing a model employing undergraduate research, mentoring and community based activities to engage, include and retain undergraduate students within the university community. The Consortium is currently developing and testing the programs at three very different institutions. The STEM retention model being evaluated and modified is the Learning Environment and Academic Research Network (L.E.A.R.N.TM). This model was developed at one of the universities targeting first-year students (FTIC) focusing in a three-tiered approach including Research, Mentoring and Community building. The F-LEARN (freshmen) programs consists of exposing students to research through two courses, while promoting a community of learners that live in the same dormitory for their freshman year. A second university has adapted this model to meet the unique needs of transfer STEM students with a research- intensive experience. The T-LEARN (transfer) programs consist of two courses on developing scientific communication skills, while students conduct a research project under the supervision of a faculty mentor. Both programs also promote community -building activities such as field trips and volunteering in the community. Both F-LEARN and T-LEARN programs are being pilot tested at all three universities. A preliminary evaluation of the first 12 months

(Fall 2016, Spring and Summer 2017) reveals gains in student learning outcomes through qualitative measures from focus groups, where student report increases in confidence in communicating scientific findings, understanding of the scientific process and involvement in research. Nevertheless, students report that the programs are demanding with a high workload. Quantitative results from a Critical Thinking Test (CAT) suggest that there was no improvement in these skills at the end of each semester for students in both F and T Learn across the three institutions. It is possible that critical thinking skills may need to be retested after a longer period of time.

Poster #4 Using what we have: Assessing critical and creative thinking development through existing assignments Paisley Worthington*, University of Guelph; John Dawson, University of Guelph [abstract #14]

Critical and creative thinking is a complex transferrable skill that we rely on to thrive in our constantly changing work force, yet understanding how it is developed and assessed in post-secondary education is challenging. Post-secondary programs aspire to stimulate sophisticated thinking and while we assume student thinking is improving, little evidence exists to confirm this claim. Post-secondary education needs flexible methods to understand how students learn to think critically and creatively so all students can be supported in their development. Critical and creative thinking is an amorphous, higher-order skill pertinent to problem solving (PS) and can be measured through PS activities. This research will focus on evaluating student mastery of critical and creative thinking by developing a framework rooted in PS assignments from the [MAJOR] program at the University of [CITY]. We will examine PS from three perspectives pertinent in discussions about learning outcomes assessment: program intentions, student achievement, and student perception. Part 1: Program intentions. The [MAJOR] program uses many potential authentic signature assignments (ASAs) that can be used as PS checkpoints. To obtain a progressive view of students' PS development, we will select one ASA from each year of the program and work with instructors to identify how PS is incorporated into the assignment. Part 2: Student achievement. We will prepare a developmental rubric detailing elements of PS development and collaborate with course instructors to map this rubric to ASA grading keys. Additionally, we will map this PS rubric to the institutional critical and creative thinking rubric. To understand students' critical and creative thinking abilities, selected ASA rubrics with student grades will be mapped to the institutional rubric. Part 3: Student perceptions. A survey exploring student perceptions of assessment authenticity and confidence in their ability to successfully use CCT skills in new scenarios will be administered after completion of the ASAs. Contributions: This study proposes and tests a framework to collect data describing student learning and transferrable skills development. Data of this nature are crucial in guiding discussions about the value of a university education, graduate employability, and ways to enhance curriculum.

Poster #5 What does an allele look like (in a textbook)? Marisha Boyd, UBC; Emily Chow, UBC; Gagan Daliaho, UBC; Zahra Fazal, UBC; Devyani McLaren, UBC; Gizol Shah, UBC; Jade Shivak, UBC; Pamela Kalas*, The University of British Columbia [abstract #214]

Purpose: Working collaboratively as a students/faculty team, our first objective was to rigorously document how first year biology textbooks depict alleles in their illustrations, how frequently each type of depiction is used and, crucially, how they are interpreted by students vs. faculty. A second, more long-term goal is to explore the feasibility, benefits and challenges of including undergraduate students as co-researchers in SoTL and DBER projects. Rationale: Genetics is a notoriously challenging subject for many biology students, and confusion and misconceptions around the crucial concept of allele are common and often deep-rooted. Biology instructors and textbook developers have traditionally taken advantage of diagrammatic representations to illustrate abstract concepts or microscopic objects, such as alleles, to students. While these representations are extremely valuable in a discipline as visually oriented as biology, students often struggle or fail to interpret them accurately. Illustrations are usually reviewed/evaluated by content experts who, unlike novice students, also have a great deal of discipline-specific visual literacy. As a result, textbook illustrations meant to support student understanding may instead have counter-productive effects. We therefore wondered whether the ways in which they depict alleles might actually be contributing to students' misconceptions. Methodology: We performed a qualitative analysis of all the depictions alleles in five major introductory biology textbooks. Each textbook's depictions were independently characterized (described) by at least three authors (including students and faculty). We then compared our characterizations and developed a common set of codes to categorize the depictions; we resolved the few cases in which disagreements arose through discussion until we reached a consensus. The authors also documented any thoughts, questions and observations that they had during the process. Expected contributions to biology education research: To the authors' knowledge, this pilot study represents the first explicit, quantitative documentation of how alleles are illustrated in a set of major introductory biology textbooks. Educators in various disciplines have used content analyses to uncover representations that could be unintentionally reinforcing students' misconceptions. Here, we expand the potential of textbook analysis by involving first year undergraduates as co-researchers in the process, which affords us the opportunity to "view" the relevant material through the eyes of the textbooks' main audience: the students themselves. We expect that an analysis of our data in relation to documented student difficulties around the concept of allele will help us propose targeted resources to support student learning. Also, the thoughts, questions and comments from the student-researchers should be particularly valuable in the development of such resources for our classrooms.

Poster #6 Self-regulated learning strategies and attitudes towards learning of students who improve their grades on introductory biology exams Amanda Sebesta*, Saint Louis University; Elena Bray Speth, Saint Louis University [abstract #205]

Self-regulated learning (SRL)—defined as metacognitive, motivational, and behavioral engagement in one's own learning—characterizes successful, "expert" learners. Specifically, self-regulated learners plan, monitor, and evaluate how they learn; possess adaptive motivational beliefs of confidence in their learning abilities and responsibility for their learning outcomes; and adopt study strategies that are context-appropriate. Previous work has well established that students who self-regulate their learning also have high academic achievement. However, little work has investigated if SRL attributes characterize students who improve their academic performance in a course over a semester, despite poor outcomes on early exams. Therefore, we examined if use of SRL strategies and attitudes towards learning differed among students who increased, maintained, or decreased in their exam performance over time in a large-enrollment, active-learning introductory biology course for majors. We administered a set of surveys to students in five course sections over two semesters (n=410 for cohort 1; n=260 for cohort 2). A week before the first exam, students reported their attitudes towards learning in a suite of validated survey instruments (grit, perceived academic control, self-efficacy, need for cognition, and critical thinking/elaboration disposition). After receiving each of their first two graded exams, students were asked to report how frequently they used each of 17 SRL strategies when studying for the exams. For both cohorts, students' Exam 1 grade was significantly correlated with the average grade of Exams 2, 3, and 4 (Spearman's rho = 0.8555 for cohort 1; 0.8332 for cohort 2). We performed a generalized linear model to determine whether any attitudinal measures, along with Exam 1 grade, explain students' subsequent exam grades; preliminary analysis indicates that self-efficacy and Exam 1 grade significantly explain performance. Self-efficacy is well known to influence students' achievement, and consistent with previous reports, our data indicate that students' performance on course exams is strongly correlated to their grade on the first exam. Although this finding is not surprising, we are interested in characterizing the learning attitudes and SRL strategies of students who deviate from this pattern and improve their grades during the semester. Our previous work had shown that students who improved from Exam 1 to Exam 2 reported using specific SRL strategies more frequently than their peers. With the current dataset, we are extending the analysis to consider student exam performance throughout the semester. Contingency analysis supports and extends our prior findings that higher exam grades are associated with reported frequent use of specific SRL strategies: namely, monitoring understanding, studying from previous years' exams, and reviewing graded work. We will apply a suite of statistical analyses to identify which attitudes and SRL strategies (if any) differ among students who improve upon their initial exam grade and their peers who do not improve. Altogether, knowing which SRL strategies and attitudes differentiate students who improve their performance over time will allow instructors to coach students on adopting and developing these attributes, in order to support their academic achievement in introductory biology.

Poster #7 Expert-novice comparison reveals student deficiencies in the process of reading primary literature April Nelms, University of North Georgia; Kristen Howard, City of Gainesville, GA; Emma Thomaswick, Clemson University; Miriam Segura-Totten*, University of North Georgia [abstract #6]

Student analysis of the scientific literature increases critical thinking, scientific literacy, data evaluation, and science process skills. However, little is known about the process through which biology undergraduates read scientific articles. Understanding student shortcomings during the analysis of research articles could lead to the use of evidence-based approaches to support them in this process. We hypothesized that comparison of the skills that faculty members (experts) and students (novices) employ while reading a research article might reveal some of the things that would be helpful to students during the analysis of the literature. To test our hypothesis, we did think aloud interviews of biology faculty ($n=6$) and undergraduates ($n = 11$) as they read through a research article. Additionally, we performed focus groups of undergraduates ($n = 11$) to obtain their perceptions on reading and analyzing articles. We qualitatively analyzed these interviews using the constant comparative method. The codes encountered were organized into overarching themes and were compared between faculty and students. Within the theme of Scientific literacy, faculty more often interpreted statistical analyses ($p = 0.005$) and understood research design ($p = 0.001$) when compared to students. Faculty also demonstrated higher order thinking more often than students: they analyzed and synthesized information correctly significantly more often than students ($p < 0.001$ and $p = 0.011$, respectively). Conversely, students incorrectly synthesized information at a significantly higher proportion than faculty ($p = 0.038$). These findings were reinforced by student perceptions in the focus group: not only did students reveal issues related to understanding experimental design and analyzing graphs, but they also identified these issues as reasons why they do not like reading scientific articles and why they find articles confusing. Students also reported that, as a result of reading the primary literature, they made gains in experimental design and the ability to evaluate scientific arguments, both components of scientific literacy. Additionally, faculty summarized information more often than students while reading through the research article ($p = 0.015$). The summarizing that participants did can be viewed as self-explanation of the material. Self-explanation improves students' understanding of a text and their course performance, particularly for those with low levels of initial knowledge. Also, summaries that connect the material to prior knowledge are linked with better student performance. The role of prior knowledge in summarizing argues for providing students with information on experimental techniques and design related to an article prior to implementing summarizing as a classroom activity. Analysis of student opinions supports the importance of prior knowledge in understanding a research article: students mentioned issues with lack of prior knowledge, especially familiarity with scientific techniques, as a reason why they found articles confusing. The first take-away from our study is that students require support with and development of scientific literacy in order to approach reading the scientific literature more like experts. We suggest that instructors include resources in literature discussions that aid students in understanding research design. The second take-away from our findings is that students face barriers to understanding a research article, such as lack of prior knowledge and the inability to summarize information. Based on our findings, we recommend two approaches to support student understanding of research articles: scaffolding literature discussions with resources to allay student issues related to lack of prior knowledge, and using the technique of summarizing. Based on our findings, suggestions of specific classroom approaches and the use of particular published methods for the analysis of the literature will be discussed.

Poster #8 Comparing experts and student problem-solving strategies in Genetics Oscar Whitney*, University of Colorado Boulder; Betsy McIntosh, University of Colorado Boulder; Jennifer Avena, University of Colorado Boulder; Jenny Knight, University of Colorado, Boulder [abstract #138]

Research from many disciplines has demonstrated that experts and students approach problem solving differently. Characterizing these differences could be instrumental in finding strategies to help students improve their problem solving. Are there key processes that both experts and students use that lead to success? Do experts use different strategies that are important to teach to students? We previously found from a small number of interviews on genetics problems that experts are more likely than students to use metacognitive and orientation practices such as clarifying what a question is asking, identifying the type of content knowledge required to solve the problem, and recalling relevant information. To further compare expert and student strategies, we characterized how students and experts solved the same questions on four different topic areas in genetics: probability using a pedigree, nondisjunction in meiosis, determining mode of inheritance using a gel and a pedigree, and determining inheritance probability with recombination. Participants answered a series of questions on these topics online and documented their problem-solving process as they answered the questions. We scored each answer as correct or incorrect and then categorized the processes used by assigning representative codes to each statement. Fifty-two experts provided 180 answers, of which 79% were correct, which we compared to 1,692 already-scored student answers, of which 59% were correct (see Avena et al. and McIntosh et al. abstracts). Significantly more experts than students ($p<0.001$) check their work, orient themselves to the problem by clarifying what a question is asking, and recall information. Significantly more experts than students ($p<0.001$) also use task execution processes, such as using and integrating information, creating visual representations, and abstractly stating their problem solving process, as well as using reasoning for their ideas. Experts are also more likely to eliminate possible answers ($p<0.05$), although this is a less used process. When experts answer incorrectly, 45% include an incorrect use of information, while only 6% of correct expert answers contain this process ($p<0.001$). In addition, expert answers are longer than those of students, containing an average of 16.8 codes per answer, compared to an average of 8.9 codes per student answer ($p<0.001$). This suggests that experts are more thorough at documenting their problem-solving process, which may help them reach a correct final answer. Additionally, several processes found in more expert than student answers, including checking one's work, clarifying question content, creating visual representations and integrating information, appear critical for correct problem-solving.

Poster #9 Teaching freshman biomedical chemistry through discovery as a sequence of three course-based research experiences Susan Flynn*, Binghamton University; Nancy Stamp, Binghamton University [abstract #160]

The Freshman Research Immersion (FRI) program has introduced advanced biomedical chemistry concepts to freshman as part of a sequence of three semester course-based undergraduate research experiences. Students who are invited to participate in the biomedical chemistry stream of the FRI are immersed into a unique research and learning environment where students discover by conducting authentic research. During the three semesters of the program students work in small teams to develop an expertise in advanced laboratory techniques, improve on scientific communication--both written and oral--and polish their professional skills. Currently, our research spans from chemistry to molecular and cell biology as achieved through conducting research, investigating complex and novel questions as a class and a subset of questions designed by students as a team. Additionally, the stream works with the chemistry department faculty to focus research on protein chemistry and aims to understand the role and requirements of specific modifications involved in cellular oxidative stress and glutamate transporters. In this “flipped” and highly interactive course, the student comprehension is assessed regularly through verbal responses, quizzes, presentations, data organization, and written analysis. By the end of the three semesters, the students will have walked in as a freshman and walked out a researcher. As an educator for this unique program, it is important to keep an active learning environment focused on teamwork, student-centered learning, and clear goal setting.

Poster #10 Developing a digital tool to evaluate and teach graphing in introductory biology Elizabeth Suazo-Flores*, Purdue University; Stephanie Gardner, Purdue University [abstract #169]

Increasingly, undergraduate biology curricula include activities in which students engage in the practices of science as a means to learn science. These practices include designing and executing experiments, and grappling with the data that result from those experiments. Students need to evaluate and identify relevant variables, organize and summarize data, and typically visualize those data in the form of a graph in order to answer research questions and draw conclusions. However, students struggle with the knowledge and skills necessary to be successful in these endeavors. Although there are some tools and resources to assist instructors and students as they engage in data analysis and visualization, they are often brief in duration, general in their context, or difficult to implement at scale. Therefore, we sought to leverage the affordances of the digital environment to create a graphing tool that can be embedded in diverse, authentic biological contexts, capture student data handling and graphing behaviors, and use those student data to better understand student competence and difficulties. Our work is informed by the evidence-centered design and design-based research frameworks. We have engaged in five iterative design cycles informed by the literature in experimental design, data analysis and visualization, expert feedback, and student pilot interviews. We are now using think-aloud interviews to test how well the tool can characterize student graphing behaviors. We are also comparing student work in the digital tool to student work with pencil and paper. Data from these interviews are being used as evidence to support claims that choices and products in the digital environment can be characterized as representing specific lines of students’ reasoning with data and data visualizations (i.e., features of the student models of graphing). Here we present critical features of our design process, examples of student difficulties we aimed to capture and new ones that have emerged, as well as evidence in support of our student model claims gathered from students’ use of the digital graphing tool, supported by data from interviews. The product of this work will be digital teaching and assessment modules that can be used to reveal student knowledge and skill, providing real-time formative feedback to instructors and students, and be used without the need for instructor grading of individual work in classroom settings of all sizes.

Poster #11 Exploration of the "murky middle" through a modeling-based introductory biology course Bethany Gettings*, Michigan State University [abstract #22]

Universities and colleges in the United States frequently prioritize two groups of students for recruitment and student-success initiatives. High-achieving students are often rewarded for their accomplishments through merit-based scholarships, awards, and fast-track programs that enable acceleration. Lower-achieving students are offered academic interventions such as instructional support and remedial programs that aim to increase engagement and enhance retention through improved educational experiences. As a consequence, many students who would be considered "middle-achieving" are neglected by educational opportunities. In 2014, Inside Higher Ed brought attention to students who complete their freshman year with a GPA between 2.0 and 3.0, typically considered neither low- nor high-achieving, but ultimately do not end up graduating. This population of students has become referred to as the "murky middle". For my dissertation research, I am developing a project on the murky middle inspired by two studies conducted in 2012 and 2015 that focused on modeling-based instruction in a reformed introductory biology course for majors. Students from high-, middle-, and low-performing tritiles constructed models of gene-to-evolution phenomena during the course and again in an interview study 1-2 years post-course. Data analyses from both studies revealed that middle achieving students outperformed both the low- and high-achieving students in their follow-up interviews on aspects of metacognition, causal reasoning, and generative thinking. These findings suggest that prior achievement did not predict retention of either content knowledge or science process skills that were measured during the interviews. When compared to other groups post course, middle-achieving students retained a more coherent and robust understanding of elements related to course content and improved ability to re-engage in modeling tasks. For my dissertation research, I propose to build off of prior work and examine whether middle-achieving students have a fundamental restructuring of cognitive structures that differs from that of high- and low-achieving students. I will investigate this through a series of clinical interview studies and analyses of students' written work. Through this, I will be able to make a novel contribution to educational research through quantitative and qualitative investigation of the "murky middle": something which has yet to be undertaken. Ultimately, this project hopes to inform instruction, success initiatives, and retention efforts that are best focused on students where the biggest impact can potentially be made.

Poster #12 Characterizing student approaches to science communication Heather Bergan-Roller*, Northern Illinois University; Shupei Yuan, Northern Illinois University [abstract #49]

From the development of life-saving medicines to the ever-increasing yields of staple crops, science has expanded our understanding of the natural world in a manner that benefits the general public. However, in order to maximize the realized benefit of these advances, the public should be aware of recent scientific advances, have a general understanding of their impact, and value the newfound knowledge afforded by these advances. Unfortunately, communicating science with the general public (herein referred to as SciComm), can be difficult and sometimes counter-intuitive. For example, previous work show that individuals often weigh their personal values and beliefs over scientific evidence, even with a clear understanding of the evidence refuting those beliefs. Findings of this nature have helped motivate improvements in how science is communicated with the public. Scientists are commonly looked upon to communicate with the public about science yet receive little or no training on effective communication strategies. Recently, several groups have put forth considerable efforts to understand how scientists engage in SciComm and to train scientists in effective SciComm approaches. However, little has been done to examine how these skills and techniques are cultivated in prospective scientists, specifically undergraduate life science students.

Communication is an important professional skill essential to the undergraduate curriculum, even for students who do not pursue careers as scientists. In this study, we examined how environmental science students, tasked with creating a public outreach instrument, communicated science with the public. Thirty SciComm projects were analyzed using Mercer-Mapstone and Kuchel's 12-strategy framework for effective science communication with a mixed methods approach. Results will describe the average number of strategies used, which strategies were the least and most commonly considered and implemented, and the quality of the implemented strategies. We will discuss the quality versus quantity of effective SciComm strategies students used and how this compares to established scientists as well as strategies recommended in evidence-based literature. Finally, we will discuss recommendations on how to engage undergraduate students in effective SciComm approaches.

Poster #13 Examining Scientific Literacy Research to Define Research Literacy
Christopher Lam, Florida International University; Matthew Kararo*, Florida International University; Melissa McCartney, Florida International University [abstract #62]

Achieving scientific literacy has emerged as a common learning objective for post-secondary educators of discipline-based science courses. However, inconsistencies in the literature discussing scientific literacy has resulted in a proliferation of ambiguous and confusing definitions, often encompassing both the consumption and production of scientific content. There is also an observed overlap in the literature between the terms scientific and research literacy. This can lead to inconsistencies in how scientific literacy is measured and evaluated in course and program outcomes. While it may be necessary for all students pursuing a degree in a scientific field to have a requisite ability to produce scientific content in order to become successful in their future careers, it is not necessary, or perhaps appropriate, to expect non-science majors to obtain the same abilities. However, it is important for students completing a post-secondary degree, whether in a scientific or non-scientific field, to graduate with a requisite level of ability to consume scientific content as part of a comprehensive higher education program. In order to ensure this goal is accomplished, a singular concise and reliably measured scientific literacy definition must be developed that is centered around consumption of scientific content. Although there has been considerable progress made towards this goal, a consensus remains elusive. This is crucial to determine relative program and course qualities, to know where we stand comparatively as a population, and to know where improvements can be made. Currently, in the literature, scientific literacy appears to be broadly defined as either knowing facts about science, or having the ability to analyze data, recognize patterns, and interpret and apply scientific information. Specific definitions observed in the literature examined for this study number in the dozens, further revealing the need for both a comprehensive broad consensus-based definition of scientific literacy, but also specifically conceptualized and measurable variables that all exist within the broader term. In this study, we propose a reconceptualization of scientific literacy as evolving and resulting in two separate terms—scientific literacy and research literacy. Both literacy terms are conceptualized as continuums, with scientific literacy constructed around the skills and knowledge required to consume scientific content, and research literacy constructed around the skills and knowledge required to produce scientific content. By integrating concepts from literacy research, the continuums will range and contain benchmarks such as scientifically and research illiterate, scientifically and research literate, and scientifically and research fluent. Future research will further investigate these benchmarks on the continuums and potential pedagogical interventions targeting key variables within these constructs.

Poster #14 Student Argumentation, Knowledge and Values Related to Biofuels Jyothi Kumar*, UNL; Jenny Dauer, University of Nebraska-Lincoln; Madeline Eischen, UNL [abstract #167]

In order for citizens to engage in sense-making and argumentation about biofuels, they must be able to trace carbon in processes like photosynthesis and combustion (Parker et al 2014). In large STEM majors and non-majors required course designed around the learning goals of science-informed decision-making, media literacy and systems thinking, we examined students' argumentation quality around the controversial socioscientific issue of biofuels. Our classroom goal was for students to understand, prioritize and argue about the multiple dimensions of the issue related to climate change, renewability, conservation of soil and water, economics and ethics. We measured students' carbon-tracing knowledge and their value orientations and examined how these variables related to students' overall stance on the issue and argumentation quality. We collected data from 34 students in Spring 2016. We coded students' open-ended pre- and post-responses to "Should we use corn ethanol as a biofuel?" for their stance (pro, moderate, con) and argumentation quality level. Following Kuhn (1997) we considered quality arguments as those that reasoned about the functional basis for biofuels, including whether or not biofuels reduce carbon dioxide in the atmosphere, as opposed to arguments that are non-functional or non-justified. We measured egoistic, altruistic and biospheric value orientations (DeGroot & Steg, 2008) using a survey at the beginning of the course. We coded students' performance on photosynthesis and a combustion quiz question at the end of the 2-week biofuel unit using matter and energy learning progression levels (Mohan et al. 2009). We found that overall students primarily had a medium argumentation quality level where their reasoning centered on non-functional uses of biofuels such as economics and a vague sense of what is good or bad for "the environment." Few (6 students) reasoned about greenhouse gases on the post response. Our preliminary analysis suggests that those who did have higher quality argumentation, also had higher carbon tracing quiz scores. Argumentation quality level did not have the relationship with students' stance on the issue nor their value orientations. This research helps instructors understand the landscape of complex variables that play a role in students' argumentation ability. Despite classroom interventions that included a focus on life-cycle analysis and matter and energy tracing in carbon processes, many students did not see a reason for these elements of the issue in their post-response. However, those who did also had higher quiz scores suggesting that understanding carbon-transforming processes may be related to students' greater attention to greenhouse gases during argumentation. More explicit instruction on argumentation skills may improve students' ability to connect and prioritize multiple dimensions of complex issues, including knowledge and values.

Poster #15 Evaluating the Impact of Service Learning by Exploring Student Long Term Memory and Emotion Amy Kulesza*, Center for Life Sciences Education; Kelsie Bernot, North Carolina A&T State University; Judith Ridgway, The Ohio State University [abstract #172]

We added a service-learning activity to an honors introductory biology class, which supported national efforts to educate a scientifically literate citizenry. Grounded in Kolb's experiential learning theoretical framework, our inquiry-based service-learning model guides students in applying scientific process skills and connecting classroom content to real-world community issues. Kolb intended learners to cycle continuously through four stages (concrete experiences, reflective observations, abstract conceptualization, and active experimentation) as they developed expertise. Like Kolb, we expected the brief experiences to trigger repeated cycles of service or research linked to learning; thus, we investigated long-term differences between service learning (SL) and research projects (RP). In many service-learning models, students participate in extensive service-learning throughout the semester, with well-documented benefits. Less attention has been paid to brief service-learning models such as ours, which involve <10 hours of service-learning per semester. From 2016-2017, we collected survey data from students who had taken SL (n=19) or RP (n=30) versions of the course three years prior. The survey included open- and closed-response items that measured participation in additional service or research activities, persistence in STEM major, memories of the project, relevance of biology to student lives, motivation to learn biology and influence of project on career choice. Strikingly, we observed dramatic differences in students' recollection of their projects; 60% of RP students demonstrated no memory of their research project; whereas 85% of SL students articulated vivid descriptions of their service learning. However, we were unable to detect statistically significant differences in science motivation, impact on career choices or persistence in STEM, possibly due to limited sample sizes or because our population consists of highly motivated honors students. We hypothesized that the striking differences in memory of the project may be related to emotions elicited from participating in service learning. Student focus groups and individual interviews were conducted using a semi-structured interview protocol, in addition to students completing the Positive and Negative Affect Schedule - Expanded Form (PANAS-X) to identify strong emotions tied to the service-learning project. We will present emotional themes from the PANAS-X. We will also discuss emergent themes of the open-ended responses in relation to student perceptions of their learning gains, impact on their understanding of the process of science and the relationship between science and the community. We will compare student responses from surveys taken immediately after they completed the project to their perceptions three years later to discern lasting impacts.

Poster #16 Investigating knowledge and attitudes of prairies between visitors of Minneopa State Park and the general public. Addeline Theis*, Minnesota State University, Mankato [abstract #194]

For successful conservation and the continuation of restoration projects, public understanding, acceptance and support are essential. While research into public views and behaviors related to environmental restoration exist, large gaps remain. Studies examining behaviors, attitudes and value orientations related to conservation are limited and even fewer studies investigate these constructs in relation to demographic, societal or cultural factors. This lack of research is more pronounced when researching prairies and/or prairie restoration. Tall-grass prairies we were once a dominate biome in Minnesota but now are an endangered ecosystem. While conservation is occurring throughout Minnesota to restore and create new prairies, there is a lack of information examining the relationship of prairie restoration and the public's views. New prairie restoration programs include the used of bison as flagship species which can serve to promote engagement and education. Minneopa State Park recently introduced a herd of bison and provides an ideal study site to investigate the public's understanding of prairies, their attitudes, values and behaviors related to prairie and restoration. This state park has seen a sharp increase in visitors since the introduction of the bison herd. Our research goal is to investigate the public's knowledge of prairies and their attitudes, behaviors related to conservation. As part of this research, a survey instrument has been created and is currently undergoing validation and continued development. The statements on this instrument are on a 5-point Likert scale and were designed to measure three constructs people's attitudes, behaviors and knowledge. The instrument includes statements that are designed to elicit individual's general knowledge, attitudes and behaviors related to conservation and specifically to prairie ecosystems. As part of the development and validation process, a literature review was conducted and experts in the field were consulted. The instrument has been piloted and has undergone factor analysis and measures of reliability (e.g. factor analysis and Cronbach's alpha). In addition, demographic information will be collected. Data collection is planned to occur in Minneopa State Park beginning in Spring/Summer 2018. Preliminary data shows a significant negative relationship between behavior and knowledge ($\chi 2[2, N=379]=23.994$, $p<0.0001$) and attitude ($\chi 2[2, N=593]=26.518$, $p<0.0001$). Individuals who indicated positive attitudes towards conservation are likely to indicate positive behaviors. However, these individuals demonstrated a novice-level of knowledge. This study will not only add to research investigating the public's views of environmental conservation but specifically of prairies. Additional, the information gained from this study could be used in educational research and have implication in future conservation efforts for both private conservation groups as well as state natural resource department.

Poster #17 Identifying Core Bioethics Content Using Course Descriptions Lygie Lunyanga, Crown College; Tiffany SInclair, Nova Southeastern University ; Aeisha Thomas*, Crown College [abstract #233]

Bioethics is an important interdisciplinary area for the practice of science in multiple realms. Initiatives, such as Vision and Change, have shown the value of identifying core content by a consensus approach. The goal of this study is to identify fundamental bioethics content from within the education community. Although course descriptions are a snap shot of courses and thus limited in depth, they are an easily accessible and comparable source of data from multiple institutions. Thus to characterize current bioethics classes, biology related ethics course descriptions from 100 institutions were collated. The courses were categorized into general bioethics (n=29), medical ethics (n=34), environmental ethics (n=40), healthcare professional ethics and other courses. The first three groups were analyzed further. The presence of the four themes: ethics principles, public/policy, individual and decision-making was determined in all three categories. Ethical principles was the most common. Each course category was also assessed to identify content emphases in addition to the four above. Preliminary findings identified the most common theme for each category to be: (a) ethical problems in general bioethics courses, (b) practice of medicine in medical ethics courses and (c) moral/values and human were similarly frequent in environmental ethics courses. This study of course descriptions highlights other core bioethics content based on the similarities across curricula from different institutions. The results provide both a big picture view of the discipline as well as a potential source of guidelines for course development and revision. The focus of this initial analysis was on content. Future analysis could focus on teaching approaches and differences between types of institutions and departments of record.

Poster #18 Natural Wonders: a library and museum collaboration Katherine O'Brien*, OSU; Marymegan Daly, OSU [abstract #237]

Natural History Museums are attractive venues for informal STEM learning. However, these often have fees for entry and are limited in number and geographic occurrence, reducing access to these opportunities. Although a visit to a natural history museum can be an impactful experience, it is usually an isolated one, occurring in a single annual or less frequent visit. From an institutional standpoint, exhibits are costly to develop and maintain, and the ways in which visitors interact with them may not be the most effective way to foster engagement and learning. Our campus' biological diversity collections are designed for research only and lack exhibit space. As an alternative to exhibits, we develop and extend programming with community organizations, putting biodiversity content in a variety of spaces throughout our city. These partnerships support repeated encounters with biodiversity themes and allow multiple points of access to museum specimens and content experts. Taking natural history specimens out of research collections and using them to catalyze learning in informal spaces. In collaboration with our local library, we have developed a biodiversity displays kiosks that change monthly starting in October of 2017. Each display includes specimens, text, and images designed in collaboration with librarians and museum staff. In addition each kiosks features self-guided interactive features with either sounds, a craft or learning game. The display kiosks are showcased in the atrium of the library, where they are encountered by >10,000 patrons weekly (and 25,000 unique visitors annually). Informal feedback and observations of patron interactions with the kiosks indicate that take away activities like crafts are especially effective at engaging both young people and their parents. While the open-ended interactive games that don't require intervention from a docent hold the attention of school-aged children and inspire conversation. Kiosks with sounds are attractive and accessible to diverse age groups. Each kiosk includes 4 manipulate-able boards with text that slide out from under the vitrine are not intuitive for many patrons and need to be made more obvious and accessible. There is limited evidence to date for an increase in requests for books and other materials related to the content because we chose themes that naturally lend themselves to increased circulation at the time of display. For example books on bats and other nocturnal creatures were on display for “Creature of the night” in October. We have used the number of crafts used each month as a count of engagement but are looking to extend our assessment of the program as we expand our partnership to other area libraries.

Poster #19 Mid-sized Midwestern University & Summer Health Professions Career Camp: Rurality’s relationship to college enrollment, major choice and graduation. Benjamin Halbkat*, South Dakota State University; Sumadhuri Pamarthi, South Dakota State Univesity; Greg Heiberger, South Dakota State University [abstract #246]

The Summer Health Professions Career Camp is held every summer on this university’s campus as a means of allowing soon-to-be high school juniors and seniors the chance to pursue interests in the Science field of STEM, primarily Health-based careers. Students are able to interact with health care professionals as they are walked through hands-on demonstrations and tours of various health care facilities. Students learn important aspects of health care professions in the fields of nursing, pharmacy, medical laboratory science, and more. This program began on campus during the summer of 2008, and has continued to operate every summer since its inception. Initially, only 13 students from various high schools both in and out of state signed up for this opportunity, but the numbers have grown significantly to more than 50 students participating each summer. A total of 368 recorded students have attended, of which 317 have or are currently attending a public undergraduate institution within the state. The goal of this research was to identify any relationships attributing to college enrollment, major choice, and graduation rate in accordance with rurality of each student’s hometown. After attending camp, 54% of the total students attended a public state university, of which 70.7% attended this university. Approximately 52% of students chose a major within the field of STEM and 37% chose within the field of Health for their primary Program choice. Concerning graduation, 28% of students attending either this university or any other public state university graduated with a major in STEM and/or Health for their primary Program. After determining the rurality for each student’s home county, the data denoted that the average rurality of the students’ homes was the same as the rurality of the university. Analysis indicates that the Summer Health Professions Career Camp could be replicated to other campuses, career fields and supports minor modifications to the camp moving forward.

Poster #20 The CREATE instructional strategy as a transformative experience for faculty
Lindsey Warnock, University of California San Diego; Stanley Lo*, University of California San Diego [abstract #30]

CREATE is an instructional strategy that aims to develop undergraduates’ understanding of scientific concepts and the nature of science through immersion in primary literature. CREATE has been shown to have diverse positive impacts on students in STEM courses: significant cognitive and affective gains in experimental design, critical thinking, attitudes about their learning, and epistemological beliefs about science. Because CREATE represents a substantial departure from traditional instruction, we examined the long-term impacts on faculty from teaching with CREATE. To explore instructors’ developing conceptions and approaches to teaching, learning and other related domains, we took a phenomenographic approach to examine the variations in their experiences with active learning, memorable teaching moments in the classroom, and the impacts of these moments on how they understand students, teaching, and learning, as well as how they view themselves as educators. Data were collected through interviews with 30 advanced CREATE implementers (attended CREATE workshops two or more years ago and taught at least one undergraduate course using CREATE). Interviews were transcribed verbatim and were analyzed using both deductive and inductive approaches: Codes were generated from the data using thematic analysis and were then grouped into categories by combining existing frameworks from literature. The memorable moments were coded into eight emergent categories. Instructors also reported that they experienced changes in their conceptions of and approaches to five domains related to teaching and learning: curriculum, instruction, learners, learning environment, and the professoriate. Specifically, the most common impacts that were mentioned involved teaching skills instead of strictly content and using active learning in the classroom. Furthermore, 62% of these CREATE faculty thought that they would not have experienced similar moments and impacts without using CREATE. Together, our data indicate that classroom experiences while teaching with student-centered instructional strategies provide unique opportunities for instructors to rethink and change their conceptions and approaches to a variety of domains related to teaching and learning. Our results uncover the interactions that instructors found most influential in shaping their current conceptions and approaches to teaching and learning.

Poster #21 Supporting Educators in using Primary Scientific Literature in the STEM Classroom Melissa McCartney*, Florida International University; Marie Janelle Tacloban , Florida International University [abstract #55]

In recent years, Science, Technology, Engineering, and Mathematics (STEM) education has shifted away from content memorization and toward promoting a deeper understanding of the nature of science. What is the most effective way to teach the nature of science? A growing body of research shows that primary scientific literature is a valuable and useful tool for teaching the nature and practices of science. For example, discussing primary literature in a classroom setting engages students in the scientific practice of discussion and debate around interpretations of experimental data. However, do teachers have the correct training to bring primary literature into their classrooms? How do we make primary literature more accessible to teachers? We developed a one-day workshop designed to (1) help teachers understand of the nature of science; (2) show teachers where to find appropriate primary literature to fit their curriculums; (3) increase teachers confidence in being able to read primary literature themselves; and (4) show teachers how to design a lesson plan for using a primary literature as a way to teach the nature of science. Participants consisted of 8 pre-service teachers, 15 high school teachers, and 8 undergraduate faculty members. The workshop consisted of expert speakers in the fields of science standards and teaching with primary literature. Participants were asked to work in groups to develop lesson plans and curricular units using primary literature as a pedagogical tool. Participants self-reported gains in their ability to find and select appropriate primary literature for classroom use and in their confidence to guide students in reading primary scientific literature. Participants reported no gains in their understanding of the nature of science. The workshop succeeded in showing teachers how to select primary literature that they can use in their classrooms. However, we did not provide teachers with the tools necessary to connect the nature of science to primary scientific literature. While primary literature and the nature of science are related, participants did not make this connection through our workshop presentations and activities. Why is this? We are continuing to code qualitative data collected from participants as well as the transcripts from workshop speakers to identify where we did, or did not, explicitly connect scientific practices to the nature of science. As we revise our workshop for additional offerings, we will integrate activities focused on highlighting the nature of science through primary scientific literature.

Poster #22 Current Literature on Biology Graduate Teaching Assistant Teaching Professional Development (GTA TPD): Mapping a Research Agenda Grant Gardner*,

Middle Tennessee State University; Beth Schussler, "University of Tennessee, Knoxville"; Kris Miller, University of Georgia; gilim Marbach-Ad, University of Maryland; Judith Ridgway, The Ohio State University; Joshua Reid, Middle Tennessee State University; Miranda Chen, University of Tennessee, Knoxville [abstract #130]

Research Problem Graduate Teaching Assistants (GTAs) are critical yet under-appreciated instructors in the movement to reform undergraduate biology education through evidence-based instructional practices. GTAs support a large number of gateway courses, including laboratories, shown to be critical for the success and retention of early undergraduates. Despite this important role, GTA Teaching Professional Development (TPD) continues to be limited or nonexistent at many institutions. The disparate nature of peer-reviewed research literature related to TPD offers little in the way of best-practices in the field. Research Design We present results from a critical synthesis of the literature related to biology GTA TPD and align it with a research framework to inform the state of the field and recommend future directions for research and practice. Data sources included peer-reviewed articles on GTA TPD published since 1980. The authors conducted independent searches to assure comprehensiveness of the sample (n = 147). We conducted a broad search that included a diversity of article type and quality as well as across all disiplines. Each article was coded by type (literature review, TPD program description, or TPD research), content discipline, type of TPD [coded using Schussler et al. (2015)], research design, and relevant TPD outcome variables [coded using Reeves et al. (2016)]. Analyses and Interpretations 4.76% of the articles were literature reviews (two in the sciences), and 15.65% of the articles described a TPD program (n = 6 were biology-specific). The remaining 79.59% (n = 116) measured some sort of outcome variable related to the TPD. This poster focuses on 48 articles related biology (32.65% of the original sample) with some outcome data. If described, type of TPD was coded (39.58% did not indicate TPD type). The most common types of TPD studied occurred during instructional lab meetings (n = 13 studies) or as semester-long department programs (n = 11 studies). Review of teaching evaluations as a form of TPD was the only type not represented in the literature. The majority of outcome variables were related to GTA beliefs about teaching and learning (28.0% relative frequency), GTA instruction (22.7% relative frequency), GTA pedagogical knowledge and skills (20.0% relative frequency). The least represented outcome variables studied were GTA instructional planning (1.3%) and undergraduate student retention (2.7%). We will synthesize the relevant findings related to these and other outcome variables. Contributions This literature synthesis and alignment with a research framework found that there was a disparity of certain outcomes being measured. This provides a view of the state of the current field of biology GTA TPD best practices. In concert with the NSF-sponsored Biology Teaching Assistant Project (BioTAP), this data is used to construct a research agenda and promote collaborative research teams in this strand.

Poster #23 Supporting undergraduate STEM educators' instruction: A longitudinal investigation of faculty instruction post-professional development program Blake Whitt*, University of Georgia [abstract #136]

Active learning is an important instructional approach to improve the learning of undergraduate STEM (Science, Technology, Engineering, and Mathematics) students (Freeman et al., 2014). One way to support STEM faculty's adoption of active learning instruction is through professional development programs (PDPs). However, without continuing support in the form of social and/or instructional resources, it is difficult for faculty to make lasting changes to their instruction. To improve the efficacy of PDP efforts, it is important to understand how STEM faculty support and enact their use of active learning approaches after PDP participation. The aim of this study is to describe university STEM faculty's perceptions and use of active learning instruction over time with respect to available supporting resources. 22 STEM faculty instructors were interviewed and observed throughout a semester following or concurrent with participation in one of several PDPs intended to promote the use of active learning instruction. Of this group of instructors, 6 volunteered to continue participating throughout the following academic year. During the first academic year, semi-structured interviews were conducted both before and after the observed semester to examine instructors' views of, and experiences with, active learning instruction in their undergraduate STEM course. Instructors participating in the second year were only interviewed at the end of semester and asked to discuss their perceptions and continued use of active learning instruction. These qualitative data were analyzed inductively by project researchers using consensus, which supported the validity of the conclusions. Classroom observations were made several times throughout each semester using the COPUS (Classroom Observation Protocol for Undergraduate STEM) to assess the degree of active learning instruction in each class. These quantitative data were collected by multiple researchers after inter-rater reliability was established. Both qualitative and quantitative data collection for the second academic year of this study are currently underway and will conclude in early May of 2018. The interview and observation data from instructors participating in the longitudinal extension of this study will be analyzed to understand how they did (or did not) enact and support their use of active learning. We anticipate our findings will provide insight into how faculty's perception of active learning changes years after participating in a PDP and important implications for PDP design regarding resources' influence on how and why faculty continue their use of active learning instruction.

Poster #24 The University Classroom Observation Program: Connecting middle and high school teachers with university level STEM instruction Erin Vinson*, University of Maine; Michelle Smith, University of Maine; MacKenzie Stetzer, University of Maine [abstract #174]

The University Classroom Observation Program (UCOP) invites middle and high school teachers to the University of Maine to observe instruction in undergraduate STEM courses. As part of the UCOP, middle and high school teachers observe faculty using the Classroom Observation Protocol for Undergraduate STEM (COPUS), reflect with other teachers regarding the use or absence of evidence-based teaching strategies, and give feedback to faculty based on information they request (e.g., Am I paying attention to all parts of the classroom equally?). In addition, middle and high school teachers engage in group discussions with faculty regarding common issues in teaching and learning at all educational levels. The goals of the program include: - developing a clearer understanding of the current state of STEM instructional practices at the university level through classroom observation, - using observation data to help design faculty professional development opportunities around evidence-based teaching strategies, and - providing discussion and networking opportunities for middle and high school teachers to reflect with one another and with faculty on their own teaching. Over the course of four years, 84 middle and high school teachers completed 580 observations in 234 course sections across 26 different STEM departments, with 186 instructors. Over 11,000 undergraduate students collectively attended all courses observed. We have published peer-reviewed articles using data collected through UCOP in journals such as Science, Life Sciences Education, and Frontiers in Education. Survey results show that both teachers and faculty have found the experience to be beneficial and want to continue having opportunities for observation and discussion. We also found that by using observation data to inform the design of professional development opportunities for faculty, we are better able to create more targeted opportunities that are attended by a greater number of faculty members. Based on the positive outcomes of the program at the University of Maine, there continues to be interest in replicating the program at other higher education institutions. Therefore, this poster will describe UCOP outcomes (including professional development opportunities for teachers and faculty, collection of observation data, design of future faculty professional development opportunities, and publishing results), share lessons learned, and explore ideas for other colleges and universities that wish to replicate parts of this program.

Poster #25 Professional Development of Instructional Team Members Working to Improve Opportunities for Student Learning in Large Enrollment Undergraduate STEM Courses by Focusing Independently on Classroom Management and Student Thinking
Jonathan Cox*, University of Arizona; Katelyn Southard, University of Arizona; Young Ae Kim, University of Arizona ; Lisa Elfring, University of Arizona; Paul Blowers, University of Arizona; Vicente Talanquer, University of Arizona [abstract #176]

While overwhelming evidence in support of active learning has propelled many undergraduate courses toward transformation, instructors often encounter challenges in implementation in large enrollment introductory STEM classrooms. Some of these challenges can include designing and implementing high quality tasks that demand high-level thinking, collecting evidence of student reasoning and using it responsively to make instructional decisions, juggling complex classroom management issues, and effectively using learning assistants. We have sought to address some of these challenges through the implementation of a unique instructional team model, Learning Teams (LTM), and supporting professional development (PD) opportunities. The aim of this LTM is to help instructors create: 1) high-functioning instructional teams focused on student learning, 2) high-quality instructional tasks that maximize student learning, and 3) effective formative-assessment opportunities that provide information to improve instruction. In this model, the instructional team includes four interconnected roles: 1) a Lead Instructor (LI), who plans and leads the implementation of the course; 2) a Learning Researcher (LR), who engages in formative assessment of student thinking and provides feedback to the instructor; 3) an Instructional Manager (IM), who helps manage the instructional team; and 4) a team of Learning Assistants LAs who support student work during in-class tasks. We have piloted this instructional team model with eighteen faculty in 9 STEM departments. While the LI is a faculty member, the remaining roles are typically fulfilled by undergraduate and graduate students. Each role has specific responsibilities that are uniquely supported through different professional-development opportunities. In addition to describing the Learning Teams model, this poster presentation will highlight some of the accomplishments faculty and students have realized in adopting the model. We further identify some of the challenges faced by participants and present some of our supporting PD to facilitate change. Although elements of the IM and LR PD will be presented, we will focus on the LI Faculty Learning Community and the LR Course curriculum, with specific examples illustrating the communication of undergraduate LRs about students' learning difficulties in their daily Learning Reports to the LIs.

Poster #26 Pedagogical Change in Academia: A Cultural Evolutionary Model Daniel Grunspan*, Arizona State University; Michelle Kline, Simon Fraser University; Sara Brownell, Arizona State University [abstract #217]

The benefits of student-centered active learning approaches are well established, but this evidence has not directly translated to instructors adopting these evidence-based methods. To date, promoting and sustaining pedagogical change through different initiatives has proven difficult, but research on pedagogical change has advanced these efforts. To help these efforts, we apply cultural evolutionary theory to the process of pedagogical change, creating a conceptual model that stresses the global nature of this issue, and the generational time that change requires. In our model, cultural transmission processes and selection events shape not only who teaches in higher education, but also how they choose to teach. By social transmission, we mean the beliefs, practices, and various artifacts from other individuals that future and current professors acquire within the social and institutional contexts they experience throughout their career in academia. By selection, we mean that certain individuals are filtered out of the academic pipeline of becoming a tenured professor, which can occur by their choice or the choice of someone else. These selection events are largely driven by incentives and barriers set by hiring and promotion criteria. Over time, these transmission and selection processes shape the kinds of pedagogy we observe among the professorate. Since the specifics of these processes likely differ for each phase of an academic career and type of institution, we consider dynamics at each sequential career phase at both research-intensive institutions and teaching-focused institutions. We expand on this conceptual model by constructing a simulation model based on these cultural evolutionary dynamics within the academic system. This population-based simulation tracks instructional behaviors over time, and is parameterized based on empirical data from hiring networks in academia and classroom observation protocols. We use this model to explore how pedagogical practices may evolve in the future, and how interventions, including faculty and graduate student training, may impact pedagogy in the long term.

Poster #27 A Longitudinal Study Examining How Scaffolds Support Metacognition in Undergraduate Biology Students Jaime Sabel*, University of Memphis; Kathryn Parsley, University of Memphis; Rand Alqirem, University of Memphis [abstract #7]

Providing feedback to students as they learn how to integrate individual concepts into complex systems is an important way to help them to reach robust understanding, but it is difficult in large, undergraduate classes for instructors to provide feedback that is frequent and directed enough to help individual students. Instructors can support students to generate their own feedback by engaging in self-regulated learning by monitoring their own work, generating internal feedback, and using that feedback to adjust their learning strategies. Various scaffolds, or instructional supports, can help students evaluate their ideas and generate their own feedback to improve their learning. However, more work is needed to understand the particular ways in which scaffolds can be designed and used to support students in considering biological concepts. Our previous work examined scaffolds for engaging undergraduate students in self-regulated learning and metacognition. We found that the scaffolds were useful to help students enhance their understanding and engage in metacognition, and that instruction on scaffold was an important part of maximizing their use and benefit for students. In the current study, we examined how these scaffolds support students from their first introductory biology course through each of the five required core courses for the biology major. We recruited students in each of the five core courses over multiple semesters and asked them to complete two surveys: one at the beginning of the semester and one at the end. We also randomly selected a subset of students from each class and invited them to interviews. We performed statistical analysis on the metacognitive score generated from each survey and grades collected at the end of each semester. We performed qualitative trend and case study analysis on the open-ended survey questions and on the transcripts from the semi-structured interviews. The analysis includes an examination of how students are using scaffolds, how they are engaging in metacognition, how both may affect their performance in the individual course, and how early engagement with these scaffolds may support their development as biology majors. Because we are recruiting in subsequent semesters, we are able to track individual students as they progress through the major to see how early exposure to the scaffolds may affect their development as biology majors, their engagement in metacognition, and their overall understanding of biological concepts. We plan to continue this study to follow individual students all the way through the major, but we will present preliminary findings from the first three semesters of data collection. Results from this study will help to structure how future scaffolds and instructional tools are created and utilized to best support students in learning and understanding biological concepts.

Poster #28 Student gains in understanding of science epistemology through participation in biology education research Dennis Lee*, Clemson University; Mallory

Wright, Clemson University; Dylan Dittrich-Reed, Clemson University; Lisa Benson, Clemson University [abstract #93]

Biology undergraduate research experiences (UREs) have been shown to increase student understanding of the processes of science through exposure to authentic scientific practice, however few studies have examined how biology education UREs affect student understanding of science epistemology, the nature of knowledge and knowing in science. Researchers studying UREs suggest that when students write about their research experiences, it helps them to activate metacognitive processes through written reflection. Using metacognition, students can begin to construct their own ideas about what constitutes knowing. In this way, students transition from thinking about science to knowing about science. In this study, we used reflective writing as an intervention and examined how it affected one undergraduate researcher's understanding of science while participating in a biology education URE. During the URE, the participant analyzed research papers written by undergraduate biology majors to determine the kinds of epistemic practices (processes used to determine if something counts as knowledge) these students used to build an argument. While this project did not provide our participant with an opportunity to understand science epistemology through authentic scientific practice, it did provide an opportunity for her to directly study science epistemology. The researchers and participant co-constructed a case study to answer the research question "How does participation in a biology education URE affect student understanding of science epistemology?" We applied the Epistemic Thinking framework to analyze the student researcher's written reflections, research papers and interviews through open coding. We chose the Epistemic Thinking framework because it integrates epistemology with metacognition while distinguishing between epistemic cognition (the processes individuals use to determine what counts as knowledge) from epistemic metacognition (the metacognitive skills, knowledge and experiences that individuals use to think about knowledge). Though our analysis, we found that the participant's metacognitive processes were activated through the reflective writing activities, and helped to clarify her understanding of how scientific knowledge is produced and its implications. In her reflections, the participant describes her realization that much of the public, including herself, "expects scientists to always be right and scientific research to be absolute." Through reflection, the participant determined that education research conclusions are produced through inferences made by researchers, one of the central concepts in the Nature of Science. This work suggests that biology education UREs promote deep understanding of research, and may promote student learning through explicit discussions on topics important to learning such as metacognition and epistemology. Based on these results, we have explored possible ways to expose more students to this kind of experience by introducing aspects of biology education UREs into the classroom.

Poster #29 Making Plans For Success In Intro Bio Scott Horrell*, Harris-Stowe State University [abstract #179]

Metacognition is the awareness and understanding of one's own thought processes. The ability to successfully metacognate has been associated with increased ability to problem solve and improved student performance. The beginning of a student's undergraduate studies is a crucial period for development of metacognitive skills because this is a major transition period in their lives where they are likely to encounter novel challenges. Harris-Stowe State University is an open-access school where 60% of our students enrolled in our introductory biology courses are concurrently enrolled in developmental courses. Students generally report a lack of challenge in their previous high school environments as well. Thus, many of our students have not had the opportunity to develop metacognitive skills necessary to thrive in a challenging STEM program. However, we currently lack information about our student population's metacognitive abilities making it difficult to design intervention approaches specifically for our

students. The goal of our study is to characterize our students' metacognitive abilities as well as test the effectiveness of a reflection assignment in promoting student metacognitive growth. To achieve this aim we had students complete reflection assignments after their first and second tests in an introductory biology course for majors. These assignments investigated several aspects of how students prepared for the test such as 1) how much time students dedicated to preparing, 2) how far in advance students began preparing, and 3) what was their general plan to prepare for the test. We also ask them to reflect on why or why not their specific plan was successful in preparing them for test. Lastly, after the first test we also provide them a list of various study strategies and suggest that they make a new plan to prepare for the second test. We obtained multiple results indicating that the reflection assignment was successful in promoting student metacognition. Even though most students did not have a good plan prior to the first test, 82% of students attempted to make a new plan after the first test providing us a strong indication that students are interested in improving their approach. Of these students that attempted to make new plans, 83% were successful in making a plan that had evidence of their personal reflections indicating they are able to identify approaches that may be successful for them personally. 61% of students were able to successful execute their plans as well by either beginning sooner or prioritizing their studies and making time. Additionally, after the first test 64% of students stated they needed to study for a longer amount of time to prepare for the next test. Of these, 67% report studying more. These data indicate that our reflection assignment is effective in promoting metacognitive growth within our student population. Our data will help refine the development of future assignments as well.

Poster #30 Interdisciplinary inquiry on pain to deepen undergraduates' epistemological understanding of science Stiliana Milkova, Oberlin College; Kelly Bezio, Texas A&M - Corpus Christi; Liliana Milkova, Oberlin College; Pam Snyder, Oberlin College; Ellen Wurtzel, Oberlin College; Taylor Allen*, Oberlin College [abstract #227]

This report presents the design and assessment of an interdisciplinary project that used pain as thematic avenue for bringing together undergraduates from biology and the humanities at a selective baccalaureate institution. The project's goal was to confront a key epistemological concept underlying each discipline and posing difficulty to learners: that knowledge, science, fact are cultural and social constructions and hence contingent. Two research questions were addressed: 1) whether the project intellectually engaged students, piqued their curiosity, and promoted dispositions of high-end cognition; and 2) whether the project advanced students' epistemological understanding. The research used quantitative data obtained with direct and indirect assessments as well as qualitative data from content analysis of students' metacognitive reflections. For the project – which in its final form involved 4 hours of joint class time spread over 4 weeks – students in multidisciplinary teams investigated the human face of pain as revealed in literature and art and the alignment of these depictions with biological understanding of pain. All students read and discussed von Sacher-Masoch's Venus in Furs and sections from Jacob de Voragine's Golden Legend, on the lives of saints. Biology students also read literature on pain. Complementing study of literature was analysis of artworks depicting saints and martyrs. The student teams developed and presented to class members a mini-exhibition of 3 or 4 artworks on the theme of pain. Each artwork's significance and inclusion in the exhibition was explained through a team-developed extended figure legend drawing on and integrating the three primary disciplinary lenses within each team, based on the courses represented by the students: an introductory organismal biology course, a gateway course to the major in comparative literature, and an advanced undergraduate seminar in history. Indirect and direct assessment with quantitative instruments, e.g., Student Understanding of Science and Scientific Inquiry (SUSSI), indicated that the project meaningfully enriched the undergraduates' study of pain and that students' understanding of the nature of science shifted away from naïve views and toward views held by science experts on observations and inferences. Supporting the quantitative data on deepening epistemological understanding was an emergent theme from content analysis of students' metacognitive reflections on the project: students gained awareness of the influence of personal perspective on knowledge and ways of knowing. An exemplary quote for this theme was, "We saw that our disciplines affected our cognitive vocabulary in subtle but substantial ways…our disciplines, themselves bodies of knowledge, often unconsciously influence the pathways of our thinking and thus the knowledge at which we arrive." Thus, the multidisciplinary project offers an effective way to nurture students' epistemological understanding.

Poster #31 Student engagement in direct instruction, undergraduate microbiology laboratories Eva Nyutu*, WMU [abstract #1]

IIntroductory laboratory courses are a standard component of undergraduate science programmes and historically taught using direct instruction/confirmatory lab models. Previous studies have shown that inquiry-based labs enhance student engagement in science courses. However, research on how direct instruction introductory lab courses effectively engage undergraduate students is lacking. This study, therefore, using a mixed model design, examined student engagement in an introductory direct instruction microbiology lab. Data was collected through self-report surveys, classroom observations, and interviews at a Midwestern university in the USA. The findings suggest that students found the lab activities engaging. This study provides baseline data which describes student engagement and student perspectives in a direct instruction undergraduate microbiology lab course. This baseline data can be used in further research against which comparisons can be made when studying other types of lab teaching interventions.

Poster #32 Building Excellence in Scientific Teaching: The BEST approach for training teaching assistants to make their labs more active Lorelei Patrick*, University of Minnesota; Hillary Barron, University of Minnesota; Julie Brown, University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #5]

Active learning (AL) teaching techniques – such as clicker questions, group work, think-pair-share, and other activities – benefit all students and can close the achievement gap for under-represented minority, first-generation, and female students in STEM disciplines. Consequently, many courses have been integrating these techniques into their labs and lectures. Several initiatives have focused on training faculty, however there has been relatively little emphasis on training teaching assistants (TAs) in the use of AL in their labs. Specifically, will TAs feel more knowledgeable about AL, find AL more useful, and use AL more often if they are presented with evidence for AL's effectiveness or if they are able to facilitate AL themselves? To investigate this question, we offered an AL workshop and split participants into an Activity (A) group and an Evidence (E) group. The A group worked in teams to learn an AL technique in depth with a workshop facilitator, then these teams modeled the activity with their peers acting as students; only a small portion of time was devoted to presenting or discussing the evidence of AL effectiveness. In the E group, facilitators modeled the activities with all TAs acting as students and spent significant time presenting evidence of AL's effectiveness. Pre- and post-workshop data were analyzed to assess TA perceptions of AL and the usefulness of the demonstrated techniques in their labs. Post-semester survey data will be collected and lab observations are in progress. Based on our preliminary survey data, E group participants reported greater knowledge of AL after the workshop than A group participants. However, A group participants found all of the active learning techniques more useful than E group participants. Both groups reported that the most useful active learning topics were Easy Assessment Techniques and Sequence Strips, which can be easily integrated into lab settings. There was little agreement on the least valuable techniques but TAs from both groups reported techniques requiring more time, materials, and planning as among the least useful aspects of the workshop. This is somewhat surprising given that some of these techniques – Case studies and Games and Simulations – are already commonly used in several of the lab courses taught by participating TAs. These results suggest that actually modeling AL techniques made them more useful to TAs than simply experiencing the same techniques as students—even with the accompanying evidence. Furthermore, assembling an easily implemented toolkit of strategies transferable to any course will facilitate TA adoption of AL. These lessons will be especially important for biology TAs who are called upon to facilitate different types of inquiry as they assist with the development of the next generation of scientists.

Poster #33 ENCOUR: Establishing a Network for the Integration of Ethics/RCR Education into CUREs in the Biological Sciences Jay Bhatt, UTEP; Ginger Fisher, University of Northern Colorado; David Esparza, University of Texas at El Paso; Laura Diaz-martinez, University of Texas at El Paso; Aimee Hernandez, University of Texas at El Paso; Jeffrey Olimpo*, The University of Texas at El Paso [abstract #10]

The prevalence of course-based undergraduate research experiences (CUREs) within national biological sciences curricula has grown exponentially within the last decade. Current evidence suggests that CUREs offer an innovative platform to engage large numbers of students in novel research, thereby familiarizing these individuals with authentic scientific practices and enhancing their ability to "think like a scientist." One such critical component of scientific practice is the Responsible Conduct of Research (RCR). However, an initial literature search revealed a lack of studies on ethics/RCR integration in CUREs. Furthermore, survey and semi-structured interview data collected from CURE instructors, designers, program directors, and stakeholders (n = 12) indicated that a large majority (~85%) of individuals agreed that ethics/RCR education should be integrated within CUREs despite a perceived lack of current planned and intentional integration of ethics/RCR education into such learning environments. In response to this need, the Ethics Network for Course-based Opportunities in Undergraduate Research (ENCOUR) was formed to initiate a national conversation and exploration of effective approaches for integration of ethics/RCR education into CUREs. The goals of ENCOUR are to: (1) Describe and evaluate current practices that integrate ethics/RCR into CUREs; (2) Identify gaps that need to be addressed to advance our understanding of the intersection of ethics/RCR and CURE instruction; (3) Promote integration of ethics/RCR education within CUREs in the biological sciences; and (4) Promote research to advance teaching, scholarship, and professional development at the intersection of CUREs and ethics/RCR. In addition, the ENCOUR website serves as a hub for resources aimed at aiding CURE instructors/designers in the development, implementation, and assessment of ethics/RCR instruction in CURE contexts. We anticipate that poster-based discussion with SABER attendees around these goals and the aforementioned findings will serve to catalyze future teaching and scholarship efforts in this area.

Poster #34 Course based undergraduate research experiences expose students to scientific obstacles and afford opportunities to practice scientific coping Lisa Corwin*, University of Colorado Boulder; Joseph Harsh, James Madison University; Stevie Ellis, University of Colorado, Boulder; Nina Gustafson, University of Colorado, Boulder; Bri Hill, University of Colorado, Boulder; Elizabeth Woolner, University of Colorado, Boulder [abstract #39]

Course based Undergraduate Research Experiences have been lauded for involving more students in undergraduate research and providing students with opportunities to achieve numerous positive outcomes that they may not achieve in traditional laboratory settings. One such outcome, which is yet under-explored, is the development of students' ability to navigate scientific obstacles both cognitively and emotionally. This outcome is important as the ability to navigate scientific obstacles and failures is considered a hallmark of a scientific disposition and has been hypothesized to increase students' persistence in STEM. Our study uses a qualitative approach to investigate how students develop this disposition by asking: "What coping mechanisms do students employ when faced with a scientific obstacle in a CURE context?" We draw upon well-vetted models of coping previously used in in education, healthcare, and entrepreneurship studies to inform our work. We asked 120 students in 6 laboratory sections of a large introductory CURE course taught at a large comprehensive university to report on their feelings, behaviors, and learning experiences after experiencing scientific obstacles (e.g., not succeeding in extracting DNA). We are coding this data using a-priori codes based on known coping mechanisms. Our preliminary analyses indicate that a majority of students report the use of proactive adaptive coping to deal with scientific challenges including problem solving, seeking social support, and positive reframing of the obstacle. However, a subset of students report the use of maladaptive coping mechanisms such as displaying helplessness or opposition (e.g., blaming others) when faced with obstacles. These results suggest that CUREs provide students opportunities to practice coping with scientific obstacles and that we, as instructors, have the opportunity to facilitate students' development of positive coping strategies. Development of targeted instructional strategies to help students navigate obstacles will prove especially helpful for students who use of maladaptive coping mechanisms that hinder their progress and present risks to well-being.

Poster #35 The Impact of Course-based Undergraduate Research Experiences (CUREs) on Student Conceptions of the Nature of Science Jessica Dewey*, University of Minnesota; Anita Schuchardt, University of Minnesota [abstract #40]

A major goal of improving undergraduate science education is the incorporation of scientific processes and skills that students need to know and understand in order to do science (scientific inquiry). However, only elevating their understanding of scientific inquiry may not provide students with all of the scientific knowledge and understanding that they need to be well prepared, scientifically literate citizens. In order to be informed consumers of science, students also need to know about the nature of science (NOS), which in this study is defined as the values and culture intrinsic to science. Having an understanding of both scientific inquiry and NOS will help students have a clearer conception of what science is and how it works. This will help them interpret the science they are exposed to as citizens, such as climate science and vaccine research, with a more informed understanding of the field. While there is some disagreement about the number and extent of NOS values, some consensus ideas include that science is iterative, science involves imagination and creativity, and there is no single method for doing science. Other examples developed from studies of the culture of scientific work include that scientists work collaboratively, and that science is not straightforward. There has been some disagreement in the literature as to whether students' views on NOS can be developed implicitly in the classroom through participation in scientific practices or whether students need to receive explicit instruction. The goal of this work is to determine whether participation in Course-based Undergraduate Research Experiences (CUREs), which engage students in the scientific practice of authentic research, implicitly relays information about NOS. Informal interviews were conducted with students at a large Midwestern university during poster sessions held at the end of a second semester introductory laboratory course, where students had engaged full-time in a CURE. Students presented their research projects and were then asked three broad questions: 1) What did you like best about this experience? 2) What did you find the most challenging about this experience? 3) What will you take away from this experience? Thirty-eight student interviews were recorded, transcribed verbatim, and coded for themes relating to the major aspects of scientific inquiry and NOS. The preliminary findings of this work indicate that students may implicitly gain an understanding of some of the aspects of NOS, such as science is iterative and scientists work collaboratively, through this CURE experience. Prior to this poster presentation, interviews from the current semester will be analyzed to see if the preliminary findings will be supported with more data. This study is an important first step in addressing how students' participation in a CURE affects the development of not just scientific inquiry skills, but also a deeper understanding of the Nature of Science.

Poster #36 Development of an Open-Ended Laboratory Curriculum in First Year Chemistry Courses Elijah Farley*, University of Minnesota Duluth Department of Chemistry; Victoria Fringer, University of Minnesota-Duluth; Brian Gute, University of Minnesota Duluth; Jacob Wainman, University of Minnesota Duluth [abstract #44]

The introductory General Chemistry lab curriculum at the University of Minnesota Duluth suffered from several issues. The course was poorly connected to lecture and was also lacking in opportunities for students to develop critical laboratory skills. We aimed to update these courses, in line with current education research to establish a laboratory course that better aligned with the lecture and that better developed students' experimental design skills. Learning objectives for the laboratory courses were updated to emphasize vital skills that a student pursuing a STEM degree should have prior to entering upper level courses. This lab revitalization project began in June 2017, and has been comprised of several important steps: evaluation of existing labs, backward design of new experiences, revision of existing protocols, and implementation. First, the learning objectives for the laboratory were revised to better connect to the lecture component of this course. Next, the existing course material was evaluated on how well it was meeting these objectives. Laboratory protocols were intentionally designed to conform with the improved standards. Importantly, small changes were introduced into the existing laboratory experiences that provided students with open-ended opportunities to design meaningful experiments to assess questions with known answers. These changes were piloted during the 2017-2018 academic year. With the improved lab design, we anticipate that the students will be more prepared for their upper division classes with improved experimental design and analytical skills. We have preliminary data from student evaluations suggesting that these experiences are well received by students. We are currently designing an strategy to assess gains in understanding of chemical concepts, ability to design and implement experimental techniques, and drive to pursue a STEM degree. More broadly, we believe the incremental yet impactful changes introduced in these labs will be □汰捩抲敬□瑯□□□牴攀捵湰潧匠□ⅾ慬湴慮湰潧□睃獾□楬獨映物瑳穫慥□楎汯獴ᵎ□□□□**歲**

Poster #37 Non-biology majors' preferences for student-led inquiry vs. broadly relevant research experiences Sadie Hebert*, University of Minnesota; Jessamina Blum, University of Minnesota; Deena Wassenberg, University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #48]

Course-based undergraduate research experiences (CUREs) are laboratory experiences that involve students in five dimensions - use of scientific practices, discovery, broadly relevant work, collaboration, and iteration. Implementing the "broadly relevant work" dimension is logistically challenging in a large-enrollment, non-majors course and it is unclear if this dimension is necessary for positive student outcomes. To understand how broadly relevant research experiences impact student outcomes, we surveyed non-biology majors following participation in a student-led inquiry or broadly relevant research experience. Students in the student-led inquiry research experience asked their own research question but did not contribute new information to the scientific community, whereas students in the broadly relevant research experience (a CURE) were assigned a research question and did contribute new information to the scientific community. In the survey, students were asked whether they preferred choosing their own research question for which the results are already known; they would not contribute new information with broad relevance to the scientific community (hereafter "choice") or being assigned a research question for which the results are not known; they would contribute new information with broad relevance to the scientific community (hereafter "relevance"). For students that participated in the student-led inquiry research experience, 47% preferred "choice" and 53% preferred "relevance". In contrast, students that participated in the broadly relevant research experience overwhelmingly preferred "relevance" (90%) over "choice" (10%). There was a significant association between research experience and preference (x2 (1) = 23.24, $p < 0.001$). For students that participated in the student-led inquiry research experience, significantly more students than expected preferred "choice" ($z = 2.63$) and as many students as expected preferred "relevance" ($z = -1.76$). For students that participated in the broadly relevant research experience, significantly fewer students than expected preferred "choice" ($z = -3.02$) and significantly more students than expected preferred "relevance" ($z = 2.02$). The most common reasons students chose "choice" were personal interest (37%) and confirmation of known results (37%). The most common reasons students chose "relevance" were wanting to work on something broadly relevant (36%) or interesting (31%), and a lack of subject expertise required to ask a good question (24%). The results from project ownership questions showed that students that participated in the broadly relevant research experience reported a greater sense of project ownership compared to students that participated in the student-led inquiry research experience. Future analysis will investigate these students' science attitudes, confidence, and identity to determine whether broad relevance is necessary for positive student outcomes in this population.

Poster #38 Aligning Learning Objectives, Activities, and Assignments to Promote Enduring Understandings in a Cell Biology Laboratory Julie Roden*, Wellesley College [abstract #75]

In response to the nationwide call to transform undergraduate biology, the lecturing faculty of our intermediate Cell Biology course have begun making modifications to address these challenges. However, the laboratory portion of the course has not had a significant update in over a decade. We defined three overarching laboratory goals for students and concluded that the in-lab activities and homework assignments were not effective at fostering these enduring understandings. Next, we examined student evaluations and an attitudinal survey, which suggest that students appreciate what they learn but have difficulty identifying each assignment's relevance, making connections between assignments, and integrating data with primary literature and computational analyses. We identified three themes to improve the course: 1) create clear learning objectives to make the relevance of the assignments more transparent, 2) change assignment content to align better with the enduring understandings, and 3) revise how assignments are scaffolded and incorporate more practice and peer review activities to build towards the final, summative assessment for each laboratory unit. These changes will better align our laboratory with recommendations from the Vision and Change Initiative and provide a stronger foundation for the next generation of scientists and health professionals. Over the past year, we converted some assignments that students reported as "busywork" to in-class activities and provided in-class time for students to work through calculations and ask questions of their peers and instructors. We reframed assignments to focus on building scientific communication skills by describing the results and conclusions drawn from these calculations and comparing these results to published literature. These assignments are more directly connected to the final, summative assessments of a formal results/discussion section and a scientific poster. We also introduced or expanded opportunities for peer review throughout the semester. At the end of this semester, we will collect and compare anonymous attitudinal survey data and student course evaluation data from pre-revision, before the changes were implemented, and post-revision, after the first iteration of the new approach. We will code student evaluation responses to identify occurrences of particular keywords and compare both quantitative and qualitative data. Outcomes we will focus on assessing are 1) increased student confidence, fluency, and skill in written and oral scientific communication, 2) decreased student stress, anxiety, and confusion about assignments and workload, 3) increased student understanding of what they are learning and why. If successful, this study could provide a framework to other laboratory courses looking to improve student attitudes and experiences without modifying the underlying content and approach of the laboratory exercises.

Poster #39 Comparison of student perceptions of research practices in a traditional versus research-based introductory laboratory course Kelly McDonald*, California State University, Sacramento [abstract #83]

In response to national calls to teach science as it is practiced, with more inquiry, autonomy and discovery-based research, our faculty has re-design 12 biology laboratory courses, coordinated with research-based curricula that address an important, local issue – human impacts on the American River Ecosystem. The American River, running through our campus and listed as impaired since 1972, is a microcosm of human impacts, supporting industry, agriculture and recreation. The research-based courses span the department's curricula, providing all biology majors with multiple opportunities to gain research experience and contribute new knowledge to the scientific community concerned with Northern California's waterways. The first lab to be developed using the principles of Course-based Undergraduate Research Experiences (CUREs), and to be implemented and assessed for student learning and attitudinal outcomes, was BIO2: Introduction to Cells, Molecules and Genes. Over 16-weeks, students use various tools to compare microbial abundance and diversity across differentially-impacted sites along the American River; perform, troubleshoot and repeat two experimental modules; and collaboratively develop a lab report and present their data to the class. As part of our ongoing efforts to assess the impacts of the CUREs, we have initiated a qualitative study designed to probe students' perceptions of their research experiences. We compared the responses of BIO2 students from Fall 2014, prior to CURE implementation, to BIO2 students from Spring 2016, after the third run of the new curriculum to the question "Do you think you were performing real research in your course? Why or why not?" Qualitative and demographic data were managed and analyzed using the Dedoose software application, and a codebook was developed based on frequently observed student responses and a priori codes representing CURE design elements. Two researchers independently reviewed a subset of the data (50 subjects), and an interrater reliability test yielded a Pooled Kappa score of 0.80. Disagreements were resolved and the codebook was refined before further analysis. Out of 112 responses, 80% of CURE students responded favorably and only 5% responded negatively (the remainder were unsure or unclear). This is compared to 48% positive and 29% negative responses from the Fall 2014 comparison group. Demographic differences were observed only in the 2014 cohort, with males and Asian students responding positively more frequently. Further analyses indicated that CURE students based their positive responses on the use of scientific practices (66%), project relevance (23%), and the original nature of the research (16%); to a lesser extent, positive responses related to iteration, collaboration, engagement, independence and a new way of thinking. The coding strategy developed here will be used to analyze and compare data across all redesigned courses as part of the overall assessment plan.

Poster #40 Waking Students Up with Explorations of Metabolic Dormancy: Are CUREs Effective for Nontraditional Student Populations? Emma Goodwin*, Portland State University; Daniel Zajic, Portland State University; Jason Podrabsky, Portland State University; ERIN SHORTLIDGE, PORTLAND STATE UNIVERSITY [abstract #108]

A national goal for education reform is to provide opportunities for all biology undergraduates to participate in research. Traditionally, undergraduates gain research experience by apprenticing in faculty-led research labs; however, only a fraction of undergraduates have access to these opportunities. Course-based Undergraduate Research Experiences (CUREs) are a type of laboratory course where students conduct experiments to answer relevant research questions, and CUREs are increasingly being implemented to allow undergraduates to gain authentic research experience at a large scale. Most CURE research to date has been conducted on traditional undergraduate populations, and the impact of these courses on nontraditional students has not been studied. Our university serves a large population of mostly transfer, low-income, older students who are rarely studied in education research. Our students are unlikely to have time to participate in apprentice-style research, as they often lead lives outside of school, and we predict that their previous life experiences may lead them to have different perceptions of CUREs compared to traditional students. To increase equity in research opportunities for biology undergraduates, and to research the impacts of CUREs on nontraditional students, we have designed and implemented a CURE, which was piloted in selected sections of our introductory biology for science majors series. Over six weeks, students designed experiments to test how different biotic factors impact the tendency of embryos of the annual killifish Austrofundulus limnaeus to enter Diapause I, a profound state of metabolic dormancy and developmental arrest. Little is known about what causes embryos to arrest in Diapause I, and this novel student work contributes to biology faculty's research program. Students randomly enrolled in four CURE pilot sections (~90 students of the 500 enrolled in all laboratory sections). In order to measure students' perceptions of the extent to which their labs met three CURE components ("collaboration," "discovery and relevance," and "iteration"), students in both the CURE and non-CURE sections completed the Laboratory Course Assessment Survey at the end of the term. All students also answered multiple-choice questions about their interest in research and their non-academic pursuits and responsibilities. CURE students answered additional reflection questions about their experiences in the course, their interest in research, and challenges they experienced during the CURE. Results will be used to assess the effectiveness of the CURE curriculum and will be analyzed with an effort to identify any differences in perceptions for nontraditional student populations.

Poster #41 Investigating students' expectations about laboratory courses Lara Appleby*, Tufts University; Matthew Simon, Tufts University; Robert Hayes, Tufts University; Liren Fu, Tufts University; Aditi Wagh, Tufts University; Julia Gouvea, Tufts University [abstract #111]

Inquiry-based laboratories are more uncertain and open-ended than more traditional labs that focus on skill-development and demonstrating predetermined conclusions. Students who have had prior experience with "cookbook" type labs may expect labs to guide them to particular answers through careful procedures. These expectations can in turn hinder students' progress in a more open-ended lab course. Our research seeks to understand (1) students' incoming expectations about various components of laboratory instruction and (2) how these expectations shifts after a semester in an open-ended inquiry-based laboratory. The context of this study was lab course that was intentionally designed to create uncertainty by posing questions that did not have certain answers, allowing students to design their own experiments, and having students work with computational models with complex dynamics. The course was also designed to communicate the value of working with this uncertainty for learning science. Finally, the assessment structure valued students making well-reasoned arguments over demonstrating particular results. We designed and administered a survey in which we asked students about their expectations (e.g. "I expect that data I analyze in lab will reinforce concepts from lecture") and their anticipated reactions to various components of a lab course (e.g. To what extent do you expect to feel frustrated... "When my findings are unexpected" or "When I design experiments"). We also conducted interviews with focal students over the course of the semester in which we asked them to discuss lab activities and to describe specific moments in lab when they felt frustrated, challenged, excited and/or interested. We report on the design of the survey and preliminary results comparing student responses at the beginning and end of a one-semester inquiry-based lab course (N = 270). Initial analyses of interview and pre-semester survey indicate variation in students' incoming expectations with most students preferring clean results over uncertainty and indicating that they find unexpected findings to be frustrating. Other students did not show a strong preference and finally a smaller subset of students seemed to expect and prefer uncertainty and ambiguity in lab. Preliminary analyses of interviews suggest that focal students came to appreciate uncertainty and messiness as a valuable part of learning science in lab. We plan to examine post-semester survey responses to see if this shift is representative. This research contributes to our understanding of students expectations about biology learning and how curricula can be designed to shift those expectations.

Poster #42 Assessing the effectiveness and impact of a large-scale two-semester course based undergraduate research experience focused on DNA Barcoding for introductory biology students Joseph Harsh*, James Madison University; Emily Miller, James Madison University; Rachel Boyce, James Madison University; Sarah Coleman, James Madison University; Julia Cumins, James Madison University; Thomas O'Neil, James Madison University; Oliver Hyman, James Madison University; John Nguyen, James Madison University; Jonathan Popham, James Madison University [abstract #135]

In preparation of the next generation of STEM workers and educated citizens, course-based undergraduate research experiences (CUREs) have become an increasingly popular feature of introductory science curriculum to provide all students an early window to research practices. While several well-designed models exist, CUREs developed for large introductory courses that engage students in authentic research activities without requiring substantial resources, allow student/instructor flexibility, or are transferable between institutions are rare. This study reports on a new common-themed two-semester DNA Barcoding CURE for a large-enrollment introductory biology sequence, in which students (~1200 per year) learn research-related skills and concepts from the fields of ecology, molecular biology, and bioinformatics. This initial study to the effectiveness and impact of this new CURE model uses quantitative and qualitative survey data drawn from validated measures to evaluate: How do the lab courses influence students' future academic and career intentions? What gains do students identify as a result of participation? What design features contribute to the conferred student outcomes? Data used in this analysis are from ~1800 students (70% female, 22% URM, 77% 1st/2nd year, 45% biology majors) collected over four terms. Early findings indicate the positive contributions of the lab courses on students' STEM intentions; particularly for 1st/2nd year biology majors who indicated significantly higher levels of interest in pursuing research opportunities, advanced courses, and research-related careers after participation than their non-major and more senior peers. For those students whose academic or career intentions changed while enrolled in the lab courses (40%), one in three identified how the experience either attracted them to or refined/clarified interests in research careers. Most students identified gains in a variety of key measures including research-related and lifelong skills, knowledge building, affect, and project ownership, with similar patterns found across groups (gender, ethnicity, academic standing, major). Differences in gains were noted, however, between lab courses reflecting the sequential design. After the first course, which exposes students to DNA Barcoding and general community practices, students reported highest gains in research-related skills, whereas, after the second term where collaborative student-driven projects are designed and carried out, gains in affect (e.g., confidence in research) and communication were more commonly identified. Student feedback also regularly highlighted design features such as working hands-on, opportunities for independence, creative autonomy, iteration, and effective mentorship as being key to their learning. These results provide evidence of the efficacy of this two-semester lab sequence in supporting introductory biology students' developmental trajectory.

Poster #43 Multi-Week Inquiry-Based Laboratory Modules Improve Introductory Biology Student Understanding of Core Concepts and the Scientific Method April Wynn, University of Mary Washington; Deborah Zies, University of Mary Washington; Dianne Baker, University of Mary Washington; Michael Stebar*, University of Mary Washington [abstract #143]

Biology education research has shown that incorporating authentic research experiences into introductory biology courses can improve student learning, understanding of the research process, and interest in their biology course. In 2016, we developed a set of multi-week research modules with a consistent framework. In each module we introduced students to relevant equipment, methods and content. Students used their observations and content knowledge to form questions, develop hypotheses, design experiments and make predictions. After instructor review, students carried out their experiments, statistically analyzed their data, formulated conclusions and presented their research as a team. Each module focused on a core biological concept covered in lecture: 1) animal behavior and homeostasis, 2) osmosis and diffusion, and 3) the structure and function of enzymes. Preliminary data and faculty perceptions from 2016 inspired us to refine and expand the module framework and to conduct a more robust assessment. In 2017 we implemented two modified modules (animal behavior and enzymes) and a newly designed third module (photosynthesis). Student understanding of the biological concepts was assessed with pre- and post-module quizzes. The questions were divided into three categories: concepts, scientific method, and data analysis. Initial analysis of the 2017 data from modules 1 and 2 (second iteration) showed that a majority of students improved in all three categories (concepts 86% and 57%, scientific method 70% and 63%, and data analysis 58% and 70% respectively). Data from module 3 (first iteration), showed that most students improved in their understanding of the concepts (66%), but not in scientific method or data analysis (25% and 22% respectively). Semester-wide changes in understanding of the scientific method and student perception of their understanding were assessed in both module-based sections and traditional lab-based sections with a pre- and post-course quiz and survey. Initial analysis shows that while students in both groups improved in their understanding of the scientific method, more students who completed the research modules improved (79% compared to 62%). Students in both groups perceived that they improved in their understanding of the scientific method. Statistical analysis and breakdown by student demographics is currently underway.

Poster #44 Integrating scaffolded responsible conduct of research instruction into a multi-disciplinary course-based undergraduate research experiences program Kelly McDonald*, California State University, Sacramento; Allison Martin, California State University, Sacramento [abstract #152]

Through a multi-year Faculty Learning Community (FLC), supported by the Sustainable Interdisciplinary Research to Inspire Undergraduate Success (SIRIUS) project, our faculty have redesigned 18 laboratory courses (across four STEM departments) to include Course-based undergraduate research experiences (CUREs) or research modules focused on the human impacts on the American River Ecosystem. Each summer, the SIRIUS FLC meets to develop and peer-review curriculum, share data and classroom experiences, and continue efforts to align and assess the SIRIUS projects' impact on students. Summer sessions also provide faculty with the opportunity to identify weaknesses in the curriculum and collaboratively work on improvements. While the inaugural, week-long SIRIUS FLC meeting hosted a session on responsible conduct of research (RCR), there has been no concerted effort to integrate RCR instruction into the SIRIUS lab courses, despite this being an important component of research training. Furthermore, there are no universal requirements and few opportunities at our institution for students to obtain formal RCR training; therefore, we posited that students are receiving varying degrees of instruction through classes and extramural research. To explore this, we evaluated responses to a prompt from an existing science identity survey that asked participants to “name some qualities of a good scientist.” Using qualitative methods and focusing our analysis on RCR principles most relevant CURE activities (e.g., Data Acquisition, Management, Sharing; Collaborative Science; Social Responsibilities of Researchers), we developed a codebook from first cycle in vivo coding of responses. We then performed magnitude coding to identify the presence or absence of “ethics codes.” An initial analysis detected “ethics codes” (e.g., honesty, unbiased, objective) in 20% of introductory student (2 courses; n=233) and 26% of upper division student (4 courses, n=227) responses. Ethics codes were further identified in the responses of 43% of URE students (n=35) and 57% of SIRIUS FLC faculty (n=26) surveyed. Our data confirm that some students are receiving training or acquiring an appreciation for the importance of ethical practices in research; however, there is plenty of room for gains through explicit instruction. An absence of an “ethics code” does not suggest a lack of ethics, as participants may not have provided an exhaustive list of qualities in their responses. However, these findings provide one source of baseline data regarding our students’ awareness of, or value placed on, ethical behaviors in research prior to implementing formal RCR instruction. The SIRIUS program provides an excellent venue for developing RCR curriculum, impacting a large number of students, and studying the impacts of the interventions. A plan to design, scaffold and assess RCR instruction in CUREs will be the focus of the 2018 Summer SIRIUS FLC meeting.

Poster #45 Introdcution of short research experiences in existing laboratory courses as a way to increase student engagement with the process of science Caroline Dahlberg*, Western Washington University; Benjamin Wiggins, University of Washington; Suzanne Lee, Western Washington University; Anna Groat-Carmona, Western Washington University; David Leaf, Western Washington University [abstract #180]

Full-length Course-based Undergraduate Research Experiences (CUREs) are valuable for immersing students in relatively long-term research projects and provide similar positive outcomes to independent mentored research. However, full-course CUREs can be difficult to introduce into existing curricula, especially at larger institutions. In order to reach more undergraduate biology students, we have introduced modular, scaffolded research opportunities to introductory- and intermediate-level courses. Importantly, these research modules build on the existing curriculum between the courses to increase the interconnectedness of the curriculum for students. By using short, modular designs, we propose that multiple instructors for each course can introduce more students to research and provide them with practice in experimental design, experimentation, and data analysis related to their own research labs. In an introductory Cell and Molecular Biology course, we embedded a the three-week laboratory module that is flexible and has allowed us to addresses fundamental cell biological questions through two topics: 1) Genetic experimentation within the model organism (Tetrahymena thermophila), and 2) Sampling experimentation of local ecological protist populations. This short authentic research module serves as a model for introducing authentic research into large, diverse, introductory courses. At the intermediate level, we have introduced a one-week research experience to a Molecular Biology Laboratory techniques course. Student researchers use PCR genotyping to determine whether CRISPR-Cas editing has taken place in strains of the model organism, C. elegans that are generated at a nearby research university. This short research experience introduces students to experimental design and collaborative research. Pre-post survey responses of students who did and did not participate in the introductory research module suggest that participation did not change student opinions of their engagement with the process of science, and in particular with problem solving in Biology. However, those students gave more, and more sophisticated, responses to a task-based question that required practice in self-direction and self-reflection. We also conducted interviews with students at all levels of undergraduate Biology education at our institution. Their responses support our assertion that short, research modules that are supported by existing course frameworks and scaffolded in-and out-of-class exercises succeed in helping students feel engaged and invested in the research experience. Students express ownership and authenticity even within these smaller modules, indicating that the lack of degrees of freedom compared to larger CUREs may not be detrimental. These findings are helping inform the how we study students' engagement with the process of science, and how best to enhance course-based research at the undergraduate level.

Poster #46 Implementing a CURE Curriculum at Primarily Undergraduate Institutions and a Community College: Faculty Experiences and Instruction Sue Ellen DeChenne-Peters*, Georgia Southern University; Jentayah Young, Gerogia Southern University; Yue Yin, University of Illinois at Chicago [abstract #189]

Course-Based Undergraduate Research Experiences (CUREs) have been developed to provide a wide variety of students the benefits of participating in scientific research (Wei and Wooden, 2011). Lack of time, resources, experience with CUREs, and professional support, are barriers to the design and implementation CUREs, especially at primarily undergraduate institutions (PUIs) and community colleges (CCs) (Spell et al., 2014). To overcome these barriers, we provided professional development (PD) and continuous support for implementation of an established CURE curriculum at two PUIs, one CC, and one research institution. We studied faculty experiences with the implementation of a supported CURE curriculum. In particular, we ask the following research questions 1) What are the perceptions of the instructor before and after the CURE PD? 2) How do experienced instructional faculty teach laboratories? 3) How do experienced instructional faculty teach a CURE differently from teaching a non-CURE laboratory? We collected surveys from seven faculty that targeted their needs for instructional support before, during, and after PD (RQ1). We interviewed the same seven faculty before professional development and will interview them after implementation of the CURE to understand adoption and implementation of a CURE (RQ1). We will use qualitative research techniques to analyze common themes among the interviews. We videotaped three laboratories classrooms of three instructors before and after implementing the CURE (RQs 2 and 3). Laboratory instruction is being analyzed using the Laboratory Observation Protocol for Undergraduate STEM (Velasco et. al. 2016) which records instructor and student behaviors every two minutes during a laboratory period. This observation protocol has been utilized to describe instruction with teaching assistants at research institutions, but not experienced instructors at PUIs and CCs. Preliminary analysis of the interviews indicates that the participants were most interested in learning the laboratory and teaching skills need to teach the CURE. Analysis of the surveys indicated increased knowledge of this CURE curriculum, increased understanding of student benefits of CUREs, and increased confidence in teaching this CURE. In agreement with the needs expressed during the interviews, the surveys found the most effective parts of the professional development to be those related to implementation of CURE instruction, data collection, and creating CURE exercises. Preliminary analysis of laboratory observations indicates highly interactive teaching styles by the experienced faculty. Comparisons between CURE and non-CURE teaching are on-going. The results of this study will increase our understanding of laboratory teaching and CURE faculty professional development in PUIs and CCs.

Poster #47 Designing Independent Research Experiences for Biology Students Enrolled in a Traditional Senior Biology Course Sheryl Gares*, University of Alberta [abstract #208]

Students who engage in independent research projects tend to enjoy grade improvements and integrate scientific knowledge and thinking better than students who restrict themselves to traditional course-based learning. However, even though it might be beneficial for each of our students to have a research experience before graduation, there are typically too few faculty available to supervise individual independent research projects for all the students majoring in the discipline. Is there a practical way to design our courses that enable each of our students to have an authentic research experience during their degree? I explored the feasibility of incorporating independent research projects for all of the students enrolled in a senior microbiology course that I regularly teach. The structure of the course is a traditional weekly 3 H lecture + 3 H laboratory course. The goals of the laboratory component are to help students learn scientific techniques in the discipline, to deepen the intellectual ability to think analytically and critically and to gain research experience. However, due to the constraints of the scheduled three-hour laboratory session, instructors and departmental assistants do all the organization and preparation required for each laboratory session and students simply carry out the experiment. Unfortunately, this means students are not fully engaging in the research process, only in completing the technical aspects of each exercise. This is an issue at all or most campuses. Furthermore, annual assessments by biology faculty of the thinker and researcher skills of our senior biology students consistently find that achievement levels range from poor to moderate for these skills. To work toward improving these learning outcomes and to create more authentic laboratory experiences, I re-designed the laboratory component of my senior microbiology course such that the latter half of the term involved each student carrying out an independent research project for approximately 5 weeks. Each student was responsible for gathering and preparing materials needed to undertake the research project, for the experimental design and for carrying out every step of the project. I acted only as a facilitator. The research data generated by each student was presented as a poster during our end of term campus research day. I will present the process I used to ensure each student could select and carry out a feasible research project in which I anticipated real, but solvable problems would be encountered. I will also present feedback collected from students regarding their sense of research competence and scientific thinking before and after completing their independent research projects.

Poster #48 Urban Wildlife Ecology CURE in an Introductory Biology Laboratory: Preliminary Results on Implementation, Student Perceptions, and Student Gains Sarah St. Onge*, University of Colorado Denver; Laurel Hartley, Cu Denver; Tod Duncan, University of Colorado Denver [abstract #211]

Course-based Undergraduate Research Experiences (CUREs) can increase understanding of scientific processes and increase retention in STEM programs by promoting a student's identity as someone who can contribute meaningfully to authentic research. CUREs can be particularly impactful in introductory courses, where many studies have shown positive student outcomes of increased interest and motivation, addressing negative perceptions of science, forming an identity as a scientist, forming scientific career goals, and acquiring skills like problem solving and critical thinking. In addition, these positive outcomes are especially seen with underrepresented groups. The goals of this research are to create, implement, and evaluate the effectiveness of a new "Urban Wildlife Information Network (UWIN)" CURE on educational outcomes, and to assess if the implementation aligns with previously published CURE design features and outcomes. This CURE is based on a long-term, national urban wildlife monitoring project using camera traps that focuses on relevant issues of urban ecology, and has multiple activities designed to teach the process of science that would be applicable to any scientific research. We are piloting this CURE at one institution that is part of the national Urban Wildlife Information Network. Our ultimate objective is for this UWIN-CURE curriculum to be usable by any university, in any city, leading to long-term national or worldwide urban wildlife data along with achieving the goals of promoting inclusivity, stimulating retention, and attaining inquiry-based learning goals for undergraduate students. Pre/post surveys and course assessments are being used to evaluate CURE curriculum alignment, student perceptions of scientific identity, motivation to continue in biology, and student gains of scientific skills. The instruments we are using include the Laboratory Course Assessment Survey, the Persistence in the Sciences, and the Biological Experimental Design Concept Inventory. We hypothesize that incorporation of relevant and authentic research into introductory undergraduate courses will result in positive changes to student interest, increase motivation, and promote retention in biology. Moreover, we hypothesize that the implementation of the urban wildlife CURE will reduce the achievement gap between students of different races, ethnic backgrounds, and socioeconomic status. The first implementation of the CURE is underway for the spring 2018 semester. In this poster, we will present an overview of the UWIN-CURE curriculum, the student-level normalized gains and effects sizes for the surveys we administered, and results of multiple linear regression modeling the effects of demographic variables on the outcome variables of learning gains and scientific identity.

Poster #49 "Homeostasis: The Game"— Using a game to teach the relationship between the endocrine system and homeostasis Cynthia Harley*, Metropolitan State University [abstract #224]

The endocrine system is a difficult item to teach through active learning. The reason is that most hormones take days to weeks to cause a measurable effect. Furthermore, these assays would necessitate using animals, which causes its own set of obstacles. Herein, I describe a card game, which I developed to teach about the endocrine system while also illustrating the concept of homeostasis. During the game, students play hormone cards to help 'Bill,' a person who makes poor life decisions (ex. Taking health advice from a Kardashian), maintain homeostasis through monitoring the variables of pH, blood pressure, and blood glucose. The intended learning outcomes of the game are as follows: 1) explain how hormones help to maintain homeostasis, 2) describe inhibitory or antagonistic effects of hormones, 3) describe how one hormone can act on multiple variables, 4) explain the effect that releasing hormones have on their related hormones, and 5) describe the actions of released hormones. Here, I focus my reporting on goal 1. During the Spring 2018 semester, the game was played by students taking a non-majors physiology course ($n = 18$). Students completed an assessment before and after gameplay to evaluate the effectiveness of the game as a teaching tool. While the current pilot data set is small, it is intriguing. Prior to gameplay, the average number of hormones each student was able to name was 0.67; following game play, students exhibited a statistically significant increase in the number of hormones they could name to an average of 2.72 ($p<0.006$, Wilcoxon test), many for which they could also describe the function. Student answers to the question, 'How do hormones influence homeostasis?', exhibited positive changes with 10 students improving their answer, 7 students exhibiting no change in answer quality (5 of those were correct in their original answer), and 1 student having a worse answer than they did prior to the game. On a Likert scale to assess student perceptions of the game (where higher scores indicate higher satisfaction), students rated the game as 7.1/10 (SD = 1.85) as being helpful for them to understand how hormones influence homeostasis and 7.75/10 (SD = 2.06) for their enjoyment of the activity. Finally, when asked what they learned from the game, 10 students indicated that they noted that a single hormone could influence many physiological variables, half indicated increased understanding of the function of release hormones, and a majority (12 students) indicated a greater level of comfort with their understanding of the actions of specific hormones. The preliminary research on the effectiveness of the homeostasis game on student learning is promising and further data collection and analysis will be conducted to investigate the learning gains of this game.

Poster #50 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; Elli Theobald, University of Washington; Mariah J. Hill, University of Washington - Seattle; Grace E.C. Dy, University of Washington - Seattle; Elizabeth H. Glenski, University of Washington - Seattle; Elisa Tran, University of Washington; Alex Ting, University of Washington - Seattle; Matt Sievers, University of Washington - Seattle; Michael Pelch, University of Washington; Peter Conlin, University of Washington; Hannah Jordt, University of Washington; Benjamin Kerr, University of Washington; Scott Freeman, University of Washington [abstract #231]

Previous studies have shown that students who perform experimental research are more likely to: 1) improve their critical thinking abilities and understanding of how science is conducted, 2) identify themselves as belonging in the scientific community, and 3) pursue science-related careers. To enhance equity of access to research opportunities for all students at XX, we created a course-based undergraduate research experience (CURE) that we are integrating into the first 2 quarters of the introductory biology series (XX and XX). CURE students engage in authentic research, performing experiments to address presently-unanswered questions about evolution of antibiotic resistance. During the first quarter of the CURE, students select E. coli strains bearing mutations that confer resistance to antibiotics, and characterize changes in the relative fitness and resistance levels of these strains over the course of a long-term evolution experiment. In the second quarter, students perform molecular and bioinformatic analyses to determine the basis for the antibiotic resistance profiles exhibited by their bacterial strains. To investigate how CURE participation influences students' scientific 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 in each condition). At the beginning, middle, and end of the XX-XX series (January-June, 2018), we administered a curated set of published survey items to assess students': 1) understanding of key ideas in evolutionary biology [ACORNS], 2) ability to design experiments [E-EDAT], and 3) attitudes regarding science and their ability to overcome challenges [MSLQ, PERTS, and S-Grit]. We incorporated a slight modification in the ACORNS items: to evaluate students' ability to draw connections amongst genotype, phenotype and fitness when reasoning about natural selection, we added a clause prompting students to consider factors at the molecular and organismic levels. Initial qualitative data indicate that CURE students consider their research relevant for society and for their future careers. Furthermore, Peer Facilitators (CURE alumni who mentor current students) describe the CURE as a research gateway that fosters inclusivity. The XX Introductory Biology CURE provides students with an authentic research experience over 2 quarters, in which students' experiments address questions with unknown outcomes. Unique features of the XX CURE include the experimental nature of the research (most prior CUREs have engaged students in descriptive research), and the scale and context of the course: the XX CURE will serve 1000's of students per quarter at a large research-based university. Therefore, the findings of this study may set a precedent and help inform the design and implementation of future high-enrollment CUREs at other institutions of higher education.

Poster #51 A Mixed-Methods Evaluation of Plant Blindness and Botanical Literacy in Undergraduate Botany Students Kathryn Parsley*, University of Memphis; Jaime Sabel, University of Memphis [abstract #4]

Plant blindness is the inability to notice plants in an environment, which can lead to the naïve and anthropocentric point of view that plants are not important (Wandersee & Schussler, 1999). Wandersee and Schussler (1999) have defined four components that contribute to plant blindess: attitude, attention, knowledge and relative interest. Botanical literacy, a subset of scientific literacy, is exhibited by students when they are able to apply knowledge to make scientifically sound decisions regarding societal issues like food ethics, climate change, and plant conservation. Authors of studies examining plant blindness have suggested a relationship between plant blindness and botanical literacy may exist. However, this relationship has not been tested. To determine the extent to which undergraduate students exhibit plant blindness and botanical literacy, we developed and administered two new instruments: the Plant Blindness Index (PBI) and the Botanical Literacy Inventory (BLI). The PBI measures the extent to which all four aspects of plant blindness are present., The BLI is a concept inventory that includes core concepts published by the American Society of Plant Biologists and that align with Vision and Change. We tested these instruments in a pre-post model with students in a required undergraduate botany course at a small liberal arts college in the Midwest. We identified students from a range of plant blindness scores (as determined by the PBI) and invited them to interviews. The interviews explored why plant blindness occurs, and the factors that affect and contributed to students' levels of plant blindness and botanical literacy. Findings suggest that the PBI and BLI are significantly correlated ($R=0.621$, $p<0.01$), and that three of the four aspects of plant blindness are also correlated with each other and the BLI. We will present more in depth quantitative results and the findings from the trends in students' ideas as collected in the interviews. We submit that students can increase their botanical literacy and decrease plant blindness if given explicit ways to do so. Implications for instruction include how to assess plant blindness and botanical literacy in undergraduate biology courses, how to address misconceptions in undergraduate botany classrooms, and how to improve general biology courses by adopting a more robust plant module. Implications for biology education research include new ways to evaluate plant blindness and botanical literacy, and a new way of defining botanical literacy through the lens of socioscientific issues (SSIs) and functional scientific literacy.

Poster #52 The Development of a Tool to Assess Student Growth in Experimental Design Skills in an Introductory Biology Course Tess Killpack*, Salem State University; Sara Fulmer, University of Guelph [abstract #27]

Designing an experiment and applying the process of science is a core competency and learning objective for many introductory courses and CUREs (Shortlidge et al, 2016). However, experimental design is a complex process that challenges many students (Dasgupta et al, 2014) and needs to be assessed early to inform instruction to support learning. We designed an assessment task and scoring tool to assess experimental design skills in an introductory course. We will discuss the development and reliability of the tool, effectiveness of the tool in detecting variability and growth in experimental design skills, and flexibility in using the tool in various contexts. Our research design began with development an experimental design task with laboratory course instructors. Then data were collected from all students in Spring 2016 and Fall 2016 semesters as a pre- and post-assessment in the second and final weeks of the course. We then developed the scoring tool in six phases, which will be presented in detail. Briefly, we used examples of existing published tools and a subset of student responses to create our initial tool, and then engaged in an iterative process to refine the criteria to maximize consistency and objectivity in scoring. The final tool contained five components (Hypothesis, Rationale, Exp./Control Groups, Data Collection, Observations) with multiple criteria for each (20 points total). The criteria formed a checklist such that a high quality response satisfied all criteria. The criteria also required students to align the different components of their experimental design. All student responses were scored by three faculty. We assessed how well the scoring tool captured variation in skills between students and change in students' skills over the semester. Data analysis indicated excellent interrater reliability, with an intraclass correlation coefficient (ICC) of 0.945 for the total score and ICC values >0.839 for each of the five components. The tool captured the full range of student skill levels, with few students hitting the assessment ceiling or floor. Students' total scores ranged from 2.67 to 19.33 on the pre-assessment and 6.67 to 19.66 on the post-assessment. Scores on individual components indicated the strengths and gaps in students' skills. Finally, the scoring tool also detected growth in student skills from beginning to end of the semester. There were significant differences between total pre- and post-assessment scores (p = .006) and for the Data Collection (p = .025) and Observations (p = .002) components. The authentic assessment task and scoring tool developed provide meaningful feedback to instructors about the strengths, gaps, and growth in introductory students' experimental design skills and can be scored reliably by multiple instructors. The tool can be adapted to a number of experimental design prompts and learning objectives, and therefore can be useful for a variety of introductory courses and CUREs.

Poster #53 The development of a coding scheme to characterize modeling and discourse in undergraduate biology Karly Ackermann*, South Dakota State University; Adron Ung, South Dakota State University; Anne-Marie Hoskinson, South Dakota State University [abstract #50]

Biology education reform efforts promote refocusing biology student learning on core concepts and practices to improve student expertise. While curricular reforms based on these core concepts are an active focus of biology education research, fewer studies have investigated the recommended practices. Scientific practices include developing models, communicating and collaborating with other scientists, and applying quantitative reasoning, among others. Modeling in biology classrooms is still infrequent, and one reason for this may be that the student modeling process is not well-explored. We examined how undergraduate biology students interact during modeling activities, and developed a coding scheme to systematically characterize these interactions. Students collaborated in small groups to generate a model in response to a biological Fermi problem. We then developed a coding scheme informed by prior research and grounded in these data to characterize what students were doing during these group modeling activities. Initial coding revealed that certain modeling activities were more frequently associated with certain discourse activities. Mathematizing (a modeling activity) and clarifying (a discourse activity) frequently occurred together, as did validating and justifying. The coding scheme also revealed that mathematizing frequently followed periods of uncertainty. We also validated the coding scheme among multiple coders, supporting its robustness. Our next investigation will apply this coding scheme to modeling processes in a large-enrollment biology classroom to support the development of systematic model-based curricula in biology.

Poster #54 Development of a systematic coding scheme for written and drawn student responses Dylan Blomme*, South Dakota State University; Praveena Kanchupati, South Dakota State University; Anne-Marie Hoskinson, South Dakota State University; Karly Ackermann, South Dakota State University [abstract #54]

One goal of undergraduate biology education is to generate students who can organize, apply and convey their understanding of biological concepts to new scenarios. Prior research suggests that the scientific practice of modeling improves student engagement and concept mastery. An open question is which type of model representation – written explanations or drawings and diagrams – best reveals student ideas about biological concepts. To the best of our knowledge, there exist no criterion-referenced methods of comparing student models (diagrams, drawings) to written explanations of biological phenomena. We investigated whether and how different representations, written or drawn, revealed differences in student understanding of biological processes. We also explored which of the two representations better revealed naïve ideas or misconceptions about those processes. We selected four question prompts focused on the carbon cycle, developed by the Automated Analysis of Constructed Response (AACR) group, previously shown to effectively probe student mastery of carbon cycling in living systems. These questions also allowed us to investigate the effects of scale – molecular vs. organismal – on student mastery of the carbon cycle. For each of the four questions, we invited different populations to respond either with written responses or models (drawings or diagrams). Respondents were students enrolled in introductory biology courses at a medium-sized Midwestern land-grant university. We designed and developed an isomorphic coding rubric that allowed us to compare written and drawn responses for normative, unclear, or non-normative components and processes, and to identify naïve conceptions and misconceptions present. We used a small sample of the student data to refine and calibrate each question’s coding rubric (Cohen’s ≥ 0.80). After calibration, we then applied our rubric to each sample of written and drawn responses to the four question prompts. Despite the simplification required to compare two very different representations, our coding scheme still revealed interesting patterns. In some cases, model diagram responses better reveal student mastery or misconception than written responses, as for a question asking students to track a carbon atom among organisms. This work continues as we investigate which representations best show concept mastery, and under what circumstances.

Poster #55 Moving beyond experimental design: How do we assess student ability to make logical conclusions from biological experimentation? Michelle Harris*, UW - Madison Biocore Program; Tawnya Cary, Beloit College; Seung Hong, University of Delaware; Yue Yin, University of Illinois at Chicago [abstract #158]

Undergraduate students are becoming increasingly engaged in biological research in faculty labs as well as in the course-based undergraduate research experiences (CUREs), which are intended to help students understand core biological concepts, develop core scientific competencies, and become active, contributing members of the scientific community. There are growing efforts in the DBER community to assess whether and how well research experiences help students achieve outcomes related to the Core Concepts and Competencies outlined in Vision & Change. Assessments of student learning gains from research experiences are also useful for undergraduate institutions as they invest resources in learning environments and approaches that effectively address established biology learning challenges. Various tools have been developed and studied to gauge student learning from research experiences, such as surveys, interviews, and to a much lesser extent, performance-based rubrics measuring students' biological experimentation competency. However, there is a notable dearth of tools assessing students’ ability in making logical conclusions based on empirical evidence. The “Conclusions” assessment is especially critical for two reasons: (a) conclusions are required and presented in various assignments related to experimentation, such as lab reports, research papers, posters, and presentations; (b) conclusions offer instructors and education researchers a rich opportunity to deeply assess students’ ability to perform higher order reasoning tasks such as integrating literature and their own experiments, interpreting data collected, evaluating experimental design, and recognizing scientific implications and future directions. Our project has two main goals: (a) to systematically review the existing literature on tools used to assess students' ability to make logical, data-based conclusions after completing an independent research experience, identifying overlaps and potential gaps among these tools; and (b) to create a Conclusion Assessment Rubric (CAR) which renders a comprehensive evaluation of learning outcomes integrating key aspects of biological experimentation. We will present our literature review on conclusion assessments and a draft of the CAR, which we built on published assessment tools, the key competencies for biological experimentation identified in the ACE-Bio network petal model, and our own knowledge of authentic scientific experimentation skills. The CAR can be applied to multiple types of commonly expected artifacts from biological experimentation, such as lab reports, course term papers, course presentations, conference presentations/posters, and manuscripts for journals. Also it can be used on a variety of students, with a range of research experiences/skill levels from novice to truly independent/published work in faculty labs. Therefore, the CAR can be used to capture students' learning progression in a course or a program.

Poster #56 Analyzing Student Understanding About Structure-Function Using Automated Computer Models Tanner Foster*, CREATE for STEM; Rachel Yoho, Project Dragonfly; Mark Urban-Lurain, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University [abstract #163]

Structure and Function is one of five core concepts for biological literacy identified in "Vision and Change for Undergraduate Biology Education" (AAAS, 2011). The work of Linenburger and Bretz (2014) highlighted that students often have issues with this concept, which may lead to misconceptions. One common example of structure-function in introductory biology courses is enzyme-substrate binding. Our research group creates constructed response items to elicit student thinking about big ideas, such as structure-function, across disciplines. We then use a mixed methods approach to develop computer-automated assessment tools that use statistical analysis techniques to predict human expert scoring. To further probe student thinking about structure-function, we developed CR items examining student thinking about enzyme binding such as: Enzymes help in chemical reactions in living organisms. How would a molecular biologist explain the mechanism that helps an enzyme to bind to its correct substrate and reduces the possibility of incorrect interactions? To validate our question prompts as well as gain preliminary insight into student ideas, we conducted expert interviews in which we asked about their ideas and student ideas of structure function relationships. Analysis of expert interviews revealed cross-disciplinary differences teaching patterns as well as different expectations of students. Through qualitative analysis of student responses (n=487) from Introductory Biology and Upper-level Biochemistry courses at several large research universities, we developed analytic rubrics that capture key cross-disciplinary ideas used by students in their responses. These rubrics contain structure-focused categories such as 'Lock-and-Key' (kappa = 0.947), 'Induced Fit" (kappa = 0.766), 'Puzzle Piece' (kappa = 0.618), 'Physical Fit' (kappa = 0.287), 'Amino Acid Interaction/Sequence' (kappa = 0.895), and 'Physical Change' (kappa = 0.916) as well as function-focused categories such as 'Transition State' (kappa = 0.685), 'General Energy' (kappa = 0.953),'Bonding' (kappa = 0.525), 'Regulation' (kappa = 0.831) and 'Increase Reaction Rate' (kappa = 0.651). We trained 2 expert scorers who scored student responses independently followed by discussion and resolution of disagreements. Results of this scoring were used to build a computer scoring model that utilized key rubric bins such as 'Lock-and-Key', 'Induced Fit'. 'Physical Fit', and 'General Energy'. Results from the computer scoring was used for further revisions of the rubrics, which resulted in modification of some categories including 'Bonding' and exclusion of others such as 'Induce Incorrect Interaction/Cause Harm' (kappa = 0). This then creates the need for efficient rubric development to allow for effective scoring of student responses. Subsequent analysis of additional data using this model will produce reports which highlight key student ideas and provide insight into student thinking.

Poster #57 Follow that carbon atom! Using machine learning to trace carbon transformation pathways and processes Bryan MacNeill, University of South Florida; Margaurete Romero, University of Tennessee; Luanna Prevost*, University of South Florida [abstract #164]

Biology students of all ages have difficulty with the concept of tracing matter and energy. A constructivist approach to addressing this difficulty is the use of constructed response assessments (CRAs) which allow students to include, exclude and connect ideas in their mental models, rather than selecting from ideas presented in assessments like multiple choice. Yet, CRAs often are not used for they can be difficult and time-consuming to evaluate in a consistent manner. Machine learning has generated reliable results in assessing biology explanations. In this study, we investigated how machine learning can be used in a CRA asking students to trace carbon movement. Specifically, how does machine learning perform compared to human coding in identifying correct and incorrect pathways and processes for carbon transformation? We modified a published assessment to prompt students to describe the movement of carbon atoms from a dead jackrabbit into the tissues of a coyote. A total of 742 responses were collected from introductory biology students via extra credit homework assignments. Four human coders were trained to identify the presence or absence of 3 processes and 5 pathways (both correct and incorrect) in written responses until coders achieved interrater reliability of 0.8 intraclass coefficient. Each coder then independently coded a subset of the data. Lightside machine learning software was used to extract words and phrases in responses and create predictive models (one for each process or pathway). Models were built using support vector machine algorithms with a training dataset of 70% of responses. Models were then tested against the remaining 30% of responses. Models were deemed calibrated when they achieved human-computer agreement of 0.8 Cohen's kappa (almost perfect agreement). Predictive models showed high human-computer agreement on this tracing CRA (kappa ≥ 0.8) for two pathways (carbon moves from the soil to a plant; from a plant to herbivore) and two processes (photosynthesis; decomposition). We continue to develop models with moderate agreement (kappas 0.6 – 0.79) for the remaining three pathways (e.g. herbivores to coyote) and the process of respiration. Our analysis gives insight into mental models for tracing carbon by identifying pathways selected, omitted, or substituted. Most responses included a pathway from plants to herbivores (61%). However, 75% of responses omitted the pathway from soil to atmosphere. Instead, several students (37% of all responses) included an incorrect pathway describing carbon moving from soil directly to plants. This highlights a need for targeted instructional activities on the role of decomposers and the movement of carbon from the soil to the atmosphere. These models have the potential to remove a major barrier to using CRAs. Instructors can administer the written assessment and evaluate student responses in minutes with our predictive models to get insight into student mental models.

Poster #58 FABUS: A survey measuring student buy-in toward and utilization of formative assessments Kati Brazeal*, "University of Nebraska, Lincoln"; Chad Brassil, University of Nebraska-Lincoln; Brian Couch, University of Nebraska-Lincoln [abstract #192]

Formative assessment (FA) is an important way to improve student learning and persistence in STEM. While the use of FAs (e.g., Just-in-Time Teaching, Peer Instruction) has increased in STEM courses, it has also been accompanied by challenges, including students resisting them or using them in ways that may undermine learning (e.g., not taking assessment seriously, searching the internet for answers). Student buy-in and utilization thus represent critical factors that potentially limit the adoption and efficacy of FAs. Instructors need standardized tools to assess how students engage with FAs. A survey can provide instructors with rapid and specific feedback from students and can be used to answer important research questions regarding how students engage with various FAs and whether high FA buy-in correlates with deep utilization approaches. To provide instructors with a diagnostic tool and answer these research questions, we developed the Formative Assessment Buy-in and Utilization Survey (FABUS). The content of the survey was informed by theory, including Black and Wiliam's five FA objectives and literature on surface and deep approaches to learning, as well as our previous research about student perceptions and behaviors regarding FAs. We began by building a draft instrument and then refined and validated it through an iterative revision process. These revisions were based on information gained from student interviews (n=30), feedback from instructors using FAs (n=6), and statistical analyses of survey data from pilot administrations in undergraduate biology courses (n=1,268 students in 9 courses ranging from introductory to senior level). Students completed the survey online outside of class. We used exploratory and confirmatory factor analyses as well as reliability statistics to evaluate and revise the items and sub-categories. The final survey consists of eight sub-categories measuring student buy-in toward FAs and specific instructional implementation aspects (e.g., content, feedback, grading, timing) and four sub-categories measuring student utilization of FAs (i.e., surface approach, deep approach, later use, and discussion). In the final survey administration, we gathered data from over 2,500 students in 32 courses at a range of levels from multiple institutions. The CFA item loadings (ranging from 0.46-0.93) and Cronbach's alphas (ranging from 0.76-0.94) serve as evidence supporting the structural validity and reliability of the sub-categories. We will present data on the variation among instructors and FA types for the buy-in and utilization sub-categories as well as findings on the extent to which student buy-in scores predicted utilization behaviors. In addition, we will share suggestions about how FABUS can be used by instructors to monitor and improve their FA implementation in ways that can increase student engagement and learning.

Poster #59 Using Undergraduate Students' Writing to Develop a Constructed Response Item about the Origin of Genetic Variation Hailey Cockerill*, Michigan State University; Andrea Bierema, Michigan State University; Rosa Moscarella, University of Massachusetts Amherst ; Kamali Sripathi, Michigan State University; Rachel Yoho, Michigan State University; Mark Urban-Lurain, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University [abstract #201]

Genetic variation is an important core concept for undergraduate biology education as highlighted in "Vision and Change In Undergraduate Biology Education: A Call to Action" (AAAS, 2011). Although student understanding of evolution and natural selection has been extensively studied, the origin of such genetic variants in a population has not been researched. To gain further insight into this topics, we investigated the following research question: How do students think about the origin of genetic variation? We developed a constructed response (CR) item in two parts to investigate our research question: A population of buffaloes lives in a [relatively] isolated area where they do not have access to other populations of buffaloes. Over the course of a few generations, scientists observe that many individuals have a new hair color not previously seen in this population. Scientists also discover that the buffaloes with the new hair color produce more surviving offspring than those with the old hair color. 1) How would a biologist explain how this hair color first appeared in the population? 2) How would a biologist explain the rapid increase in the number of buffaloes with the new hair color? We chose the framework of CR responses to investigate our research question, because Birenbaum and Tatsuoka (1987) have shown that CR items provide a more complete and richer view of student thinking than do analogous forced choice (e.g, multiple choice) responses. A qualitative analysis of 401 responses revealed several themes in student explanation, such as variation occurs out of necessity, a random occurrence, or genetic drift. However, many students restated phrases directly from the prompt, which lead us to iteratively revise the prompt. The most recent prompt was administered to students (n=143) at two large research universities. Analysis of data from University #1 revealed frequent reference to sexual mechanisms (frequency = 123) of the origin of genetic variation. In contrast, students from University #2 talked more about genetic drift (frequency = 57). Students from both universities wrote about natural selection (frequency = 210 for University #1; frequency = 67 for University #2). The differences between student responses from the two universities could indicate different instructor styles that may influence students' writing; however, more data is needed. Next steps include collection of student responses from other institutions to diversify the data sets and rubric refinement. The results from our study will further elucidate how students think about a concept that has proven consistently challenging in undergraduate biology education.

Poster #60 A critical analysis of the state of measurement of undergraduate STEM teaching practices Marilyne Stains*, University of Nebraska-Lincoln; Robert Erdmann,

University of Nebraska - Lincoln; Binh Le, University of Nebraska-Lincoln; Zach Nelson, University of Nebraska-Lincoln [abstract #260]

The numerous calls for reform of the STEM undergraduate curriculum and associated efforts in fulfilling these calls have led to a realization that progress in instructional transformation needs to be monitored. This monitoring is essential to guide and ensure the effectiveness of on-going and future investments. As a consequence, numerous instruments have been developed and leveraged to measure the impact of instructional reforms. However, this wealth of instruments has made it difficult for users to identify and choose the tools most relevant to their context and goals, as well as for developers to identify instruments that need to be developed. In 2012, the American Association for the Advancement of Science (AAAS) convened a group of discipline-based education researchers (DBER) specializing in instructional transformation and its measurement. The outcome of this meeting was a report that summarizes the types of tools that have been developed and used to measure instructional practices. The identified tools were categorized by the method each used to collect data, i.e. survey, interview, observation protocol and teaching portfolio. The report also provided advice for best practices in measuring teaching. First, there was a universal recognition that teaching goes beyond the lecture hall and includes the laboratory, online instructional activities, field work, etc. Measuring teaching and the extent to which active learning is propagating in the undergraduate STEM curriculum thus requires conducting measurements in all of these environments. Second, instructional practices are best captured through triangulation of data sources. The goal of this study is to assist the DBER community in implementing these best practices by further organizing the wealth of available instruments according to the instructional constructs and contexts targeted by the instruments, rather than simply the method of data collection. For example, the Classroom Observation Protocol for Undergraduate STEM measures instructor and student behaviors in the lecture hall, while the Laboratory Observation Protocol for Undergraduate STEM measures instructor and student behaviors in the laboratory: each instrument measures the same instructional construct but within different instructional contexts. In order to accomplish this, we analyzed instruments using the original reports written by their creators in order to identify the instructional constructs being measured and contexts. We then classified instruments by constructs and contexts. The outcome is a complex, multi-dimensional Venn diagram that guides practitioners and researchers in the selection of appropriate instruments based on the context they are investigating and the outcome they want to measure. Importantly, the Venn diagram clearly identifies gaps in the set of tools available and thus provides a road map for instrument developers.

Poster #61 Classroom observation protocols: Implications of sampling design and frequency Andrew McDevitt*, University of Colorado Denver; Robert Talbot, University of Colorado Denver; Jeff Boyer, North Dakota State University; Laurel Hartley, Cu Denver [abstract #270]

Classroom observations are used to describe learning environments based on the occurrence of student or instructor behaviors. Observation protocols are utilized for a variety of purposes ranging from instructor feedback/reflection, to job performance evaluation, to course characterization. In this study we focus on the use of observation protocols for course characterization since sampling design and frequency impact the data's ability to accurately represent the course of interest. Rules of thumb or power analyses are commonly used to determine the minimum number of classroom observations. However, these techniques often fail to consider multiple data generating processes (DGPs) that give rise to observed classroom behaviors or non-random sampling techniques used to quantify these behaviors. In a review of recent education literature, we found methodological misalignments between the intended research objective and sampling design, sampling frame, sampling unit, and/or sampling frequency. The goal of our research is to understand the bias introduced by common sampling constraints. We used a simulation approach to explore the parameter space within 765 plausible course contexts. By simulating course data, we know the DGPs (e.g. simple random, stratified random, temporally autocorrelated) and can therefore evaluate how sampling strategies perform are at recovering this pattern. We simulate observation codes for entire courses using random multinomial distributions, stepping though probability vectors at 0.5 intervals for simple and stratified random courses and 0.1 intervals for temporally autocorrelated courses. We then apply 160 sampling designs to each of the simulated courses. Each sample design, which vary by structure and sample size, is then replicated 5000 times so that estimates of population moments (e.g. mean, standard deviation, etc.) invoke the central limit theorem. The mean signed difference (MSD), a measurement of the difference between estimated population parameters and true population parameters, is then used to identify sampling bias across the various courses. Our results describe the multidimensional relationship between the DGPs behind classroom observation code frequencies and sampling methods used to estimate those processes. For example, using simple random sampling we were able to recover the simple random DGPs as predicted through traditional power analyses. However, as sampling procedures and GDPs deviated from simple random, we saw increases in MSD. While MSD generally improved with sample size, the rate of improvement varied. Overall, we demonstrate that traditional methods for determining minimal sample size, while appropriate circumstances, do not apply in all circumstances. We leave the determination of acceptable levels of bias up to researchers and their individual research goals but suggest careful consideration of the underlying DGPs when weighing sampling design decisions and reporting interval estimates.

Poster #62 Early results of program assessment: Adopting Vision and Change into the biology curriculum Greg Heiberger, South Dakota State University; Carolyn Kennedy*, South Dakota State University; Anne-Marie Hoskinson, South Dakota State University [abstract #51]

Using multiple qualitative and quantitative methods, we assessed the incorporation of Vision and Change into biology curriculum at a medium Midwestern university. Vision and Change has given momentum to provide a more effective educational pedagogy; however, the process of integrating research-based teaching into biology courses requires an individualized approach. To facilitate this assessment process, we separated our courses into non-reform and reform, where the non-reform served as the control group and the reform group began the transition to implement Vision and Change into their teaching. We compared results between groups using the Classroom Observation Protocol for Undergraduate STEM (COPUS). Faculty completed the Teaching Beliefs Inventory (TBI), a qualitative instrument to gain a clearer idea of their perspective in adopting Vision and Change and scientific practices into their teaching. Additionally, our team conducted interviews with faculty. We also assessed the faculty's reported teaching methods through the quantitative instrument titled: The Teaching Practices Inventory (TPI). We predicted the reform group to report more active teaching methods as compared to the non-reform group, which would continue for the duration of the study. Each semester students are required to complete Bio-MAPS to assess student learning. Additionally, all graduating students are required to participate in exit interviews and exit surveys to gather qualitative data from students on their undergraduate education and elaborate on their perception of their preparedness for their future based on their educational experiences at a medium Midwestern university. We predict that students will show increased learning and increasing satisfaction with their learning and development as the implementation of Vision and Change continues. In the first semester of reform, the Teaching Beliefs Inventory and interview process showed a lack of confidence among the reform group faculty to smoothly adopt research-based teaching methods, while the non-reform group expressed a lack of eagerness to undertake new teaching pedagogies. The reform group's Teaching Practices Inventory scores were shown to be statistically significantly different than the non-reform group, with the mean score for reform group higher than the non-reform group. This suggests that the reform group reported they were adopting more active teaching methods than their non-reform peers reported. This was not supported with COPUS data. Results of COPUS analysis showed that the reform group faculty and non-reform group faculty did not spend statistically significant different amounts of time lecturing. Each of these data collection and assessment methods will be repeated in the future until the reform group has fully adopted Vision and Change into their teaching. We will share our strategic and intentional 5-year research and assessment plan, a timeline and our data collection process.

Poster #63 Lessons from the front lines of undergraduate biology transformation Anne-Marie Hoskinson, South Dakota State University; Donald Auger, South Dakota State University; Nicholas Butzin, South Dakota State University; Mandy Orth, South Dakota State University; Natalie Thiex, South Dakota State University; Yajun Wu, South Dakota State University; Greg Heiberger*, South Dakota State University [abstract #56]

The past twenty years have seen many calls for reform in how we teach STEM courses to improve student learning. Most recently, Vision and Change (V&C) and Next Generation Science Standards (NGSS) both emphasize a very few core concepts and scientific practices over the more common, lengthy list of topics to cover. While there exist accounts of single-course reform, there have been very few published accounts of efforts to reform a significant portion of a university department's courses. Building on the frameworks of V&C, NGSS, suggested approaches (e.g. Brownell at al. 2014, Cary & Branchaw 2017), and organizational change research, we report on the ongoing course reform process in the Department of Biology at a medium Midwestern university. In our usage, "reformed" refers to courses that are concept- and practice-focused and student-centered. In 2015, the faculty committed to transforming the Department's seven common core courses. We began by prioritizing both core concepts and scientific practices as the centerpieces of all seven courses, even in large-enrollment courses. Next, we mapped Departmental goals, formed by faculty consensus, onto core concepts and scientific practices (in our case, working with data, constructing explanations & predictions, building and improving models, communicating and collaborating). We just completed the first year of executing this reformed curriculum in our introductory biology sequence. Using a variety of metrics, we found that students had a lower DF rate and showed significantly higher gains in biological conceptual expertise than in traditional lecture-based courses, but the student experience rating was below normal – a common initial report from reformed or flipped courses. We also planned for self-study and collected data about instructor practices and impressions throughout the process, also using a variety of published metrics. Results from COPUS evaluations of class meetings showed that students spent almost half of class meetings working individually or in small groups on scientific practices. Finally, building on the work of Kezar & Gehrke (2015), we report on lessons specific to our Department and the open questions with which we still grapple. Following the highest aspirations of science, our purpose is to share both the successes and pitfalls of this challenging process in the pursuit of professional fulfillment and ultimately, student success in biology.

Poster #64 "They Make Us Involve Each Other - With Each Other" A case study of sense of belonging and involvement for students participating in a special biology program
Eva Knekta*, FIU; Melissa McCartney, Florida International University [abstract #64]

Regardless of a relatively large number of studies on student retention at universities and college, successes in increasing student retention have been relatively modest. Researchers argue that more focus should be put on understanding what institutions can do to help students stay engaged, and ultimately succeed. Many theories state that involvement and a sense of belonging are key factors for students' success. When considering the many variables involved in student retention, students' sense of belonging to and involvement in the institution is something that the institution can work to change. We agree that understanding what can be done at the institutional level is important to consider but argue that it might be even more efficient to focus on the departmental level, a focus rarely seen in the literature. The aim of this case study was to explore the sense of belonging to and involvement in a biology department for a group of students participating in a special biology program. The design deployed by this program aligns with several aspects that previous research suggests could create a good sense of belonging and high involvement. By exploring how this specific group of students talk about sense of belonging and involvement we hope to gain a better understanding of how these strategies seem to affect the students' experiences at the department. Ultimately, we hope that our findings can provide guidance to departments on how to continue to move towards better retention. The study is based on semi-structured interviews. Tinto's model of institutional action and Apelton et al.'s conceptualization of engagement were used as theoretical frameworks for the study. Ten students participating in the special biology program were interviewed about their experiences and interaction with the biology department, with a special focus on a sense of belonging and involvement. The interviews lasted between 37 and 60 minutes. All interviews were transcribed and data were analyzed using thematic analysis based on inductive coding. Analysis showed that the students have created a strong sense of community among peers and good relationships with specific faculty and staff. They find people friendly and they feel accepted, valued, and respected. During the interviews, several students describe how features specific to the program have enhanced their sense of belonging to or involvement in the biology department. However, the analysis also implied a strong focus on careers related to medical school among students and that students not sharing this strong focus might feel disconnected from the group. Faculty and staff might need to balance this prevailing paradigm and actively highlight and encourage alternative biology careers. Taken together, the interviews problematize several different aspects departments could consider to enhance students' sense of belonging and involvement.

Poster #65 BioSkills Guide: Developing and Validating Learning Outcomes for the Core Competencies Alexa Clemmons*, University of Washington; Alison Crowe, University of Washington [abstract #88]

Changes in the nature of biology-related careers have spurred calls to transform undergraduate biology education. National leaders have asked us to move discussions of curricula away from content (i.e., lists of topics) in favor of concepts (big ideas) and competencies (skills). Vision and Change identified five core concepts and six core competencies around which undergraduate biology curricula should be built. However, descriptions of core concepts and competencies were left intentionally broad to encourage ongoing conversations among educators about how best to implement them in the classroom. For core concepts, such conversations have taken place, culminating in the BioCore Guide, a nationally validated framework of general principles and specific statements elaborating each core concept. No equivalent resource yet exists to help educators interpret the core competencies. To help facilitate teaching, mapping, and assessment of the Vision and Change core competencies, we are elaborating the competencies into measurable learning outcomes, which we are collectively calling the BioSkills Guide. In this poster, we present our methods and preliminary data in this project. We will provide an overview of the collaborative and iterative process we are using to develop and revise the guide. To date, we have incorporated quantitative and qualitative feedback from approximately 60 educators collected through round tables, interviews, and surveys. We are currently working on expanding this sample, with a focus on inclusion of educators with a variety of teaching experiences (institution types, biology subdisciplines, course levels). We will present a subset of the survey data with the aim of promoting discussions on how best to analyze and act on the data going forward. Our goal is to gather a wide range of input in order to build a widely valuable tool for biology competency training across the curriculum at diverse undergraduate institutions.

Poster #66 Undergraduate Field Experiences Research Network Janet Branchaw*, University of Wisconsin - Madison; Kari O'Connell, Oregon State University; Roberta Nilson, Oregon State University; Alan Berkowitz, Cary Institute of Ecosystem Studies; Amanda Butz, University of Wisconsin - Madison [abstract #206]

The Undergraduate Field Experiences Research Network (U-FERN) is building a collaborative network that fosters effective undergraduate field experiences by: 1) Identifying and sharing evidence-based models and practices for engaging a diverse range of undergraduates in effective field and marine learning experiences, 2) Identifying, modifying, developing, and sharing assessment tools for understanding the impact of field and marine learning experiences on undergraduate student learning, STEM identity, and career trajectories, 3) Investigating how undergraduate field experiences may help broaden the participation and retention of students from different ethnic racial groups and physical disabilities who are currently underrepresented in field-based sciences such as marine ecology, ecology and geosciences, and 4) Establishing undergraduate learning experiences at field stations and marine labs as "interdisciplinary laboratories" for researching evidence-based practices in undergraduate research, service learning, and place-based education. We are in our first year of this NSF-funded Research Coordination Network Undergraduate Biology Education project, and in our proposed poster we will present findings from a landscape analysis, a preliminary comparison of field and non-field REU site outcomes, and discuss ways interested participants can get involved in UFERN. We conducted a limited literature review and a national survey to address our guiding research question: What is the current understanding about the design and impact of field station and marine lab and related undergraduate field experiences for undergraduate students? In the survey we asked about the design of extended field experiences, desired student outcomes from these experiences, what assessment approaches and tools are being used, and what strategies are being used to recruit, retain, and benefit students from populations traditionally underrepresented in STEM in these field experiences. We sent the survey to field stations and marine labs, geology field camps, and programs with NSF Research Experience for Undergraduates site programs. We received data from 165 different undergraduate field programs thus far and will present an analysis of this data. In addition, we will present data from a preliminary analysis comparing outcomes from 29 field and 62 non-field Biology REU sites gathered using a common assessment tool. We will discuss these findings and their implications for the impact of field-based experiences on undergraduates, the most effective ways for undergraduates to engage in field experiences, and how field experiences could be more inclusive and attract diverse students to field-based sciences. We also hope to have discussions with conference attendees about fruitful areas for future research in undergraduate-level field- and place-based learning.

Poster #67 Changing Evolution Acceptance using a Reconciliatory Model across Religiously Affiliated Universities Jamie Jensen*, Brigham Young University; John Lindsay, Brigham Young University; Adhieu Arok, Brigham Young University; Jenna Ireland, Brigham Young University [abstract #173]

For so long, well-meaning scientists have approached the intersection between faith and science using a 'Resolution model', with the intent to resolve, or settle, the conflict in favor of science by showing students the evidence. More detrimental, many scientists have approached the conflict with a 'Deficit model' in mind, firmly believing that a lack of acceptance of evolutionary theory was simply a result of a deficit of understanding or reasoning ability, i.e., ignorance. We believe that both models serve only to lengthen the divide between these two legitimate ways of interpreting the world. In two recent studies (references withheld for anonymity), we have shown a significant shift in acceptance of evolutionary theory following a classroom implementation aimed at presenting evolution in a faith friendly, non-confrontational manner, a so-called 'Reconciliatory Model'. Viewing these two studies as ecological case studies of a Christian population with notorious cultural (but not necessarily doctrinal) barriers to evolution, we attempted to transfer our process to a broader population of religious individuals across the country. In October 2017, our institution held a Roads to Reconciliation workshop bringing together four teams from four religious institutions: Brigham Young University (Mormon), Evangel University (Assemblies of God), Colorado Christian University (Evangelical), and Point Loma Nazarene University (Nazarene). Teams consisted of a university theologian, a university biologist, and a local community pastor. During the workshop, leaning on principles of Religious Cultural Competence in Evolution Education (ReCCEE), we found common ground, designed Reconciliation Modules to be run in classrooms at each respective university, and designed instrumentation to test for effectiveness and predictive factors for change. This poster will present preliminary data on the effectiveness of these Reconciliation Modules. Because much of the data is being collected currently (Spring 2018 semester), we do not have complete quantified numbers to present in this abstract. However, we anticipate having data analyzed and ready to present in a poster by SABER 2018. Preliminary analyses show shifts in evolution acceptance surrounding the presentation of this module. In addition, quantitative survey measures will show us which factors (demographics, geographic region, faith tradition, high school coverage, formal religious training, religious influence, parental influence, perceived science/religion conflict, and level of authority given to both religion and science) are likely predictive of more or less change.

Poster #68 Atheistic Definitions of Acceptance of Evolution Exacerbate Rejection of Evolution among Religious Students Sara Brownell*, Arizona State University; Elizabeth Barnes, Arizona State University; Hayley Dunlop, Arizona State University [abstract #28]

Evolution is the foundation of biology, yet it remains controversial among college biology students. Past research has shown that religiosity and understanding of the nature of science are the most predictive factors for whether a student will accept evolution. However, this research has not explored which aspects of the nature of science are particularly important for student acceptance of evolution and whether understanding the nature of science moderates the relationship between religiosity and acceptance of evolution. In this study, we hypothesized that a particular misunderstanding about the nature of science, that evolution is atheistic, would exacerbate the relationship between religiosity and acceptance of evolution. We surveyed ~1200 college biology students and measured their acceptance of evolution and religiosity. We also asked students to list aspects of religion that an individual has to reject in order to accept evolution. We then coded students' answers and identified students who held the misconception that one would have to reject the existence of God/god(s) in order to accept evolution. More than 33% of students indicated that they held the misconception that evolution is atheistic rather than the correct conception that evolution is agnostic. A hierarchical linear regression was used to test if the presence of atheistic misconceptions of the definition of acceptance of evolution predicted students' acceptance of evolution. Further, we tested whether the presence of atheistic definitions mediated or moderated the relationship between acceptance of evolution and religiosity. We found that the presence of student misconceptions about the nature of science, particularly that evolution disproves the existence of God/god(s), predicted students' acceptance of evolution above and beyond their religiosity. Further, we found that atheistic definitions of acceptance of evolution moderated the relationship between student religiosity and student acceptance of evolution; among students who held the misconception that evolution disproves the existence of God/god(s), the negative relationship between their religiosity and acceptance was much greater than among students who did not hold this atheistic misconception. This study suggests that correcting students' misconceptions about what evolution illustrates and does not illustrate about the existence of God/god(s) may increase acceptance of evolution, particularly among religious students.

Poster #69 Women in Introductory Chemistry Labs: Quantifying the Participation Gap
Connor Neill*, University of Minnesota-Twin Cities; Cissy Ballen, University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #59]

Women are underrepresented at the undergraduate level in most science, technology, engineering, and mathematics (STEM) disciplines. Over the past several decades, female enrollment in American undergraduate biology and chemistry programs reached 58% and 50% respectively, making these fields somewhat unique within STEM. However, female biology and chemistry students are more likely to leave STEM majors, contributing to the “leaky pipeline” effect, in which fewer women than men progress to each subsequent stage of academia. Student verbal participation is correlated with retention in STEM disciplines and may reflect the extent of the leaky pipeline at the undergraduate level. While studies across multiple public universities found that female students verbally interacted with instructors in undergraduate STEM classes less than their male peers, unpublished data from the laboratory component of biology classes at a particular R1 university do not exhibit this trend. The reason for this discrepancy is unknown, although it may relate to the threshold effect in which female students’ verbal participation increases when the proportion of female students in a class passes a particular threshold. Here we quantify verbal participation of female and male students in introductory chemistry laboratories at this university to assess (1) the presence and extent of gaps in participation as they vary by gender; (2) the effects of gendered group compositions on female participation. Female students participated at disproportionally low levels in five of 27 labs, and did so most commonly in equal-gender groups. In all other laboratory sections we did not observe significant gender differences in participation at the whole class level. In three cases we observed women participating significantly more than would be expected given their numeric group proportions, although each of these was a majority female group. These findings agree with previous work at other universities and support the presence of the threshold effect, despite the equal gender representation in undergraduate chemistry laboratories. Future work will benefit from a close examination of this university’s biology laboratories, which appear to have no gender participation gap.

Poster #70 Exploring the impact of student religiosity on faculty perceptions of competence, hireability, and likeability of potential PhD students in biology Elizabeth Barnes*, Arizona State University; Jasmine Truong, Arizona State University ; Dan Grunspan, Arizona State University; Sara Brownell, Arizona State University [abstract #69]

Public polls show that approximately 75% of the US public identifies as Christian, yet these same polls show that only 29% of scientists identify as Christian (Pew, 2009). Past research has argued that the difference in the percentage of scientists who identify as Christian and the percentage of the public who identify as Christian is due to lower reasoning ability and lower need for cognition among religious individuals. However, an emerging body of research is indicating that Christians may also choose not to pursue careers in science due to an unwelcoming environment for religious individuals in science; Christians are aware of negative stereotypes about their ability in science and they also experience stereotype threat when performing scientific tasks (Rios et. al, 2015). While this research shows that individuals perceive negative stereotypes about Christians in science, no studies have explored science faculty members’ perceptions of Christian students and how these perceptions may impact students. One way in which faculty members can have an impact on who does and does not get to pursue a career in science is through their selection of PhD students. We probed this question using an audit study design where individuals received a fictitious applicant to evaluate. We chose to explore this by focusing on PhD applicants in biology because biology is often thought to be the science most at odds with religion. Using the US News and World report graduate rankings, we identified biology faculty at the 4th through 55th ranked schools for best biology graduate programs and emailed 4,969 faculty to complete the survey. 228 biology faculty members (5% response rate) nationwide evaluated the application of a potential PhD student for their lab. Approximately half of faculty members randomly received an application in which the student applicant listed an extracurricular activity that was unaffiliated with any religion (non-religious student) and the other half of faculty randomly received an application in which the student listed an extracurricular activity that was affiliated with a Christian organization (religious student). All other details of the applications were identical including student gender, GPA, GRE scores, and their letters of recommendation. Using previously published survey tools, we asked faculty members to rate their applicant in terms of (1) how likely they were to accept the applicant as a PhD student in their lab (hireability), (2) how competent they perceived the applicant to be (competence), (3) how much they liked the applicant (likeability), and (4) how much they would be willing to mentor the applicant. We then performed independent samples t-tests between data from faculty who received a religious student applicant and faculty who received a non-religious student applicant. We found that faculty who received the religious student application rated this student significantly lower in terms of their hireability ($t=3.05$, $p=.003$), their competence ($t=2.18$, $p=.031$), their likeability ($t=4.83$, $p=.000$), and how willing the faculty were to mentor the student ($t=2.54$, $p=.012$) compared to the non-religious student applicant. Using a mediation analysis, we also found that lower ratings of hireability for the religious student applicant was entirely explained by faculty members' perceptions that this candidate was less competent and less likeable than the non-religious student applicant. This finding illustrates that religious students who are applying to graduate school may fare better if they do not reveal their religious identity in their graduate applications. Further, given that individuals who identify as a racial minority tend to have higher rates of religious beliefs, this finding sparks a number of questions about how racial minorities may be disadvantaged by a scientific community that is unwelcoming towards religious individuals.

Poster #71 Investigating the performance of women and men across a biology curriculum Kurt Williams, North Dakota State University; Shanda Lauer, North Dakota State University; Caitlin Anderson, North Dakota State University; Emily Berg, North Dakota State University; Jeff Boyer, North Dakota State University; Jennifer Momsen*, North Dakota State University [abstract #76]

Across all levels of education, women are more likely to earn higher course grades than men. However, recent research in STEM has found robust evidence that women underperform expectations in introductory STEM courses and that this trend permeates all STEM disciplines, including introductory biology courses (Matz et al., 2017). Research on gendered performance differences (GPD) in upper division courses, however, is limited. We therefore investigated performance patterns of women and men across introductory and upper-division biology courses taught at a single institution over seven years. Following the methodology of Matz et al. (2017), we calculated (1) grade point average in other courses (GPAO) as the cumulative GPA of a student, calculated across all semesters and excluding the current course under analysis, (2) average grade anomaly (AGA) as the difference between final course grade and GPAO, and (3) gendered performance difference (GPD) as the difference in AGA between women and men. Our data focus on didactic courses, excluding laboratory courses and seminars. Analyzing 52,271 enrollments in biology courses from Fall 2010–Fall 2017, we found a statistically significant relationship between student gender and course grade ($G(5) = 390.36$, $p < 0.001$), with post-hoc tests indicating that women earned more As and fewer Bs, Cs, Ds, and Fs than men (Bonferroni-adjusted p-values < 0.001, except B's $p < 0.05$) and equal withdrawal rates ($p = 0.666$). This trend held for introductory majors, non-majors, and upper-level biology courses, while the difference was weaker for human anatomy and physiology (HA&P) courses. AGA was negative for introductory (–0.30), HA&P (–0.37), and upper-level (–0.16) biology courses, but close to zero for non-majors courses (0.05). However, GPD at all levels was close to zero (Intro: 0.04, HA&P: –0.03, non-major: –0.02, Upper: 0.01). While women were 21% more likely to earn an A than men across the curriculum, we find no evidence of a gendered performance difference. Overall, women earned more A's than men, and did so at a level that matches expectations based on GPAO. However, across biology courses in the major, both women and men had a negative AGA: there is a clear penalty in taking biology courses. Our results do not align with those reported elsewhere, including Matz et al. (2017). Our results do not align with those reported elsewhere, including Matz et al. (2017). These findings raise further questions about differences among study populations and factors impacting gendered differences in achievement motivation.

Poster #72 Gendered Discourse in a College Biology Classroom for Non-Majors
Jonathan Andicoechea*, University of Minnesota; Gillian Roehrig, University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #89]

Background. In active learning college classrooms, small-group discussions drive the learning process. Seemingly-neutral situational cues can generate gendered and potentially inequitable discourses. Here we compare how the sex ratio of student groups in a biology class influenced how students talked about the evolution of sex. Methods. At the start of the semester, the instructor assigned students to one of three group categories: All-male, all-female, or mixed-sex. During lecture, students engaged in scientific argumentation, concept map development, and other collaborative activities. Data Collection. We audio-recorded and transcribed three group conversations during eight separate lectures spaced throughout the semester—for a total of 36 hours of student talk. The lectures covered both scientific and socio-scientific topics (e.g. the biological basis of and cultural response to homosexuality). The researcher attended every lecture and collected field notes to contextualize the transcripts. Analysis. Research on linguistic interactions underscores the advantages of combining quantitative and qualitative frameworks of discourse analysis. For our quantitative approach, we used Structural Functional Discourse Analysis (SFDA). SFDA uses a pre-coded system of analysis to categorize utterances based on their linguistic function, and then identifies patterns among discrete groups. We then used a Feminist Post-Structuralist Discourse Analysis (FDPA), which reflexively describes how gender identities are performed and policed in conversation. Critically, while SFDA quantifies inequalities in speech contributions between different groups, FDPA proposes explanations grounded in social identity theory for these differences. Interviews. Some of the students who were audio recorded consented to interviews at the end of the semester. These interviews enriched the discourse analysis by providing the researcher with the students' own perceptions of gender and their classroom experience. Findings. Men in mixed-sex groups used direct exchanges that express individuality and competitiveness more often than their female peers. Women, regardless of group identity, relied on utterances that promote collaboration and the co-production of outcomes. Men in the single-sex group rarely engaged one another, precluding any quantification of their speech patterns. Finally, men tended participate in the conversation at rates higher than their numerical representation. Two related discourses emerged across groups: The "poor boys discourse" and the "privileged femininity discourse". Together they posit that men are the socially-dominant but academically-inferior identity (and vice-versa). Implications. The social identity of group members influence how students talk to and engage with their peers. Since discourse is an integral part of learning, how students talk to one another about academic and non-academic subjects matters for educational outcomes.

Poster #73 Changes of Attitudes toward Science and Math by Gender during a STEM Camp Kara Baldwin*, Illinois State University; Rebekka Gougis, Illinois State University [abstract #115]

Mathematics achievement gaps between male and female student students have been documented for decades (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). Gender differences within science, technology, engineering, and mathematics (STEM) fields are of concern. For example, only 20% of completed bachelor's degrees in the STEM fields are awarded to women (Hill, Corbett, & St. Rose, 2010). In the last decade, some disciplines, like math and biology, have seen a surge in female graduation rates (National Science Foundation (NSF), 2014); however, numbers of women graduating with advanced degrees continues to remain below their male counterparts (Hill et al., 2010; NSF, 2014). Middle school interventions with female role models or teachers may enhance female interest in STEM and may have an impact on closing the gender gap (Wang & Degol, 2017). Discovery Academy, a two-week summer camp for middle school students, strives to increase student attitudes toward science and mathematics through hands-on and inquiry-based learning activities. To evaluate if this camp experience changed students' attitudes toward mathematics and science, students were administered the Science and Mathematics Student Motivation Assessment (SMSMA; Weinberg, Basile, & Albright , 2011), which measures students' math and science interest, students' perceptions of the utility of math and science, students' perceptions of the costs of being successful of math and science, students' beliefs about their math and science attainment, and students' expectancy of success in mathematics and science. This study compares pre- and post-camp SMSMA data for middle school students by gender/mentor categorical variable to assess the impacts of same-gender mentors on middle school student attitudes toward STEM.

Poster #74 Examining Student Perceptions of Exam Retake Opportunities Jake Peterson, University of Minnesota; Mai Vang, University of Minnesota; Hillary Barron*, University of Minnesota; Cissy Ballen, University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #137]

For many students, taking an exam is often accompanied by test anxiety and stress. The presence of anxiety and stress can influence the performance of the students in how they prepare for the exam, how they perform when taking the exam, and their perception of their own competence. Often times, the stress of test anxiety negatively impacts how the student performs on the exam. To alleviate the test anxiety and stress, exam retakes were established in this study to observe the difference in performance and stress-perceptions. Non-major introductory biology courses were surveyed as they were allowed an attempt of a retake and those results were categorized according to which exam of the semester they were given a retake option. Quantitative analyses included a linear mixed-effects model and qualitative analysis included thematic coding and grounded theory techniques. Quantitative analyses showed that students who were offered and took the retake for the second exam of the semester performed better than students who were offered and took the retake exam for the first exam of the semester. Statistically significant differences were observed across class sections. Qualitative analyses suggested that exam retakes greatly reduces an individual's perception of stress level and anxiety. This reduction in negative self-perception seemed to be a benefit as the students reported studying more and understanding concepts better. The overall responses showed that the majority of the students appreciated and liked the exams as it had some positive impact on their preparation for the exam or alleviating stress and test anxiety. Lastly, the most prevalent student response was that the retake option improved their exam score. This is particularly interesting because the statistically significant improvement of performance was not seen across all students, yet the majority of students reported improved exam performance in their qualitative responses. One implication for this is that students' perceptions of improved performance are more nuanced than what counts as such in statistical analyses (i.e. even improving one point on the exam was important to students).

Poster #75 Seminars for Students from Under-Represented Populations Support Strong Science Identity and Motivation Deborah Donovan*, Western Washington University; Emily Borda, Western Washington University; Anna Groat-Carmona, Western Washington University; Kathleen Sandelin, Western Washington University [abstract #145]

Retention of students in STEM disciplines, particularly students from under-represented populations, is an issue faced by many universities. We developed and implemented a two-quarter seminar series to support under-represented freshmen and transfer students majoring in STEM. The seminars focused on science content and process skills, research-based study skills, and peer/faculty mentoring. For science content and process, we used materials designed to help undergraduates analyze and present data, engage with research talks (“research deconstruction”), and read primary literature (CREATE). One of our primary goals was that our students view themselves as future scientists, since students who have a strong science identity are more likely to remain in STEM. We hypothesized that science identity and scientific reasoning skills would increase in students taking the seminars, and that there would be differences between transfer students and freshmen. We administered a Science Identity and Motivation (SIM) questionnaire and a Scientific Reasoning (SR) assessment to students (n=12 transfer, n=26 freshmen) at the beginning of the first seminar, then again at the end of the second seminar. SIM questions measured seven factors related to science identity and motivation, and we calculated mean scores for each factor for each student. The SR assessment had 24 multiple-choice questions that assessed students' abilities to analyze situations, make predictions, and solve problems. We used generalized linear models to test for differences in mean post scores for the SIM survey factors and SR assessment, with treatment (transfer or freshmen) as a fixed factor and controlling for prescore. Mean SIM prescores for both transfer students and freshmen were high (range of 3.91-4.47 on a 5 point Likert scale for the positively coded factors), indicating that students came to our seminars with strong science identities. For all factors, scores increased for the transfer students and decreased for the freshmen, although freshmen postscores still indicated they had very positive SIM (range of 3.84-4.24 for the positively coded factors). At the end of the second seminar, transfer students had significantly higher postscores compared to freshmen on five SIM factors: Science Identity, Intrinsic Motivation, Goal Orientation, Self Efficacy, and Self Determination. There were no differences between the two groups on Extrinsic Motivation and Anxiety-related Motivation. Mean postscores on the SR assessment were not higher than the prescores, and there were no significant differences on this assessment between transfer students and freshmen. These preliminary results indicate that the seminars were successful in enhancing or maintaining strong science identities of students from under-represented groups, particularly transfer students. All of the materials we used were research-based and freely available, making our seminars easily transferable to other institutions.

Poster #76 Peer-Led Team Learning May Decrease Impostor Feelings Isabella Cannon, Syracuse University; Ryan Dunk, Syracuse University; Kelly Schmid, Syracuse University; Mia Pepi, Syracuse University; Julia Snyder*, Syracuse University; Jason Wiles, Syracuse University [abstract #162]

While progress has been made in recent years, especially in biology, STEM disciplines have yet to achieve equitable levels of diversity and inclusion in many ways. Even within the life sciences, capable and successful women and underrepresented minorities often lack confidence in their abilities and achievements. The impostor phenomenon, first utilized to describe a group of high-achieving women, describes individuals that have internal feelings that they lack talent and skill despite significant accomplishments and achievements. Feelings such as these could result in attrition of well-qualified women and/or underrepresented minority students from STEM fields. Peer-led team learning (PLTL) is an active learning approach in which students who have successfully completed an academic course guide and facilitate small groups of students who are engaged in the same course through problem solving workshops. Aside from other documented benefits, PLTL may help to mitigate impostor feelings. In particular, women and underrepresented minorities may be less likely to struggle with impostor feelings after exposure to and interactions with potential role models (peer leaders) who may defy negative stereotypes of women and underrepresented minorities in STEM. In this study, we identified introductory biology students with few, moderate, frequent, or intense impostor feelings. Participants completed the Clance Impostor Phenomenon Scale (CIPS) at the end of the first semester of a twosemester introductory biology sequence. Additional data were collected on final grade, gender, ethnicity, and participation in peer-led team learning workshops. Data were analyzed using general linear modeling and Pearson's chi square tests. We report on impacts of participation in PLTL on students' impostor scores, as well as the impact of same-sex peer leaders.

Poster #77 Coming Out to the Class: Identifying Factors that Influence College Biology Instructor Decisions About Whether to Reveal Their LGBTQIA Identity in Class Katelyn Cooper*, Arizona State University; Sara Brownell, Arizona State University; Cara Gormally, Gallaudet University [abstract #257]

Lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) identity is an understudied, yet potentially important identity for individuals in an undergraduate biology classroom. Although the choice to "come out" or reveal one's LGBTQIA identity is a personal decision, LGBTQIA college instructors may positively impact students when they reveal their identity in the classroom. We conducted a national survey of 60 LGBTQIA biology instructors about their experience as a member of the LGBTQIA community teaching college biology. Additionally, we conducted semi-structured interviews with 11 LGBTQIA college biology instructors and applied Expectancy Value Theory to understand what influences instructors' decisions about whether to reveal their LGBTQIA identities to students in their college biology classrooms. We found that, while over half of instructors are out to their colleagues, less than 20% of instructors are out to their college science classes. Using essential elements of grounded theory, we identified a suite of potential costs and benefits associated with instructors coming out to their classes. Based on these findings, we highlight how perceiving high value and low cost to coming out is relevant for instructors' decisions to reveal their LGBTQIA identities in their classrooms.

--------------------------------------Sunday posters---

Poster #78 The Strategic Undergraduate STEM Talent Acceleration INitiative (SUSTAIN) John Tillotson, Syracuse University; Jason Wiles*, Syracuse University [abstract #168]

The "Strategic Undergraduate STEM Talent Acceleration Initiative" (SUSTAIN) project at a large, private, research-intensive (R1) university in the northeastern United States addresses many of the challenges of recruiting and retaining high-achieving, low-income students from diverse backgrounds into undergraduate STEM programs. The SUSTAIN program awards thirty $10,000 scholarships for up to two years, and provides a coherent system of academic, social, and career support services strategically designed to enhance the success of biology and chemistry students during their first and second years of undergraduate study. Program goals include retaining at least 90% of the initial cohort of 30 scholars as intended or declared STEM majors following their first university year, and to retain at least 80% of these students as declared STEM majors following their second year of participation in the SUSTAIN program.

The program has established a STEM faculty professional development workshop designed to foster the implementation of cutting-edge instructional practices that support dynamic, active learning approaches in introductory STEM courses. Scholars are provided 360-degree, wrap-around support programming that is responsive to their evolving academic, social, and career development needs as they move through their first and second university years. Research efforts are investigating the socialization experiences of scholars throughout the program to examine the efficacy of the multi-faceted series of intervention supports to assess their impact on the future STEM trajectories of students. Findings from this project will promote the identification of promising approaches, identify areas for program refinement, and result in the development of a sustainable model for providing wrap-around academic and social support services to STEM majors that can be replicated on other campuses.

Poster #79 Research Coordination Networks (RCN) as a model for globally distributed experiments in Biology Education Cissy Ballen*, University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #178]

Research Coordination Networks (RCN) as a model for globally distributed experiments in Biology Education Cissy J. Ballen and Sehoya Cotner Advancing the field of Biology Education Research (BER) requires developing theories based on relationships that integrate across institutional, regional, and longitudinal scales. Multi-institutional experiments can lead to high-impact insights that would otherwise be unachievable. Here, we introduce Equity and Diversity in Undergraduate STEM (EDU-STEM) as a new research coordination network whose theme is to identify and reduce barriers to full participation in STEM fields. We are a national experimental network (currently >45 classes in 15 institutions) that arose from a grassroots research effort. Here, we discuss the approaches and goals of EDU-STEM as a model to encourage others in the BER community to employ distributed experiments to advance our predictive understanding of equity trends and responses to interventions. EDU-STEM integrates research and teaching in evidence-based classroom experiences across Biology curricula. The four objectives are: (1) reveal differences, if they exist, in the cultural climate for women and minorities in STEM disciplines (initially focusing on biology) as a function of geography, institution type, and cultural profile of the participating departments; (2) increase the number of faculty in the United States that are familiar with barriers to inclusion in STEM, and can apply evidence-based techniques for countering known barriers; (3) develop a community of faculty that can serve as leaders--at their home institutions and nationally--in inclusive teaching and assessment; and (4) identify cultural factors associated with a shift towards evidence-based teaching, especially pertaining to inclusive teaching. These activities will be integrated throughout thousands of students' first and second years of higher education, and all of them involve evidence-based techniques and experiences. The Incubator RCN EDU-STEM meeting took place October 27-29, 2017, in Minneapolis, MN. In the months before the meeting, the EDU-STEM steering committee recruited participants from research institutions, minority-serving institutions, and community colleges across the United States. Among the objectives of this meeting was to gain a better understanding of how psychology can inform our efforts to minimize barriers to equity and develop a plan for implementation and assessment of possible interventions. Specifically, we discussed logistically feasible, scalable interventions that could be implemented in future semesters. Following the meeting, participating institutions collected post-course data from their students. We will discuss the extent of performance gaps among any demographic groups, across institution types, and outline our plan for a systematic approach to testing scalable interventions.

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Poster #80 Impact of the NSF STEM Scholars Program on Community College Student Success and Degree Completion Maire Sustacek*, Minneapolis Community and Technical College; Renu Kumar, Minneapolis Community and Technical College [abstract #235]

As institutions that serve many low-income students, first-generation students, and students of color, community colleges are an important local resource to reduce demographic disparities in science and technology through excellent, accessible STEM education. Since many community college students face substantial economic and personal barriers, inclusive pedagogy alone cannot solve gaps in STEM degree attainment – there is a need for additional high-impact student support strategies. One such promising support strategy at our institution is the National Science Foundation STEM Scholars Program. This program supplies academically talented, financially needy students in biology, chemistry, information technology, and math programs with scholarships, faculty mentoring, and STEM enrichment opportunities for up to four semesters. The NSF STEM Scholars program served 105 students over a five-year period, including 49% (52) low-income students, 19% (20) first-generation college students, and 37% (39) students of color, which is similar to the overall demographics of our institution. We assessed the impact of the NSF STEM Scholars program by examining the following outcomes: 1) GPA, 2) course completion, 3) degree completion and transfer. To determine if the NSF STEM Scholars program led to significant improvement in student success and completion, we compared outcome data for program scholars, all STEM students, and the overall student population. Of the 105 STEM scholars, 63% (66) have graduated and/or transferred within a STEM discipline, while 16% (17) remain active in the program and are making progress toward degree completion. These data represent an improvement compared to overall completion rates at our institution: only 41% of all degree-seeking students and less than 50% of STEM students completed their degree program or transfer curriculum within three years. We also saw that GPA and course completion rates were higher among scholars than the overall student population. While these initial results are promising, further work is needed to examine how much of this effect is due to the selection process for scholars and to determine which aspects of the STEM Scholars program are most high-impact.

Poster #81 Inclusive Excellence: A three-pronged approach to increasing diversity and retention in science Rita Margarida Quinones de Magalhaes*, Rochester Institute of Technology; Dina Newman, Rochester Institute of Technology; Elizabeth Hane, Rochester Institute of Technology; Lea Vacca Michel, Rochester Institute of Technology; Jennifer Connelly, Rochester Institute of Technology; Scott Franklin, Rochester Institute of Technology [abstract #247]

Across the US, the college student population is becoming increasingly diverse; yet, retention numbers for students in STEM disciplines continue to decline and remain exceptionally low for excluded identity groups, such as women (in certain disciplines), deaf and hard of hearing, and AALANA. To attract and retain a diverse student body in STEM, institutions of higher education must address issues that keep students, faculty, and staff segregated and contribute to an overall unwelcoming environment felt at all levels. Resolving equity issues in higher education must start by examining the practices implemented in both classroom and research labs. We are taking a three-pronged approach to Inclusive Excellence in Teaching and Mentoring in Science. Faculty from Biology, Chemistry and Physics were recruited to participate in one of three strands, depending on their major interest: classroom practice (n=6), research mentoring (n=10), and community (n=7). Each strand met several times throughout the year and worked to develop more awareness of equity issues, share best practices, support each other,

and apply new strategies to improve their work environment. The community strand recruited students and staff as well. The faculty in the College of Science was surveyed on issues related to diversity at the beginning of the academic year (n=135). Though the faculty showed high agreement on how important diversity is for the College of Science, it was clear that the environment is not equitable. For example, while 90% of faculty agreed that having diverse viewpoints adds value to the department, 45% avoid having discussions on gender, race, or other issues for fear of being called prejudiced and 40% have heard a statement that they thought was sexist, racist or otherwise troubling. On-going work with the three strands is improving awareness of equity, providing tools that can be implemented in real time in both classrooms and research labs, and developing a network of professionals that will function as a resource of best practices.

Poster #82 Design-based Learning and Divergent Thinking Skill Development Erin Fried*, University of Colorado, Boulder; Lisa Corwin, University of Colorado Boulder; Andrew Martin, University of Colorado Boulder [abstract #31]

National calls from NSF emphasize the need to train future scientists to generate multiple creative solutions to complex interdisciplinary problems the world faces; this is especially true of fields at the nexus of biology, land & water management, and engineering (e.g., restoration ecology, hydrology). Design-based learning practices (DBL) have been shown to help engineering students develop creative problem-solving skills. DBL involves students in solving ill-defined, complex, and open-ended problems that require ideation. During ideation, students are tasked with generating a wide variety of innovative ideas (divergent thinking) in order to expand and restructure the problem to find creative solutions. Although innovative design and divergent thinking is required in many biological careers, current biology classrooms rarely focus on creative problem solving. Instead, instructors almost always ask students to converge on a single correct answer, failing to train students in idea-generation skills. This preliminary study incorporates a new bio-inspired design discipline, biomimicry, in an undergraduate Fall 2017 Evolution course. Biomimicry is the emulation of organisms' forms and functions by humans to create sustainable design solutions. Within a biomimicry design framework, we investigate if engagement in DBL can increase students' ability to generate 1) many ideas (fluency), 2) a diversity of ideas (flexibility), and 3) unique ideas (originality) - to think divergently - in order to improve their creativity in addressing biology-related design challenges. This study employed a pre-, post-course test design to assess students' (n=75) changes in divergent thinking based on three divergent thinking tasks. Design-based learning was introduced in two phases: 1) a weeklong case study with scaffolded practice of biomimicry projects, and 2) a biomimicry final group project with two experimental conditions: control (no divergent thinking prompts) and treatment (three divergent thinking prompts during different project stages). Current preliminary analyses include development of scores for each task and individual on the three main qualities of divergent thinking. Using both pre-established engineering education divergent thinking scoring methods and novel approaches based on principles of ecological Species Richness Indexes (i.e. flexible thinking of an individual) and phylogenetic character distance matrices (i.e. originality thinking map of entire class) we quantify student divergent thinking. We will compare pairwise pre-post divergent thinking scores of an individual, and the entire classroom's aggregated shifts in divergent thinking using multiple regression and principal component analysis. Results from this study will elucidate whether DBL in upper-division undergraduate biology classes has potential to increase students' divergent thinking skills in order to create projects that help develop student open-ended problem-solving strategies.

Poster #83 The missing piece: supplemental instruction is a critical component of a biology course revision Michael Fleming*, CSU Stanislaus [abstract #219]

Bottleneck courses are defined as courses that limit students' ability to make progress toward graduation. Sometimes the bottleneck results from scheduling and advising issues or lack of facilities, but just as often the bottleneck results from a high D/F/W rate in the class, resulting in many students retaking the course and restricting access for first-time students (Dulaney 2013). One such biology course at a 4-year primarily undergraduate institution on the west coast is a large lecture, one-semester general education survey course for non-majors. Typically the course serves 400-600 students per semester over several sections. Historically (defined as AY 2008/09 – 2011/12) the class had a D/F/W rate of 41% and is designated a "bottleneck" course by the state legislature. Upon arriving at this institution I implemented a highly structured (Freeman et al. 2011) teaching format in the class resulting in a slight decrease in the average D/F/W rate. In 2013 I restructured the course; I kept the highly structured elements and began implementing a number of low/no tech interventions meant to identify at-risk students early and engage them often (Gabriel 2008). Several colleagues did the same and the D/F/W rate is now about 18-22% across all sections. A peer-mentoring program called Supplemental Instruction (SI) was critical to this course transformation. This project documents an attempt to reduce the D/F/W rate in an introductory majors biology course by transferring the highly structured/low-tech model from nonmajors course. Specifically, I tested the hypothesis that transferring the teaching model to the majors class would significantly reduce the D/F/W rate compared to the historical average of 38-40%. One major difference in the two teaching models was that limited funding prevented the SI program in the nonmajors course from being implemented in the majors course. Predictably, the hypothesis was not supported, elucidating the importance of the SI component.

Poster #84 Developing Understanding of Students' Confidence and Sensemaking of Commonly Used Mathematical Expressions in Biology Linh Chau*, University of Minnesota; Fangfang Zhao, University of Minnesota; Anita Schuchardt, University of Minnesota [abstract #38]

National organizations that aim to improve undergraduate science education have raised concerns about deficiencies in biology undergraduates' quantitative skills. These deficiencies are of growing concern given the importance of mathematics to biological research and its role in the development of quantitative and problem-solving skills. Previous research has shown that quantitative problem solving ability is improved when students make connections between mathematical expressions and the scientific phenomenon they represent. Others have suggested that recognizing the mathematical meaning of the objects and functions in mathematical expressions is important. It is not known to what degree undergraduate biology students understand the mathematical meaning (mathematical sensemaking) and biological connections (biological sensemaking) of mathematical expressions they have been exposed to in their biology classes. Student sensemaking is often related to students' confidence, which may be a factor of many variables like demographic. Therefore, this study investigated how students' confidence about specific mathematical expressions commonly used in introductory biology is related to their sensemaking of those expressions. Students from first and second semester introductory biology courses for majors were asked to complete a survey designed to assess mathematics attitudes towards five specific mathematical expressions associated with biology (e.g. Hardy-Weinberg equilibrium and T-test). Students were also asked to indicate whether each of the mathematical expressions would be useful for different scientific practices. Preliminary statistical data analysis (N=113) has shown a positive correlation between confidence and both mathematical (ρ= 0.2, p<.001) and biology sensemaking (ρ = 0.14, p<.001). Also, students had higher levels of confidence in mathematical expressions more related to biological theory (e.g. Hardy-Weinberg) than those with more statistical use (e.g. T-test) (t = -5.2608, p<.001). When we examined the differences between gender, we saw that males had a higher level of mathematical sensemaking (t = -2.3224, p=0.02) and confidence (t = -5.0491, p<.001) across all mathematical expressions. However, the degree of difference in mathematical sensemaking between the genders varied with each expression type. Interestingly, there was no difference in the level of biology sensemaking between the genders across all sets of mathematical expressions. We will examine the generalizability of these preliminary findings across additional first-semester biology courses for majors, second semester introductory biology major course and an upper-level biostatistics course. We found evidence of how the nature of different mathematical expressions can affect students' sensemaking. This suggests that students may benefit from targeted instruction techniques based on the type of mathematical expression being taught. An understanding of students' mathematical abilities and attitudes towards specific mathematical expressions will aid in creating effective and targeted interventions in students' understanding of, and ability to use, mathematics in the context of biology.

Poster #85 Measuring students' system thinking skills using model architecture Jennifer Momsen*, North Dakota State University; Sara Wyse, Bethel University [abstract #43]

Learning to reason about complex biological systems is a core component of undergraduate biology education. This skill, termed system thinking, is multidimensional and hierarchical, involving the ability to identify and organize system components and processes, recognize emergent processes, and make generalizations and predictions. Student-generated concept models are an increasingly common tool used to explicate several elements of students' system thinking skills and as a result, metrics that characterize student-generated concept models are needed. In this research, we investigated students' ability to organize system elements into a meaningful model that conveyed a provided function. We adapted and applied a holistic coding scheme to describe the architecture (linear, branched, simple cyclical, complex cyclical, and networked) of student-generated models, both pre- and post instruction. Across a semester, students (n=117) in an introductory biology course built models as part of their regular instruction. For this research we focused on student-generated models of the movement of matter, specifically carbon cycling. Model architecture is evidence of students' ability to convey the system's function, namely the cycling of carbon. We hypothesized that the majority of pre-instructional student models would be linear, becoming cyclical following instruction. Using paired student data (n=81), two independent raters coded the model architecture of all student models (86% agreement). Disagreements were discussed until consensus was reached. Prior to instruction, students' model architecture varied. The majority of students created linear (35%) or branched (28%) models; the remaining students created simple cyclical (10%), complex cyclical (11%, sub-cycles present in the model) or networked (16%, dead starts/stops in the model) models. Networked models tended to include biomass dead ends (e.g., wolf, tree, 54%), atmospheric dead ends/starts (31%), or energy dead ends (31%). Following instruction, students created exclusively complex cyclical (46%) or networked (54%) models (p<0.0001, Fisher's Exact Test). Post-instruction network models frequently included energy as a dead end (66%) or a separate atmosphere for decomposition (16%). These results demonstrate that students enter introductory biology with a limited understanding of carbon cycling, as evidenced by their generally simple, linear models and their tendency to exclude decomposition from their models. Following instruction, students readily incorporated decomposition, organizing their models as complex cycles or networks of carbon cycling. Student-generated models of biological systems provide an authentic means to capture students' understanding of biological concepts, like the movement of matter. Developing metrics to characterize student models is essential as this tool becomes more ubiquitous in the undergraduate classroom.

Poster #86 What should graduating physiology seniors know and be able to do with the concepts of Flux and Mass Balance? Mary Pat Wenderoth*, University of Washington; Emily

Scott, Univ. Washington; Jack Cerchiara, Univ. Washington; Jenny McFarland, Edmonds Community College; Jennifer Doherty, University of Washington [abstract #71]

To gain expertise in a field is to recognize, understand, and effectively use underlying disciplinary principles. Too often students rely on rote memorization rather than principle-based reasoning to solve problems. Students list steps leading to muscle contraction or generation of an action potential but cannot reason to a correct prediction when changes are introduced in the system. The most expedient approach for solving problems is to develop principle-based reasoning that applies to a broad range of situations rather than a set of situationally specific facts. The core concepts of Flux and Mass Balance are ubiquitous across all biological systems (Modell 2000). Flux describes the passive flow of substances (e.g., molecules, fluids) and heat down gradients. The rate of flux is proportional to the gradient over the resistance. Mass Balance is an application of Conservation of Mass to dynamic physical systems. Conservation of Mass states that for any closed system, the mass of the system must remain constant over time. We are creating a learning progression that describes student reasoning using Flux and Mass Balance as it develops across a course or curriculum. A learning progression describes "successively more sophisticated ways of thinking about a topic". The highest level of a learning progression represents what graduating seniors should be able to do with the concepts of Flux and Mass Balance in animal and plant physiology. To begin to define the highest level of principle-based reasoning in our learning progression, we created a set of performance expectations. We interviewed 10 physiology faculty to ask if these performance expectations were appropriate for a graduating senior in physiology and if there were any performance expectations missing. We will present the current version of our performance expectations for Flux and Mass Balance. We will also share feedback we received from these faculty as to how often they explicitly used these two concepts in their courses. From these performance expectations we will create a validation survey that will be distributed to a national population of physiologists. We will use the results of this survey to define the highest level of our learning progression for principle-based reason with flux and mass balance in animal and plant physiology. Our learning progression holds promise to reform current teaching in physiology as it could coordinate and bring coherence to three key areas of the curriculum: identifying meaningful learning outcomes, building powerful assessment and guiding and informing instruction.

Poster #87 What Makes a Good Teacher? Examining Teaching Assistants' Concerns of Their Teaching Hillary Barron*, University of Minnesota; Julie Brown, University of Minnesota; Lorelei Patrick , University of Minnesota; Sehoya Cotner, University of Minnesota [abstract #77]

Undergraduate students in science classes are more engaged and demonstrate increased performance when instructional methods implement authentic science practices and active learning strategies. In these courses, students report greater self-confidence in their abilities to understand scientific concepts, particularly female and underrepresented minority students. Creating such inquiry-based, active-learning centric, and authentic science experiences that also promote inclusion and meaningful learning in the classroom. However, these models of science instruction are typically relegated to majors-only science students. Non-majors students (i.e. those enrolled in science classes because they need to fulfill a requirement) typically receive instruction that is more lecture-based and prescribed, which often contributes to disinterest, diminished self-expectations, and lower performance. Mediating these untended outcomes is a critical part of creating an inclusive and empowering science learning community in undergraduate science. Teaching assistants (TAs) are prime candidates to engage in these change processes as they often interact more closely with students than lecture instructors. However, existing research on how TAs teach doesn't delve deeply into what concerns TAs have about their teaching capabilities. We collected data throughout an ongoing TA training

program and sought to answer the following questions: 1) what are TAs' concerns about teaching? and 2) How do TA concerns evolve over time? Are there consistencies in TA concerns over time? Data sources included pre- and post- workshop survey questions at the beginning and end of a workshop before the fall semester as well as open-ended reflection prompts given at four time points throughout the academic year. First and second cycle qualitative coding analyses were conducted to establish themes of TA concerns and to explore if and how those themes changed over time. Preliminary analysis revealed that TAs concerns in general tended to be linked specifically with science content. This indicates that TAs are comfortable with their science content knowledge yet unsure if that knowledge is effectively translated to their students. Additionally, TAs were concerned about being inclusive in their teaching practices, citing insecurity about what techniques were appropriate. Finally, TA concerns, while moderately fluctuating over time, were consistently student-centered in nature. These findings show that as teaching assistants developed their instructional techniques and identities, how to connect their teaching with their students was integral in their reflective processes.

Poster #88 Variational vs. transformational views of evolution in undergraduate written work Rachel Sparks*, Illinois State University; Julia Martin, Illinois State University; Rebekka Gougis, Illinois State University [abstract #95]

The topic of evolution is considered to be a unifying principle in biology. Many fields of science rely upon evolutionary theory as a basis for biological processes, and an accurate understanding of evolution is necessary to properly learn, practice, and apply life sciences. Scientific understanding is particularly important in the current social, political, and environmental climate in the United States, as topics like biotechnology and climate change are common in public news and debate. However, there are gaps present in understanding of evolutionary theory in all groups of students, including undergraduate biology majors, non-majors, and high school students. Students often express one of two views about evolutionary theory: variational or transformational. The more scientific perspective is variational, which shows an understanding of the roles that evolutionary mechanisms play in the change of species. A transformational view, often rooted in teleological thinking, reveals a belief that change occurs through a transformation in the “essence” of the species. In order to overcome robust misconceptions based on transformational views, it is necessary to elicit these misconceptions and provide opportunities for cognitive dissonance and conceptual change to occur. To this end, this study describes an introductory general education biology course redesigned around six evolutionary themes: adaptation, variation, inheritance, speciation, artificial selection, and extinction, with pedagogy structured according to the Teaching for Transformative Experiences in Science (TTES) model. Each week, students responded to weekly reflection questions based on the selected evolutionary lens and the associated biological concept. Their responses were then analyzed through a priori coding based on Shtulman's table of variational and transformational views of these six evolutionary themes. In this poster, we present results of qualitatively coding these reflections for variational and transformational views to identify misconceptions about evolutionary theory. When these codes were totaled at the conclusion of the course, a nonparametric Wilcoxon signed-rank test indicated that students experienced a statistically significant shift from transformational to variational views over the course of the semester. We suggest future analyses of this data and consider the implications of these results regarding the efficacy of the TTES model.

Poster #89 Disciplinary Practices Among Per-service Teachers Kara Baldwin*, Illinois State University; Rebekka Gougis, Illinois State University [abstract #114]

Both the Next Generation Science Standards (NGSS) and the Common Core State Standards for Mathematics (CCSSM) highlight the importance of disciplinary practices of science and mathematics. The disciplinary practices outlined in the standards provide a framework that focuses on engaging students in behaviors typical of mathematicians and scientists in order to develop conceptual understanding. In the wake of these reform documents, developing an understanding of the scientific and mathematics practices is essential for teachers to be effective. Because disciplinary practices are interwoven into the framework of the standards, it is reasonable to consider teacher understanding within the disciplinary practices. With limited research studies on disciplinary practices, this study uses interview data to consider pre-service teacher understanding of disciplinary practices prior to the bulk of their teacher education coursework. Pre-service teachers enter into teaching coursework with experience-based understandings of disciplinary practices. Participants had a strong understanding of the importance of questioning in science and the process of analyzing data to create meaning. Other practices were often conflated by the participants (e.g. modeling and investigations; evaluating and analysis). This research is ongoing; however, it has already revealed misunderstandings that could easily be addressed though instructional intervention to enhance pre-service teacher understanding of disciplinary practices.

Poster #90 Does exposure to primary scientific literature affect how students develop hypotheses? Sreyasi Biswas*, Rice University [abstract #125]

It has been well documented that the use of primary source of literature in undergraduate classes have a positive effect on science literacy, critical thinking abilities as well as future transitions of students to doctoral programs. A major aspect of scientific training involves training students in developing testable hypotheses. A body of work has shown that introducing students to primary literature early on improves student's ability to develop hypotheses in sciences. However, in the real world, students are constantly exposed to secondary sources of information be it biology or world politics. We wanted to evaluate if exposure to only secondary sources of literature affects how students develop hypotheses compared to if they are exposed to primary sources of literature. The results from this study are important to highlight whether primary sources are indeed necessary to train students in hypotheses development. We conducted this study in our lab course for ecology and evolutionary biology where every semester we take advantage of the popular squirrel populations on campus to introduce students to the basic foundation of scientific thinking by providing them with information/data about the squirrels on campus through secondary sources, giving students a day for observation of squirrel behavior followed by developing hypotheses based on their reading of sources and observations and finally designing experiments to test these hypotheses. In previous years, we have provided students with secondary sources of information on squirrel behavior and have data on type of hypotheses developed by students in those years. This year we introduced students to only primary sources of information and have collected data on hypotheses generated by students. In this study, we present our findings by comparing the diversity of hypotheses developed by students under the exposure to primary literature and exposure to secondary sources. We also conducted a survey to collect data on students' attitude towards primary and secondary sources of information and present our findings.

Poster #91 Visual Representations of Meiosis in Biology Textbooks Fail to Provide Important Conceptual Information Grace Elizabeth Dy, RIT; Kate Wright, Rochester Institute of Technology; Dina Newman*, RIT [abstract #126]

Despite its fundamental role in genetics and evolution, many students across all levels struggle to comprehend the process of meiosis. The DNA triangle framework outlines how mastery of meiosis requires students to understand and integrate the three levels of DNA - molecular, chromosomal, and informational. The chromosomal and informational levels are linked through the concept of ploidy, the informational and molecular levels through the concept of homology, and the molecular and chromosomal levels by mechanisms of homologous pairing. Previous work examined text-based descriptions of these essential concepts in introductory and upper level undergraduate textbooks, demonstrating that the molecular level was largely absent, particularly at the introductory level. In this study, we examined the visual representations in the same 15 textbooks to determine whether all levels of DNA were represented in the illustrations, and whether the linking concepts essential to understanding meiosis were explicitly presented to students. Across all levels of biology textbooks, nearly all the figures illustrated DNA on the chromosomal level and not a single textbook presented meiosis at the molecular level, demonstrating an imbalance in representation across the DNA triangle. Interestingly, 100% of representations of homology utilized the chromosomal level, while none used than the more appropriate molecular level (DNA sequence) and only 50% incorporated the informational (genetic content) level. Additional gaps were also detected in figures explaining mechanisms of homologous pairing, where only one introductory textbook made an explicit link to the molecular level, and no upper level textbooks focused on the molecular level. Representations that explain ploidy, especially from a non-chromosomal point of view were missing from most textbooks (80% contained chromosomal-based representations of ploidy and 30% included the information level). Overall, we observed that the visual representations of meiosis in textbooks do not fill in the gaps left by the narrative descriptions. These findings contribute to a better understanding of why so many students are left with a fragmented grasp of meiosis. The DNA triangle is a useful tool for educators to identify gaps in their lessons and curricula. Since typical textbook presentations of meiosis—both text and images—are deficient, educators should strive to make the connections more explicit when designing or supplementing their lessons.

Poster #92 Assessing Evolutionary Reasoning of Introductory Biology Students Sarah Spier*, University of Nebraska - Lincoln [abstract #134]

Accurate reasoning of evolutionary concepts is imperative for understanding important biological processes. However, many students leave their introductory biology courses with misconceptions about two evolutionary forces, natural selection and sexual selection. Studies of student misconceptions of natural selection have emphasized the role of survival, while neglecting sexual selection pressures, such as mate choice and reproductive potential. Natural and sexual selection can select for similar traits (e.g. both selecting for bright color in poison frogs), or they can oppose one another (e.g. sexual selection favors long tails in widowbirds, while natural selection favors short tails). It is important to understand how students are reasoning about the interaction between sexual selection and natural selection in evolutionary scenarios because these interactions can affect how organisms evolve. In semi-structured interviews with undergraduate biology students (n=15), we explored whether concurrent and opposing selection pressures from sexual selection and natural selection affect student reasoning of evolution. Prior to the interview, portion of the Concept Inventory of Natural Selection (CINS) was used to establish a baseline of student knowledge about natural selection. The interview introduced students to four ecological scenarios and asked them to explain the effects on fitness and the potential evolutionary implications. The survey and interview assessed students' ability to accurately incorporate components of evolution: sources of variation, inheritance, fitness, and changes over time. The misconceptions detected by the CINS were congruent with those detected by the interview. In both assessments, students related fitness to survival and described "need" as the source of trait changes. The interviews revealed more details about the misconceptions. In the scenario where natural and sexual selection were concurrent, each student did not address reproductive potential as a part of fitness unless prompted and did not describe sexual selection as a selection pressure. When natural selection and sexual selection were opposing one another, students mentioned reproduction immediately and included sexual selection in their reasoning. Additionally, when sexual selection and natural selection opposed one another, students included more of the evolutionary components required for an accurate, complete response. The results provide supportive evidence that when sexual and natural selection are opposing forces undergraduate introductory biology students display better evolutionary reasoning. This suggests that when instructors only include natural selection in instruction and assessment, they may not be challenging students to incorporate potential sexual selection pressures in their evolutionary reasoning. Utilizing scenarios where sexual selection and natural selection are opposing one another may improve student evolutionary reasoning.

Poster #93 Pushing the boundary to reveal student competence with graph choice and construction Elizabeth Suazo-Flores*, Purdue University; Aakanksha Angra, Georgia Institute of Technology; Stephanie Gardner, Purdue University [abstract #151]

Undergraduate science students are increasingly engaging in the practices of science as part of their coursework. Two of the essential practices of science are the analysis of data and the creation of visual representations of those data for exploration, interpretation, and communication to a broader audience. Research with K-16 learners has shown that students struggle with some of the necessary concepts and skills used in these practices. These include difficulties with understanding data, selecting relevant variables, understanding data and data manipulation, and choosing and creating graphs that appropriate for the data. In the context of undergraduate biology, students are increasingly given the opportunity to carry out investigations starting with posing a question through to presenting their findings. This will require that students create and use graphs to explore and summarize their data in a way that is aligned with their research question and/or hypothesis, which is something with which student struggle. In an effort to further define the areas of student competence and difficulty with graph choice and construction, we challenged students to create two different graphs from the same data set. In this study, we evaluated graphs created by 10 undergraduate biology students at a Midwestern research university. Participants were asked to work on a graphing task in a pen-and-paper think-aloud environment. There were two isomorphic biology scenarios assigned to the participants: two treatments, five time points, and three replicates within the context of an experiment. Participants were asked to graph any aspect of a given set of data in two different opportunities, which generated 20 graphs that are the units of analysis in this study. Graphs were evaluated using an evidence-based analytic rubric informed by the metarepresentational competence framework and the graphing and education literature. The analysis revealed that the most popular types of graphs were bar and line graphs. In general, all graphs created lacked of 1) descriptive titles, 2) appropriate intervals and range for the plotted data, 3) descriptions of sample size and type of data (i.e., whether is raw data or computed values), and 4) alignment with the research question or hypothesis under study. Further, many of the graphs (11 of 20 graphs) were difficult to quickly interpret due to the presence of too many plotted bars/lines. Most notably, several of students (4 of the 10) struggled to create a different type of graph with the data when prompted to create a second graph of the same data. For example, some of these students created the same graph type (e.g. bar graph), but plotted a subset of the entire dataset. This study confirms and augments previous studies and highlights the need for more explicit training and practice with data visualizations, specifically to promote knowledge of graph types and reasoning for graph choice.

Poster #94 When does knowledge get in the way of reasoning? A Learning Progression approach to evaluating students' physiology reasoning Emily Scott*, University of Washington; Jack Cerchiara, University of Washington; Mary Pat Wenderoth, University of Washington; Jennifer Doherty, University of Washington [abstract #157]

Using fundamental principles to reason about the natural world is a hallmark of scientific thinking. When these principles are combined with rich biological knowledge, students develop sophisticated reasoning frameworks that allow them to think deeply and productively about phenomena. However, assessing how students develop sophisticated reasoning frameworks can be challenging. Context-rich assessment items may solicit sophisticated reasoning from experienced students but: i) prohibit novice students from expressing their emerging ideas about biology, or ii) trigger intermediate students to provide elaborated system accounts devoid of principled reasoning. This suggests a need to develop complimentary assessment items that examine students' ideas across multiple developmental stages as they learn to use principles to explain the detailed workings of biological systems. In this study, we created "generic context" (GC) and "physiology context" (PC) constructed response assessment items designed to capture student reasoning as it matures through time. These items are part of a larger learning progression (LP) project describing how students develop sophisticated reasoning frameworks around the Conservation of Mass principle (i.e., mass balance) in the domain of physiology. GC items portray generic scenarios that describe the movement of a material into and out of a compartment (e.g., a cell in which "molecule AB" exits through a membrane channel where it is catabolized by an "enzyme"). PC items portray similar processes but are situated in a physiological context (e.g., the release of acetylcholine into the synapse where it is catabolized by acetylcholinesterase). We hypothesize that i) GC items will provide opportunities for novice students to exhibit mass balance reasoning, and ii) GC and PC items together will reveal whether or not intermediate students have mass balance ideas that are being obfuscated by their attention to content knowledge. We administered GC items to 50 novice students (in an entry-level biology course) and GC and PC items to 100 intermediate biology students (in the final course of the introductory biology series) at an R1 institution in the Pacific Northwest. We scored student responses using an LP-based rubric for mass balance. Our preliminary results showed that our GC item solicited mass balance ideas from 16% of novices examined. For intermediate students, 68% scored higher (i.e., used mass balance ideas) on the GC item than the PC item while only 11% scored higher on the PC item, suggesting many of these students subjugated principled reasoning when presented with context-rich items. These data suggest using a combination of GC and PC items successfully captures both novice and intermediate students' emerging principled reasoning as they learn detailed physiological knowledge.

Poster #95 Visualizing Biological Variation with Avida-ED to Shift Students from Transformational to Variational Understanding Cory Kohn*, Michigan State University; BEACON Center; Michael Wiser, BEACON Center for the Study of Evolution in Action; Louise Mead, Michigan State University; Robert Pennock, BEACON Center; Jim Smith, Michigan State University [abstract #166]

It is difficult for students of evolution to understand the importance of variation between individuals. Novices apply a transformational model, with evolution occurring by individuals in a population changing their "essence" over time, e.g. a moth population collectively becoming greyer each generation. The scientifically valid model is variationalism, in which variation between individuals is so important that evolution is defined by this change, e.g. a mutation creates a dark morph that becomes more frequent in the moth population due to genetic drift and/or natural selection. Because transformationalism is rooted in intuitive essentialist thinking, shifting to variational understanding is particularly challenging. Research has shown that instruction in evolutionary processes is insufficient; students must understand not only that variation exists between individuals but that this variation is consequential. Research-validated instructional and assessment materials addressing conceptual understanding of variation are lacking. In this study, we present our use of the digital evolution platform Avida-ED to explore transformational and variational understanding in undergraduate biology students. The digital organisms in Avida-ED provide a simplified evolutionary model that directly compares to biological organisms. Mutations lead to genotypic variation, which produces phenotypic variation and fitness differences. The Avida-ED platform also provides a powerful visualization of variationalism, as individual organisms, “Avidians,” can be color-coded by fitness, with sensitivity such that slight differences are apparent. Finally, Avida-ED provides students with the opportunity to carry out experiments in evolution in real time. Our hypothesis is that these features of Avida-ED will help students shift their understanding from a transformational to a variational model. Our course for non-life sciences STEM majors, Integrative Biology: From DNA to Populations, featured the Avida-ED lab curriculum, interactively presenting mutation, natural selection, and genetic drift. This experience included inquiry-based research in which students closely interacted with the evolutionary processes. Further, the lab was integrated with case studies emphasizing integrative thinking, exploring the evolution of a phenotype from its genotypic basis through its change in prevalence among individuals over time, providing biological context to analogize with Avida-ED. To assess transformational and variational reasoning we used a modified published assessment featuring the melanic moth example, described above. Here we present our work to determine the validity and reliability of this instrument for our population and present initial pre/post-test findings using a chi-squared significance test. Finally, we offer suggestions on incorporating course material to engage student understanding of variation, including integrative thinking and experimental evolution.

Poster #96 Mechanistic Reasoning Across Levels of a Learning Progression in Undergraduate Physiology Lauren Jescovitch*, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University; Mark Urban-Lurain, Michigan State University; Jack Cerchiara, University of Washington; Emily Scott, Univ. Washington; Jennifer Doherty, University of Washington [abstract #184]

Learning progressions (LPs) are frameworks which outline cognitive paths of students and can provide reference points for student progress. LPs are built using evidence about student reasoning collected by a complex and iterative routine of LP development, assessment item and rubric development, data collection, human coding and re-alignment of LPs. This project is currently developing LPs in undergraduate physiology focusing on how undergraduates use principle-based reasoning (PBR) when reasoning about flux. Rubrics associated with the LP categorize students that use PBR in upper levels of the LP. Mechanistic reasoning (MR) is a type of PBR in which students can reason with scientific explanation. Thus, our research question is to understand the extent and qualities of MR students engage in within different levels of the flux LP. To capture these characteristics, we applied a MR coding scheme developed by Russ et. al (2008). We chose this framework to identify different aspects of MR and allow a more fine-grained examination of PBR within the different levels of the LP. We chose to code aspects of MR into 6 of Russ et al.’s categories for: describing the target phenomenon, identifying setup conditions, identifying entities, identifying activities, identifying properties of entities, and identifying organization of entities. These categories were applied to 3 constructed response items related to the proposed flux LP. We coded a total of 180 student written responses, collected from a large, public university, that were distributed across all five levels of the LP. Preliminary data shows that across all 3 items, at least 92% of the students engage in MR by identifying entities and at least 90% of students identify properties of entities. Discrepancies in the occurrence of other types of MR can be classified by comparing across levels of the LP. On one item that has been scored for LP achievement, 70% of students at levels 1 and 2 of the LP could identify activities and 73% could identify organization of entities. In contrast, 100% of students at levels 3-5 of the LP could identify activities and 98% could identify organization of entities. Even though 100% of students could identify activities, the language used showed wide variety and ranged from “moved from higher to lower concentration”, “attracted or repelled”, “pushes/pulls”, “drives”, “will naturally flow”, “want to equalize”, etc. As this analysis progresses, we will be able to capture details of each category such as the specific activities identified within each level of the LP. These results provide support that the LP-aligned scoring for PBR is aligned with aspects of Russ et al's MR framework. Therefore, the MR described in the Russ et al. framework could be a potential way to identify analytical thinking to support our principle-based LP in physiology.

Poster #97 Probing Students' Mental Models about Structure-Function Relationships in the Cell Membrane Kamali Sripathi*, Michigan State University; Hailey Cockerill, Michigan State University; John Knapp, Michigan State University; Mark Urban-Lurain, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University [abstract #187]

Structure-function relationships have been identified as a Core Concept of biology education as described in "Vision and Change in Undergraduate Biology Education" (AAAS, 2011). These relationships are typically highlighted in proteins both in research and in the classroom. However, student understanding of structure-function relationships has been relatively unstudied in the context of the cell membrane and its components. Existing research focuses on diffusion or transport of small molecules across the membrane. Because we were interested in the unformed ways that students understand structure-function relationships in the cell membrane, we investigated our research questions through the framework of mental models (Forrester, 1971). 1) What are students' mental models about structure-function relationships among the cell membrane and its components? 2) How do students understand the underlying concepts of the mental models they describe? To answer these questions, we collected written responses to constructed response (CR) questions (n = 777) from undergraduate biology courses at two large public research universities in the US. We followed up with semi-structured interviews (n = 19) so that students could explain their mental models using spoken words, drawings and gestures. We characterized the student ideas in the CR responses using emergent coding to generate an analytic scoring rubric, and refined this rubric using themes from our interviews. Our analysis revealed subtler trends than expected. We found that students described their personal mental models with a combination of analogies and intuitive types of thinking. Our preliminary results indicate that students often engaged in anthropomorphic thinking (e.g., "...phospholipids want…") when reasoning about interactions with other molecules (e.g., other phospholipids, water, etc.). Such language has been extensively investigated in biology and chemistry education literature, among other literature bases. Students also stated axioms as essential properties (intuitive "essentialist" thinking, Coley and Tanner, 2012) from which to support their reasoning about phospholipid interactions, such as "Like attracts like…" We found that students initially used these less formal ways of description even if they were able to give more scientific explanations later on in the interview. Our findings elucidate student thinking about structure-function relationships in a relatively unstudied context in biology: that of the cell membrane. Additionally, they provide an important justification for research into instructor language in the classroom. These findings also have instructional implications in the following ways: 1) making clear distinctions in the classroom between analogy, axiom, and scientific explanation and 2) designing assessments (e.g., writing) and classroom activities (e.g., group discussion) that more deeply probe student mental models.

Poster #98 A Bayesian approach to understanding how students respond to multiple-choice and multiple-true-false questions Brian Couch*, University of Nebraska-Lincoln; Chad Brassil, University of Nebraska-Lincoln [abstract #191]

Within undergraduate science courses, instructors often assess student thinking using closed-ended question formats, such as multiple-choice (MC) and multiple-true-false (MTF), where students provide answers with respect to pre-determined response options. While MC and MTF questions both consist of a question stem followed by a series of options, MC questions require students to select just one answer, whereas MTF questions enable students to evaluate each option as either true or false. Thus, we aimed to address several research questions related to how well MC and MTF responses approximate the proportion of students that have complete, partial, or little understanding of the response options. We employed an experimental design in which identical questions were posed to students in both formats during the exams of a large introductory molecular biology course. We used Bayesian modeling to understand how responses in each format compared to inferred student thinking regarding the different options. Our data support a quantitative model in which students approach each question with varying degrees of comprehension, which we label as mastery, partial mastery, and informed reasoning. MTF responses more closely estimate the proportion of students inferred to have complete mastery of all the answer options as well as more accurately identify students holding misconceptions. The depth of instructional information elicited by MTF questions is demonstrated by the ability of MTF results to predict the MC results, but not vice-versa. We further discuss how MTF responses can be processed and interpreted by instructors. This Bayesian model supports the hypothesis that students approach multiple-choice and multiple-true-false questions with varying levels of understanding and demonstrates that the multiple-true-false format has a greater capacity to characterize student thinking regarding the various response options. This research provides guidance for instructors and researchers interested in using closed-ended question formats to diagnose student conceptions.

Poster #99 Insights into model-based reasoning skills of introductory biology students
Konnor Brennan*, Elena Bray-Speth, Saint Louis University [abstract #195]

Biologists routinely interpret, generate, and evaluate visuals and models to communicate their findings and understanding of how living systems work. To align education with this practice, instructors are being encouraged to promote visual literacy and modeling competencies in STEM students, by incorporating model-based reasoning into their curricula. In the context of an introductory biology course for majors where instructors incorporate frequent modeling activities, we aim to investigate: 1) whether students use provided models as sources of evidence to generate claims backed by reasoning and 2) to what extent student-generated models are consistent with the understandings students demonstrate in other, related, questions on exams. The data collected for this analysis were exams from two sections of a large enrollment introductory biology class for STEM and pre-health students (n=240) where modeling is an overt practice and a learning outcome. Three unit exams and one cumulative final exam contained a variety of model-based questions, essentially of two kinds: (a) questions that provided a model and asked students to interpret it and, (b) questions that required students to generate a model. Both question types were either scaffolded or followed by additional short-answer question items intended, respectively, to guide students' model development or to further probe their understanding of a provided model. Consistent with our hypothesis that student-generated models are accurate representations of their understanding, we expected to find little to no discrepancy between their models and other answers on exams. We developed and used rubrics to code related sets of models and short answers for correctness and internal consistency. Preliminary analysis indicates distinct patterns in students' model-based reasoning. When asked to reason with a provided model (DNA replication), 82% of students correctly identified the function of the model, but only 58% explicitly mentioned model elements as evidence. Interestingly, 18% of students based their reasoning on evidence that was not present in the model. One possible reason for this is that students may not be using the model as a source of evidence, rather they use facts they have memorized and try to fit these retrospectively onto a given model. When asked to generate a model of how gene expression leads to a phenotype, students produced models that were largely consistent with what they had answered in scaffolding questions leading up to model construction. While 78% of the students, for example, developed models showing as an outcome the phenotype they had identified in writing before drawing the model, we found that 22% of student models revealed inconsistencies with their claims. We hypothesize that this kind of discrepancies may be due to students demonstrating procedural display when generating models, and failing to connect conceptually their drawings to their understanding.

Poster #100 Is there a time for telling and a time for failing in biochemistry? Instructional Design Approaches for Teaching Noncovalent Interactions Stephanie Halmo*, University of Georgia; Logan Fiorella, University of Georgia; Cheryl Sensibaugh, University of Georgia; Paula Lemons, University of Georgia [abstract #218]

Students struggle to understand the physical basis of noncovalent interactions in the context of chemistry and biochemistry. Our research goal is to develop instructional interventions that take into account students' specific difficulties with biochemistry problems, principles from cognitive science, and the context of undergraduate education. From the constructivist perspective, we know pure discovery learning through problem solving alone is not beneficial; some direct instruction or guidance is necessary. Cognitive load theory suggests worked example-problem pairs are optimal for learning due to limited working memory capacity. Alternatively, instructional design approaches in mathematics known as productive failure suggest that "failure" in the initial phase of instruction prepares students to learn from subsequent instruction. Finally, scaffolded problem solving is a popular instructional design where support is provided as needed and fades away as expertise is built. Interestingly, the literature lacks a head-to-head comparison of these three instructional design approaches, especially in the domain of biochemistry. This study investigates the following research questions: Among worked examples, productive failure, and scaffolded problem solving, which instructional design will improve biochemistry students' conceptual knowledge and support their knowledge transfer of the physical basis of noncovalent interactions? In Spring 2018, ~150 students from an introductory biology course at a research-intensive institution were recruited to participate in a one-hour lesson outside of class for extra credit in their course. Participants were randomly assigned to one of three instructional conditions: (1) a direct instruction approach where students were guided by the instructor through two worked examples and completed two problems on their own with no guidance, (2) a productive failure approach where students explored a set of two problems followed by instructor-led direct instruction of two worked examples, and (3) a guided inquiry approach where students worked through four problems with guidance from an instructor and peer learning assistants. Prior knowledge was equivalent in all groups. After completing the instructional phase, participants completed an assessment which included conceptual knowledge post-test items and transfer problems. Comparisons of mean conceptual knowledge gains and a comparison of mean transfer problem-solving performance between the three conditions were conducted. This work contributes to biology education research by refining the conditions for instructing students about macromolecular structure. The findings can be applied more broadly to problem solving in other domains that rely less on algorithms and more on conceptual understanding. The tested instructional design approaches will be of general interest to biology educators looking for ways to address student difficulties in their own classrooms.

Poster #101 Core Principles of Evolutionary Medicine Daniel Grunspan*, Arizona State University; Randolph Nesse, Arizona State University; Elizabeth Barnes, Arizona State University; Sara Brownell, Arizona State University [abstract #220]

Evolutionary Medicine (EvMed) is a young, but growing field, that applies modern evolutionary theory to understanding human health and medicine. A course in evolutionary medicine can increase the relevance of evolutionary theory to students, enrich biological understanding of disease, and provide a unique perspective on how evolution can affect human health and disease. A current impediment to developing evidence-based EvMed instruction is the lack of consensus on core principles – big ideas that are central to a field and broad in explanatory power. National recommendations suggest that instruction should focus on core principles. Thus, identifying the core principles of EvMed represents a foundational step for developing evidence-based curriculum. We used the Delphi method to elicit and validate a list of core principles for EvMed. This method utilized four surveys administered in sequence to 56 expert panelists. The initial open-ended survey created a list of possible core principles; the three subsequent surveys winnowed the list and assessed the accuracy and importance of each principle. Response rates to the surveys ranged from 50-66% of the 56 expert panelists. After the four surveys, we found fourteen core principles that elicited a consensus of at least 80% of the panelists agreeing that they were important core principles for EvMed. We report on these disciplinary core principles and areas where consensus lacked among panelists. These principles represent central ideas to construct learning goals for curriculum focused on evolutionary applications to human health and disease.

Poster #102 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 long, Michigan State University; Keenan Noyes, Michigan State University; Christina Schwarz, Michigan State University; Caleb Trujillo, Michgan State University; Jon Stoltzfus*, Michigan State University [abstract #221]

The fact that STEM programs have prerequisite course structures suggests students should apply what they learn in prerequisite courses to subsequent courses. Additionally, many undergraduate STEM education reforms are redesigning courses and curricula to focus on science practices, core disciplinary ideas, and crosscutting concepts. Therefore, there is a need to understand how students connect core ideas and science practices in linked STEM courses. In this study, we focus on the science practice of mechanistic explanation related to the core idea of structure and function in three linked STEM courses, chemistry (Chem 1), cell and molecular biology (Bio1), and organismal biology (Bio2). Mechanistic explanations involve reasoning systematically through underlying factors and relationships that give rise to phenomena and are an essential component of developing scientific models. Our main objectives for this research are to: (1) document patterns found in students' mechanistic explanations; (2) explore how the sophistication of students' mechanistic explanations of intermolecular forces from Chem1 influences their ability to explain protein structure and function in Bio1; and (3) explore how the sophistication of students' intermolecular forces and protein structure and function explanations influences their ability to explain phenotypic variation in Bio2. Our central hypothesis is 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 prompts and coding schemes for diagrammatic, model-based explanations of phenomena based on intermolecular forces, protein structure and function, and phenotypic variation. We used 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. These analyses reveal a wide range of sophistication in students' explanations that allow analysis of how students use ideas from one discipline to construct mechanistic explanations in other disciplines, identify gaps in student knowledge and shortcomings in knowledge application, and reveal roadblocks to mastery of science practices. Future plans include a cross-sectional study to establish if and how students use mechanistic explanation at different time points in an introductory STEM curriculum and explore 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.

Poster #103 Teaching for acceptance, how to teach evolution so students can accept, and a look into the factors that increase the likelihood of acceptance Clint Laidlaw*, Brigham Young University [abstract #240]

Biological evolution lends cohesiveness to the field of biology. When it is not accepted, biology becomes a loosely connected collection of facts to be memorized, repeated, and forgotten. Thus, if we are going to teach biology, it stands to reason that we should teach so that evolution, the unifying theory, can be accepted. One may even assume that acceptance should naturally accompany instruction, but that is not consistently true. So, what attributes of instruction make the difference? Using a single instructor at a single institution, we implemented a full factorial design testing the effects of active instruction vs lecture, constructivist teaching style vs behaviorist teaching style, and journaling vs not journaling to determine if the way that teachers present the content of their class can alter acceptance of evolution in their classes. We find that acceptance gains exceeding one standard deviation are possible utilizing any combination of the aforementioned teaching techniques. We also analyze the journals of students who did not accept evolution at the beginning of the semester to determine which concepts predict whether a student will continue to reject evolution or will accept it over the course of instruction. This information shines a light for instructors to see both how to teach, and what material to present, in order to maximize the likelihood of their students accepting evolution as a result of instruction.

Poster #104 Rapid response rubrics generate individualized feedback to improve student understanding of natural selection in large-enrollment courses Rachel Salter*, North Dakota State University; Jennifer Momsen, North Dakota State University [abstract #241]

Large-enrollment classrooms, typical of undergraduate education, require tools to provide timely feedback to both instructors and students. Rubrics are a common tool used for grading purposes in undergraduate classrooms and can also be a learning device for students by clarifying instructor expectations or telling students how they can build their conceptual knowledge. We sought to develop a rubric that could facilitate rapid and individualized feedback on constructed-response assessments related to evolution by natural selection, especially in large-enrollment classrooms. The rapid response rubric (3R) about evolution by natural selection is adapted from the Bishop & Anderson Diagnostic Instrument, as modified by Bray Speth et al. (2009). Student survey data from spring 2017 prompted us to make several changes to the 3R to address students' interpretation problems, including the addition of information to the fitness key principle to help students contextualize the information to various case studies. Our final rubric, developed and refined over several years, targets three key principles of natural selection: variation in a population, inheritance, and fitness, and depicts evolution as the outcome of those key principles. We also created instruction to scaffold students' use of the rubric, including peer- and self-evaluation activities. During spring 2017 and 2018, we used the 3R in an introductory biology course for science majors. Students (n=219, n=220) completed isomorphic constructed-response, ACORNS-style assessments pre- and post-instruction. Instructors used the 3R to provide rapid feedback (i.e., by the next class period) to students on three in-class activities. Students interacted with the rubric through three distinct activities: decoding feedback from the instructor on their in-class activities, providing peer feedback using the rubric during class, and coding their own pre-assessments. Finally, students completed a survey describing how the 3R contributed to their learning of natural selection. Analysis of pre- and post-assessment data from spring 2017 showed significant improvement on all key principles (McNemar test, all $p<0.01$). Qualitative analysis of in-class student artifacts showed that students' initial in-class responses were incomplete and highly variable. However, after use of the 3R intervention the majority of student responses include most of the key principles, demonstrating improved understanding of evolution by natural selection. Student surveys from both semesters report that the rubric language and structure were helpful and made instructor expectations clearer to the students. Supporting sustainable instructional practices is of critical importance as enrollments in introductory science courses continue to grow. Our rubric demonstrates one method instructors can use to employ constructed-response assessments while still providing rich, evidence-based feedback.

Poster #105 Vision & Change beyond the biology major: Designing a foundational biology course for engineers Jeffrey Klemens*, Thomas Jefferson University; Rajanikanth Vadigepalli, Thomas Jefferson University [abstract #262]

We were asked to design an introduction to the life sciences for engineering majors. The purpose of the course was to serve as a “crash course” in biology that would prepare students for a bioengineering specialization. The sequence would vary by student, and could include courses as varied as systems biology, bioinformatics, biomechanics, and medical device design. A major challenge was that a successful course would deliver a broad-based introduction to the field of biology while providing specific foundational knowledge for other courses in the sequence. To define learning outcomes we turned to the Vision & Change in Undergraduate Biology Education (V&C) core concepts. We created a matrix relating V&C core concepts to a set of assessable activities, which were themselves expressed in terms of V&C core competencies. As we developed the plan of activities, we worked backwards to define specific course learning outcomes. This resulting learning outcomes were: After completing this course, students will be able to: 1. Decompose and categorize the shared "building blocks" that are common to biological systems. Categorize the building blocks in terms of the levels of biological organization and diversity of structures and functions into which these building blocks can be recombined. 2. Describe a biological system in terms of flows of materials and energy. 3. Describe a biological system in terms of flows of information. 4. Given a biological system, describe that system in terms of relationships and interactions across levels of biological organization. As the competencies of modeling and computation were associated with many of our assessable items, we sequenced our learning activities such that modeling complexity would steadily progress as biological concepts were introduced. The four units of the course were thus designated "Building Blocks," "Mass and Energy," "Information," and "Integrative activities," with the final unit emphasizing models that cross multiple levels of biological organization. We will present evidence of student development as biological modelers throughout the course, particularly with respect to how, in our experience, that development differed compared to biology students of comparable year in school. Unsurprisingly, student engineers were immediately comfortable with quantitative descriptions of phenomena. On the other hand, they reported lower tolerance for non-hierarchical categories or ambiguity or overlap in nomenclature, and exhibited a preference for explanations that were explicitly grounded in physical or chemical interactions. Lessons learned from this course development process will inform redevelopment of an undergraduate biology curriculum, particularly with respect to the integration of systems biology concepts and modeling and computational competencies into the majors biology sequence.

Poster #106 Restructuring introductory biology to improve conceptual understanding of evolution Rachel Sparks*, Illinois State University; Alex Kew, Illinois State University; Rebekka Gougis, Illinois State University [abstract #99]

It is well-known that evolutionary theory is the foundation to all biological processes, including genetics, cell structure, biodiversity studies, and immunity, among many others. Given that evolution is such a central topic in biology, it is surprising that knowledge of evolutionary concepts is not retained long-term compared to other biological concepts, and that all groups of students exhibit deficits in evolutionary understanding. In fact, science teachers disagree about whether it is feasible and desirable to teach evolution at all, let alone as an overarching concept in biology. This discrepancy, in addition to methods of teaching, ultimately impact student understanding and lead to a number of misconceptions regarding evolution. Students' prior knowledge and experiences shape their cognitive structures, and as they are exposed to new knowledge, this information is incorporated into these preexisting conceptual frameworks. Based on the theory of conceptual change, naïve conceptions are deeply rooted within students' conceptual frameworks. Thus, course material needs to be made relevant to students' lives in order to access their conceptual framework and produce conceptual change; however, students rarely connect evolution to their daily lives. In this study, an introductory general education biology course was redesigned around six evolutionary themes considered critical to understanding evolutionary theory: variation, inheritance, adaptation, domestication, extinction, and speciation. This course used pedagogy structured according to the Teaching for Transformative Experiences in Science (TTES) model. The TTES model is based upon the view that quality science education should be connected to students' experiences, relating back to the theory of conceptual change. While this model was taught previously over a three-day intervention, this study utilized this model over the course of a full semester. Quantitative and qualitative data were collected throughout the semester in the TTES section and in a conventionally taught section of introductory biology. Student scores on pre-course and post-course assessments of conceptual knowledge were analyzed using a two-factor analysis of variance in order to determine the efficacy of the TTES model in increasing student understanding of evolution and the six themes considered essential to understanding evolution. This poster describes the results of these analyses and evaluates directions for future implementation of the TTES model.

Poster #107 Identifying and analyzing student ideas about the effects of a non-coding mutation Jenny Knight*, MCDB; Scott Sieke, University of Colorado Boulder; Betsy McIntosh, University of Colorado Boulder [abstract #197]

Understanding student ideas in large-enrollment biology courses can be challenging. Traditional multiple-choice questions offer a relatively simplistic view of students' understanding, often missing that students can have both correct and incorrect conceptions. As a part of the larger inter-disciplinary Automated Analysis of Constructed Responses (AACR) project, we have collected student answers to a question that asks about the effect of a mutation in a non-coding region of DNA. Although such a mutation should have no effect on transcription, nor on the sequence of the resulting mRNA, students have many incorrect ideas about its potential effects. Using an analytic rubric to identify different categories of student ideas, we have characterized answers from 1,127 students at three different institutions over five semesters, enrolled in eight different large-enrollment introductory biology courses. We hand-scored student answers, iteratively generating a computer model, which can now score answers with a mean Cohen's Kappa of 0.76 agreement with human coding. Student answers fall into three categories of correct ideas and five categories of incorrect ideas. Overall, 52.7% of student answers are completely correct, 36.4% are completely incorrect, and 10.9% contain both correct and incorrect ideas. By looking at individual student answers, we found that incorrect responses most commonly included identifying the non-coding mutation as a "frameshift mutation," and causing a "change in mRNA composition." To test whether student ideas change after instruction, we asked this question of introductory genetics students at two time-points: just prior to learning about mutations in non-coding regions (but after learning about mutations and gene expression) and just after implementing an activity designed to help students distinguish between the effects of mutations in different gene regions. In comparing 261 matched responses before and after instruction, we found that 82% of students maintained fully correct ideas, 30% maintained fully incorrect ideas, and 14% maintained mixed ideas. The remainder of students shifted to different ideas. 65% of students who initially answered incorrectly, shifted to correct, and 5% to mixed. Of those who initially answered mixed, 65% shifted to correct. We also saw an improvement in the sophistication of correct answers. Before instruction, only 5% of correct responses contained all 3 correct ideas, while after instruction, 14.6% of all responses contained these ideas. In particular, we saw an increase from 7% to 50% of all correct students expressing the idea that if the mutation occurred in an enhancer element, this could result in a change in the rate of transcription. Cumulatively these results show that a computer model can effectively characterize the many ideas students have when answering this question, and that students can improve their understanding of this concept with instruction.

Poster #108 Integrating Cognitive Load and Self-Regulation to Improve Student Performance in Undergraduate Science Courses Gretchen Geibel*, University of Colorado Boulder; Jenny Knight, University of Colorado, Boulder [abstract #150]

In the past several decades, cognitive load theory has become increasingly important in science education. The theory operates on the assumptions that students' working memory capacity is limited, and that this limited memory is best allocated for schema construction. To date, most cognitive load research has focused on instructional design, aiming to minimize extraneous load (working memory that is "wasted" on details unproductive to learning) so that working memory can instead be put towards a problem's content (intrinsic or "productive" load). While altered instructional materials can successfully limit extraneous cognitive load, many instructors may not be aware of cognitive load theory and/or may not design their instructional materials with cognitive load in mind. We suggest students can be taught to limit their experienced cognitive load by using self-regulatory behaviors such as metacognition to recognize when they are experiencing a high amount of extraneous cognitive load. Thus, we may be able to prompt them to refocus their attention on more productive, intrinsic aspects of the problem. To better characterize the interaction between self-regulatory fatigue and cognitive load, we are assessing how students enrolled in an introductory-level Genetics course experience both while solving challenging problems. Using the metacognitive self-regulation subscale from the Motivated Strategies for Learning Questionnaire (MSLQ) to assess self-regulation, and a published survey to measure cognitive load, we have collected data from students completing a problem-solving activity in a Genetics co-seminar course (four sections, with approximately 30 students enrolled in each section.) The students solved a challenging pedigree question involving the epigenetic phenomenon of imprinting, followed by the self-regulation and cognitive load surveys. Students then discussed the problem in small groups, from which we collected audio recordings. Following the group discussion, we collected individual cognitive load ratings again to assess how the group discussion impacted cognitive load. Additionally, the Registrar's office provided student demographic data, GPA, and predicted GPA, which we associated with the in-class data. We predict that students with high cognitive load will have lower performance on the imprinting question than their peers with lower cognitive load. We also predict that students with high cognitive load ratings but high self-regulatory capacity will outperform students with high cognitive load and lower self-regulatory capacity. If the above holds true, we can design an intervention that utilizes student self-regulatory skills (e.g., metacognition, cue utilization) to limit cognitive load, and potentially improve student performance in both a single class and over the course of a semester. Improving self-regulation could be essential in regulating students' cognitive load, and therefore increasing their learning potential.

Poster #109 A Tale of Two Assessments: A Case Study of Instructor Assessment Philosophy in an Introductory Biology Classroom Margaurete Romero*, University of

Tennessee; Ben England, The University of Tennessee; Beth Schussler, "University of Tennessee, Knoxville" [abstract #149]

An important part of the undergraduate classroom experience is assessment. In active learning classrooms, instructors implement in-class formative assessments (FA) to help students practice for their summative exams (SE). While there is research on instructor assessment practices, understanding why instructors create assessments the way they do is studied less often. Instructor beliefs about assessments (their assessment philosophy) are informed by personal experiences and can influence their classroom practices. Understanding an instructor's assessment philosophy may be a useful way to study assessment approaches. Our research used a case study of one instructor's class to ask two research questions: 1) what is the instructor's assessment philosophy? and 2) do the instructor's assessment practices align with this philosophy? We collected data from a large (N=230) cellular and molecular introductory biology course in Fall 2017. The instructor had taught the course multiple times, using active learning approaches such as clicker questions. To investigate the research questions, we collected 3 sources of data from the instructor: 1) an instructor interview, 2) clicker questions from the entire semester, and 3) exam questions from Exams 1 and 2. Interview analyses identified statements about assessment practices and used those to build an assessment philosophy profile. The assessment artifacts were analyzed by two researchers for percent multiple choice and short answer and Bloom's levels of questions. The philosophy and practices were then compared. In the interview, the instructor reported that she found short answer questions helpful for understanding how students think, but admitted that she still used a majority of multiple choice questions for ease of grading. Exam analysis confirmed that the majority of questions on her exams were multiple choice (20% short answer, 80% multiple choice). The instructor also felt that the use of multiple choice questions limited the Bloom's level of questions, which analysis of the clicker and exam questions confirmed. The proportion of Bloom levels for Exams 1 and 2, respectively, were: level 1: 0.22 and 0.29; level 2: 0.55 and 0.50; level 3: 0.13 and 0.17; level 4: 0.08 and 0.04]. The proportions for clickers were: level 1: 0.18; level 2: 0.49; level 3: 0.20; level 4: 0.11. Bloom's levels 5 and 6 were never observed in any artifact. The instructor also noted that formative assessment should be representative of what is on the exam. In order to test the alignment of clicker and exam questions, the distributions of their Bloom's codes were compared using a chi-square test of independence. The Bloom's distributions were not significantly different among exam 1, exam 2, or the clicker questions (Pearson chi-square p=0.78). Analyzing an instructor's assessment philosophy may be a useful tool to inform how professional development can enhance the instructor's classroom assessments for student learning.

Poster #110 A Qualitative Investigation of Biology Interest and Far-sighted Career Goals Effect on Students' Persistence in STEM career Pathways Ashley Rowland*, University of Colorado - Boulder; Katie Franks, University of Colorado at Boulder; Jia Shi, University of Colorado at Boulder; Sarah Eddy, Florida International University; Lisa Corwin, University of Colorado Boulder [abstract #13]

To be competitive for advanced STEM degrees or careers, students must achieve more than a high GPA; they must acquire numerous critical disciplinary experiences such as undergraduate research or volunteering. Based on multiple theories of motivation (e.g. Interest Development Theory, Expectancy-Value Theory, Social Cognitive Career Theory), we predict that students' access to these critical disciplinary experiences is influenced by the strength of their interest in a discipline and retention of specific career goals. However, students may enter college with weak to strong disciplinary interest and diffuse to specific career goals as a result of differential access to opportunities to develop interests and goals before college. This is problematic, as it may lead to inequities in the pursuit of and access to critical disciplinary experiences that enable progression to an advanced degree. Our study addresses how the timing of interest and career goal development influences students' access to critical disciplinary experiences and retention in STEM careers. To characterize the roles of interest and career goals in students' choices and paths, we are conducting retrospective interviews with late-stage or recently graduated undergraduate students that have sought admission to either medical or graduate school. We are deliberately recruiting students of diverse backgrounds (gender, race, ethnicity, socioeconomic status, etc.) to capture broad perspectives and experiences from their undergraduate education. By employing a unique interview tool called a LifeGrid, validated and primarily used in lifetime medical health research, we have produced timelines rich with descriptions of students' interest and career goal development surrounding their pursuit of and access to critical disciplinary experiences. The interviews and LifeGrid data elucidate 1) how early and how often students who advance to medical and graduate school begin to access critical experiences, 2) whether disciplinary interest and career goal development impact pursuit of critical experiences and maintenance of biology career goals in college, and 3) whether students unique identities and backgrounds influence their development of interests and/or career goals both before and during college. This work brings interest development theory and, for the first time, vocational development theory to bear on biology education research questions such as why biology professionals are not diversifying at the same rate as the undergraduate population. In addition, it emphasizes the retention of biology career goals as a measure of persistence, rather than the traditional measure: retention in the biology major. These findings will inform the design and deployment of effective interventions that target students, instructors, and/or institutional practices to address these issues.

Poster #111 Shaping Academic Success: How Declines in Motivation, Self-Efficacy, and Self-Regulation Influence Academic Performance in Introductory College Biology Students Erika Nadile*, University of Massachusetts, Lowell [abstract #34]

Research suggests that K-12 students with high self-efficacy and intrinsic motivation tend to be more academically driven in the classroom. At the college level, most studies explore the impact of only one social-psychological factor or explore multiple factors but only in the context of an intervention. Our study utilizes the Motivated Strategies for Learning Questionnaire (MSLQ) to measure extrinsic and intrinsic motivation, self-efficacy, and self-regulation in the context of varying demographics; this was completed at various time points in an introductory biology course without an intervention to better understand which factors generally contribute to academic. Based on preliminary findings, we hypothesized that A/B students would initially demonstrate higher extrinsic motivation and lower intrinsic motivation than C/D/F students. However, over the semester, A/B students would begin using more metacognitive strategies, resulting in increased intrinsic motivation (IM) and academic success; meanwhile, C/D/F students would recognize the need to improve grades, resulting in increased extrinsic motivation (EM). Furthermore, we hypothesized that first-generation college students would struggle more academically and also exhibit lower self-efficacy and self-regulation. Our cumulative (2015-2017) pre-survey results indicate that C/D/F students and A/B students were initially similar in self-efficacy, self-regulation as well as extrinsic and intrinsic motivation. However, by the end of the semester, C/D/F students exhibited statistically significant declines in each factor, respectively ($n=79$, $p<.001$; $n=79$, $p<.01$; $n=77$, $p<.05$; $n=77$, $p<.001$); conversely, A/B students maintained their levels in all of these factors. Furthermore, when comparing A/B to C/D/F students, we find that initially, they are comparable in both self-efficacy and self-regulation; however, due to the post-survey drop in both factors for C/D/F students, the post-survey difference is significant (self-efficacy: C/D/F ($n=79$), A/B ($n=117$), $p<.001$; self-regulation: C/D/F ($n=79$), A/B ($n=118$), $p<.001$). Additionally, while A/B and C/D/F students initially self-reported similar EM and IM, both groups of students were initially higher in EM than IM (A/B: ($n=120$), $p<0.001$; C/D/F: ($n=77$), $p=0.001$); however, because of the drop in both EM and IM for C/D/F students, the post-survey difference between them and A/B students is significant (A/B n=120; C/D/F n=77, EM p=0.003, IM p<0.001). Finally, preliminary demographic data suggests that those students whose parents didn't attend a four-year college (includes students whose parents attended community college) had lower self-efficacy than those students whose parents attended at least a four-year college. Together, our findings suggest that these factors, or a combination thereof, may play a crucial role in enhancing academic success in those undergraduate biology students who perform below average and who struggle academically.

Poster #112 Eliciting transformative experiences to integrate evolution into everyday thinking Rachel Sparks*, Illinois State University; Rebekka Gougis, Illinois State University [abstract #36]

Evolution is the basis for all biological processes and is the lens through which we understand the living world, and a comprehensive understanding of evolution is necessary to understand biology and to be a scientifically literate citizen. Scientifically literate citizens create an informed electorate, and evolutionary theory is the foundation for contentious topics such as conserving Earth's biodiversity, utilizing biotechnology in medical and agricultural settings, and understanding the gravitas of human-induced climate change, as well as others that individuals may encounter in their daily lives. Unfortunately, science teachers do not consistently teach evolution as an overarching concept in biology, if it is taught at all. Therefore, students often have a weak understanding of evolutionary theory and do not understand its importance in biology and in everyday life. Students enter introductory biology with certain conceptions about evolution that are often based on factors other than scientific evidence, such as exposure to science denial and anti-evolution positions, prior education, and personal beliefs. The theory of conceptual change asserts that naïve conceptions are deeply rooted within students' conceptual frameworks, which are shaped by these prior life experiences. In order to access and potentially change these naïve conceptions, course material needs to be made relevant to students' lives in order to prompt conceptual change. However, students rarely view evolution as an important topic in their lives, which prevents them from engaging in educational experiences that could change these naïve conceptions. In this study, an introductory general education biology course was redesigned around six evolutionary themes viewed as essential to comprehending evolutionary theory with pedagogy structured according to the Teaching for Transformative Experiences in Science (TTES) model. The TTES model is based upon the theory of conceptual change and uses transformative experiences to connect science content to students' lives. Transformative experiences occur when students actively use a concept in their lives, further understand an aspect of the world, and develop an appreciation for the content itself. In order to evaluate how students applied evolutionary concepts to their daily lives, the Transformative Experience Survey (TES) consisting of 18 Likert-scored items was administered at the conclusion of the course. A one-sample T-test shows that after the course, students apply evolutionary theory to their lives to a moderate degree, demonstrating that the TTES model can lead to a greater appreciation for evolution in non-biology majors. Written responses were also qualitatively analyzed to elucidate how evolutionary theory was applied in students' everyday lives, with responses demonstrating the success of the TTES model and providing insight into future incarnations of this curriculum and biology instruction as a whole.

Poster #113 Considering Coping: Different Student Coping Strategies for Different Active Learning Practices Beth Schussler*, "University of Tennessee, Knoxville"; Jennifer Brigati, Maryville College; Ben England, The University of Tennessee [abstract #70]

Although active learning definitively improves average student outcomes in STEM courses, these practices also cause anxiety in some students. According to the Control-Value Theory of Achievement Emotions, student emotions such as anxiety arise from experiences with the learning environment, and impact student achievement. Students with high anxiety are more likely to show lower course performance and persistence than students with lower anxiety. Social cognitive theory suggests that students can employ effective coping strategies to control the outcomes of academic emotions. We collected data on student anxiety and coping strategies in response to four active learning practices in introductory biology in order to examine the types and potential outcomes of these strategies. We hypothesized that 1) students use different coping strategies in response to anxiety caused by different active learning pedagogies, and 2) coping strategies differ by student anxiety level and final course grade. Students in six introductory biology courses in 2016-2017 were surveyed regarding 1) their level of anxiety (via Likert scale) in response to four active learning pedagogies (clickers, volunteering to answer a question, cold calling, and group work), and 2) the coping strategies (via open-ended responses) they used to manage this anxiety. Final course grades were matched to student responses with student consent. Coping strategies were independently sorted and then collaboratively reconciled by two researchers into categories established by Skinner et al. For clicker question anxiety, the most common coping strategy was information seeking (use notes or talk with peers) (Fall 54.9% of n= 215, Spring 53.9% of n = 141). For anxiety related to volunteering to answer a question, the most common coping strategy was escape (look down at notes or avoid eye contact) (Fall 44.9% of n = 285, Spring 50.6% of n= 253). For anxiety related to cold calling, the most common coping strategy was self-reliance (deep breathing or positive self-talk) (Fall 40.4% of n = 297, Spring 42.9% of n = 238), and for anxiety related to group work, coping was via support seeking (be social and helpful) (Fall 44.4% of n = 153, Spring 60.1% of n = 178). According to Skinner, three of the identified coping strategies are positive approaches (information seeking, self-reliance, and support seeking), while escape (volunteering to answer a question) is negative. Students with high anxiety were more likely to use negative coping strategies for clickers, cold calling, and group work than those with medium or low anxiety (Chi-square p values all < 0.001). Coping strategies did not differ based on course final grade (Chi-square p values all > 0.05). Research on the effectiveness of coping strategies to manage anxiety, or the extent to which modifying coping may help some students improve their grades, may further maximize the effectiveness of active learning in introductory biology classrooms.

Poster #114 What is the relationship between students' mindset, study habits and learning gain? Malin Hansen*, Red Deer College [abstract #84]

Students' mindset and attitudes towards learning are likely to affect their study habits and consequently their learning gain during a course. Therefore, in order to facilitate student learning, we need to gain a better understanding of our students' mindset, how it affects their study habits and engagement in course activities, and what we can do to foster a growth mindset. I hypothesized that students with a fixed mindset would be less likely to change their study habits when preforming poorly, than students with a growth mindset. Consequently, students with a fixed mindset may experience lower learning gain during a course. I used in-class self-reflective surveys to explore students' mindset and study habits in undergraduate biology courses. In the fall of 2017, I collected baseline data from 1st year biology majors (28 students). In the winter of 2018, I collected data from 1st and 2nd year non-majors as well as 1st year biology majors (106 students). The self-reflective survey was completed three times during the term during an in-class post-midterm reflective activity. The survey questions prompted students to reflect on: 1) their midterm result, 2) their current study habits, 3) their goal for the next exam, and 4) how to achieve that goal. The survey also included a number of Likert-scale questions that explored students' mindset, e.g. "I believe I can eventually get really good something that I am currently quite bad at" and "When something is difficult, I get motivated to work harder." Preliminary analysis of data (28 students) suggests that while overall, 96% of the students believe they can become good at something they are quite bad at, only

38% are likely to increase their effort when something becomes difficult. Out of students with a "growth mindset" (based on the survey results), 71% reported that they are likely to change their study habits when receiving poor results, while only 36% out of students with a "fixed mindset" said they are likely to do so. In addition, students with a "growth mindset" had better class attendance (95% vs. 80%), more diligently completed pre-class assignments (82% vs. 67%) and had higher participation in exam preparation activities (83% vs. 52%). Students with a "growth mindset" also performed better on their first midterm (80% vs. 69%) and finished their course with a higher average grade (80% vs. 66%). Finally, students with a "growth mindset" experienced a higher learning gain [(calculated as a relative learning gain (final exam-midterm 1)/(100-midterm 1)] (12% vs. 3%), although the numbers of students in this preliminary analysis was too low to determine whether there was a significant difference. A better understanding of how students' mindset affects their study habits and learning allows educators to design learning activities that aims to shift students' mindset. Implementation of such activities could have a drastic effect on the success of many undergraduate students.

Poster #115 Effects of Discovery Academy on Middle School Female STEM Interest and Careers Kara Baldwin*, Rebekka Gougis, Illinois State University [abstract #116]

Females are underrepresented in science, technology, engineering, and mathematics (STEM) occupations (Landivar, 2013). Only 20 percent of completed bachelor degrees in STEM fields are awarded to women (Hill, Corbett, & St Rose, 2010). These gaps extend into the workforce, with small percentages of women working in STEM fields, especially physics and engineering (Beede et al., 2011; Hill, Corbett, & St Rose, 2010; Goodfield Research Group, 2002; National Science Foundation (NSF), 2014). Research has focused on potential reasons for the gender gap, including the level of support for female students at the collegiate level; disinterest in STEM fields; family responsibility; implicit bias; and lack of female mentors within their field (Hill, Corbett, & St Rose, 2010; Goodfield Research Group, 2002). Discovery Academy, a two-week STEM summer camp, may provide an avenue to build female student interest in STEM. This study utilized student surveys to evaluate the impacts of a two-week camp intervention on middle school females' interest in STEM and awareness of STEM careers. Analysis revealed no statistically significant gender differences between pre-camp and post-camp attitudes toward STEM. However, write-in survey questions revealed interesting patterns: Middle school students attending Discovery Academy are already interested in STEM careers; career exploration within Discovery Academy may decrease the number of "I don't know" responses on the post-camp survey; and Discovery Academy may increase the specificity of career choice. More data will be collected the summer of 2018 to explore these patterns.

Poster #116 What happens when you remove grade motivation from an upper-division biology course? Maybe not what you'd expect… Andrea Nicholas*, UCI [abstract #147]

At what point do grades become irrelevant or even limit student investment in course content? Should some active upper-division lecture classes intentionally provide an experience that forgoes exam-based assessments? Team-based learning facilitates a well-documented increase in motivation and productivity in students. A better understanding of the principles behind the increases in student engagement and output that accompany group work would give instructors the ability to structure group activities in a way that would maximize students' productivity. There is a growing body of evidence suggesting that grading is not a powerful motivator of student achievement and grading may inhibit students reaching their full academic potential in upper-division courses. To explore these areas, we structured a class of 60 upper-division biology students in a year-long (three quarter) pre-medical course such that grading pressure would be removed and all work would be group-based. An overall GPA of 2.5 was required to join the series, thus the course was not solely comprised of high-achieving students. Students were assigned to groups to complete weekly gamified writing assignments. In addition, each group was required to design and lead gamified case-based learning experiences. Exams were also gamified and group-based. The instructor provided detailed and critical feedback on all written assignments and asked for corrections to be made, but scored generously. All turned in assignments and feedback could be seen by the entire class. Students also used rubrics to rate each other's presentations. We never defined where the bar should be set, and thus left the level of achievement wide open. Previous studies have documented two strong motivators of social behavior at opposite ends of the spectrum: altruism and anxiety. We wanted to explore whether one or both of these emotions is responsible for the motivation and productivity that results from group work. We created a series of survey questions that employed a self vs. other format with 1-9 scaled responses, for example: "I want my classmates to succeed" AND "My classmates want me to succeed." By Winter quarter, students had far surpassed both the quantity and quality of work predicted. We hypothesized that it was not grades, but peer pressure and competitive drive that motivated students to go beyond what was "required" of them. We analyzed both quality of work, peer grading and survey results over the year. Our findings suggest that anxiety may be a stronger motivator for student performance than altruism.

Poster #117 Student learning dispositions: Moving beyond the "average student" and exploring individual differences among undergraduate honors thesis writers Leslie Schiff*, University of Minnesota-Twin Cities; Julie Reynolds, Duke Universtiy; Jason Dowd, Duke University; Robert Thompson, Duke University [abstract #181]

Research suggests that various personal dimensions of students—particularly motivation, self-efficacy beliefs, and epistemic beliefs—can change in response to teaching and affect student learning. What has been lacking, however, are conceptual perspectives and methodological approaches to consider the simultaneous contribution of these personal dimensions. In this work, we address this gap in the domain of disciplinary writing. There is increasing evidence that pedagogical practices that incorporate writing foster the development of a wide range of skills and types of knowledge. Writing affords one of the most effective means for making thinking visible and learning how to "think like" and "write like" disciplinary experts. We consider the dimensions of student characteristics listed above to be representative of their learning dispositions with respect to writing. This approach allows us to go beyond simple changes in averages along single dimensions and build a more sophisticated understanding of students as complex, multidimensional learners. Our development and analysis of student learning dispositions has taken place at four institutions (Duke University, Morgan State University, University of Minnesota [Twin Cities], and University of North Carolina [Chapel Hill]) in six capstone courses supporting STEM students (Biology, Chemistry and Neuroscience), providing a diversity of student characteristics, course contexts, and institutional settings. We focus on the genre of the undergraduate honors thesis as the rhetorical context in which to study scientific reasoning and writing because we view the process of writing an undergraduate honors thesis as a form of professional development in the sciences (i.e., a way of engaging students in the practices of a community of discourse). We have previously found that structured capstone courses designed both to scaffold the undergraduate thesis-writing process and to promote metacognition can promote critical thinking skills and improve writing and reasoning skills in biology, chemistry, and economics. Here, we expand these research efforts by uncovering and defining student dispositions to capture individual differences in the development of scientific identity. Survey results indicate that while, on average, participating in a capstone support course leads to an increase in self-efficacy beliefs about writing and science, a shift towards mastery-driven motivation, and no change in epistemic beliefs, that individual students exhibit a range of views and beliefs. When student responses on all of the dimensions were analyzed simultaneously using cluster analysis, several distinct, coherent learning dispositions emerged. We explore these profiles in this work, and discuss the implications of this framework for describing developmental trajectories of students' scientific identities.

Poster #118 How should I be addressed? Factors influencing instructor preferences for how they want students to address them Jacqueline Cala*, Arizona State University [abstract #183]

Instructor immediacy, the psychological closeness between students and instructors, has been shown to positively affect students' affective experience and cognitive learning. One way in which instructors can increase their immediacy is to use their first name as opposed to using the title of Dr. However, how instructors make the decision of whether to use their first name or a title in the classroom and to what extent is this based on their perceptions of possible impacts on students is unknown. To explore the decisions of instructors in how they wish to be addressed in the classroom, we used the theoretical framework of expectancy value theory. Using this lens of expectancy value theory, we hypothesize that instructors of undergraduate courses are weighing the value and the cost of using either their first name or Dr. when deciding what they prefer students call them. In this exploratory study, we set out to identify how instructors are choosing to be addressed in the undergraduate classroom, and what factors are influencing those decisions. We interviewed over 20 instructors teaching undergraduate courses at large R1 institutions and asked them how they choose to be addressed in the classroom, and why. Interviews were transcribed and a combination of grounded theory and content analysis was used to code the interviews. We identified that most instructors choose to be addressed by a formal title as opposed to their first name. Notably, it seemed many instructors had not deeply thought about their term of address as far as costs and benefits, but suggested they chose to be addressed by their title to mirror academic culture and their perceptions of what typical instructors do. However, some female instructors intentionally chose to be addressed by their title in an effort to establish professional boundaries between themselves and the students and are worried about the relationships between students and themselves as being too casual if they used their first name. Some male instructors reported going by Dr. to establish authority, but no male instructors mentioned being worried about losing that professional boundary between students and themselves if they went by their first name. A few instructors chose to be addressed by their first name in an effort to increase their perceived immediacy. These preliminary data suggest that some instructors are evaluating the cost and benefit of their term of address in the undergraduate classroom, but many instructors are not deeply considering the significance of their title on their relationships with students. Additional interviews are ongoing, and these data will inform a larger study that will explore differences in the factors that influences the decision of how instructors choose to be addressed in the undergraduate classroom based on instructor gender, age, and status at the university.

Poster #119 More than course content: student values, attitudes and beliefs in an introductory science course Laura Beaster-Jones*, University of California-Merced [abstract #202]

The future of science has much to gain by increasing the diversity of thought and ideas into scientific approaches to problems; however many students including first-generation and underrepresented minorities (URM) can struggle in gateway science courses. To retain a greater diversity of students we need to gain a better understanding of their affect or their interests and motivations in introductory science courses. Drawing on the sociocognitive theoretical frameworks of self-efficacy and motivation proposed by Bandura and self-regulated learning by Zimmerman, we seek to recognize how students develop and maintain awareness and control of their learning. With an undergraduate population that is 71% first generation and 57% URM, we are well positioned to contribute to the future of science at our public mid-size institution. However, a recent analysis of the academic path of intended biology majors at our institution revealed that 22% of intended majors switched out of the major. In an effort to explore student interests and motivations in an introductory biology course, we assigned a values affirmation writing exercise, surveyed attitudes about writing, and surveyed views and expressions of self-efficacy at the beginning and the end of the course. We used grounded theory methodology to evaluate student writing about values affirmation and self-efficacy. Initial coding from the values affirmation data has revealed that the most important values to our students are their relationships with family and friends and learning or gaining knowledge. When students describe why their family and friends are important they refer to the support, motivation, and security they receive from these relationships and that they believe interactions with others will help push them to succeed. They describe that they are motivated to learn and gain knowledge in order to expand their understanding of the world, reach their goals and have more opportunities than their parents or relatives. The surveys regarding attitudes about writing reveal that students believe writing is a valuable study skill that will help them professionally and personally, but they are less convinced that writing is important in a science class or will help them think like a scientist. Preliminary coding of the self-efficacy statements has revealed evidence of positive affect, students express their interest and curiosity about biology, but there is less evidence of efficacy, students are unsure about how to manage time or ask for help. This work contributes additional insight into student interests and motivations. Instructors who recognize that the introductory classroom is more than a space to distribute course content can use student affect to establish positive self-efficacy and metacognitive skills early in a college career. This awareness can help increase student self-expectations and engagement in class may also have a positive impact on student retention.

Poster #120 Undergraduates' resistance to inductive teaching Lauren Kelly, Oberlin College; Marcelo Vinces, Oberlin College; Pam Snyder, Oberlin College; Taylor Allen*, Oberlin College [abstract #229]

Giving rise to this project were assessment data revealing weak multivariable causal reasoning and shallow learning approaches among fourth-year undergraduates beginning a physiology course at a selective baccalaureate college. These data prompted incorporation of hybrid project/problem-based learning (hybrid PBL) into a section of introductory biology. As a way to target multivariable reasoning, the hybrid PBL included production of causal loop diagrams. Like other inquiry-based, inductive approaches, hybrid PBL is believed to nurture reasoning skills, as well as deep motivations and strategies; yet, strong student resistance to hybrid PBL is reported in the literature. Understanding the origins of this resistance was the goal of the project, which relied on qualitative content analysis of students' written comments at semester's middle and end. To elucidate origins of students' resistance, the project progressed through three phases, each with a different offering of introductory biology. In the first, students' comments on end-of-semester ratings of teaching were analyzed. Emergent negative themes were that the course broke from expectations (codes included "insufficient memorization") and lacked an orderly flow of topics (codes included "jumping around"). Positive themes related to deep learning and a supportive learning environment. In phase two, students' mid-semester reflections were analyzed: students were prompted to view the course as a travel- or study-abroad experience and then to use a four-stage model of cultural adaptation to explain their place in the process of adapting to active-learning, hybrid PBL. Expressed by students experiencing culture shock to hybrid PBL and attendant frustration, negative themes related to discomfort: a longing for “facts” and linear presentation of material; worry about the absence of memorization of foundational material; and anxiety about speaking in class. Positive themes emerged from comments of those students who progressed beyond hybrid-PBL culture shock to the stages of adjustment or acceptance/adaptation: themes highlighted appreciation for the rich, deep understanding elicited by the course, as well as an ability to see peers as fellow learners and collaborators. In phase three of the project, currently underway, analysis is being made of similar cultural-adaptation reflections at semester's middle and end, with students additionally encouraged to offer at both time points advice to students stuck in the stage of culture shock.

This phase also introduces between the two time points a dual-purpose intervention: at one class session, students study examples including hybrid PBL in which expectations – social, cultural, scientific – have hindered acceptance of evidence-based ideas. It is hypothesized that this intervention can advance students' understanding of the social and cultural embeddedness of science as well as their progress towards adapting to hybrid PBL.

Poster #121 To be funny or not to be funny: Gender differences in student perceptions of instructor humor in college science courses Katelyn Cooper*, Arizona State University; Taija Hendrix, Arizona State University; Sara Brownell, Arizona State University [abstract #248]

For over 50 years instructor humor has been recognized as a way to positively impact student cognitive and affective learning. However, no study has explored humor exclusively in the context of college science courses, which have the reputation of being difficult and boring. The majority of studies that explore humor have assumed that students perceive instructor humor to be funny, yet students likely perceive some instructor humor as unfunny or offensive. Further, evidence suggests that women perceive certain subjects to be more offensive than men, yet we do not know what impact this may have on the experience of women in the classroom. To address these gaps in the literature, we surveyed students across 25 different college science courses about their perceptions of instructor humor in college science classes, which yielded 1637 student responses. Open-coding methods were used to analyze student responses to a question about why students appreciate humor. Multinomial regression was used to identify whether there are gender differences in the extent to which funny, unfunny, and offensive humor influence student attention to course content, instructor relatability, and student sense of belonging. Logistic regression was used to examine gender differences in what subjects students find funny and offensive when joked about by college science instructors. Nearly 99% of students reported that they appreciate instructor humor and reported that it positively changes the classroom atmosphere, improves student experiences during class, and enhances the student-instructor relationship. We found that funny humor tends to increase student attention to course content, instructor relatability, and student sense of belonging. Conversely, offensive humor tends to decrease instructor relatability and student sense of belonging. Lastly, we identified subjects that males were more likely to find funny and females were more likely to find offensive if a college science instructor were to joke about them. We hope these data can be used to create more funny and inclusive college science classes.

Poster #122 Comparison of Student Learning Gains using Open Education Resources versus a Traditional Online Biology Textbook Chrissy Spencer*, Georgia Institute of Technology; Aakanksha Angra, Georgia Institute of Technology [abstract #256]

Open Education Resources (OERs) are low- or no-cost classroom educational materials. For any learning resource, students and faculty consider cost to student, learning outcomes, usage, and perception of the quality and accuracy of the resource by both student and faculty. To date, research on OER efficacy emphasizes student and faculty self-reported usage and perception surveys. No studies to date make a direct comparison between the open education and traditional resources by the same student in a controlled reciprocal design. We addressed this gap in the literature by directly comparing the same students on OER versus traditional textbook usage, student learning outcomes, and perceptions of the resource. Over the past three years, the introductory biology courses at our R1 university have transitioned from traditional biology textbooks to a no-cost online textbook developed by faculty and structured around learning objectives. Previous research from our group (in preparation) on the transition from traditional to open education resources concurs with the existing literature that shows no statistical difference in academic achievement of students after the switch to OER. To expand the literature on OER efficacy, we explored learning gains in a direct comparison of study participants using traditional and OER alternatively. We recruited undergraduate students (n=40) who had not taken or received credit for college-level biology and randomly assigned them to treatment sequences of exposure to OER material followed by the traditional textbook or vice versa. Students were exposed to two different biological scenarios, also in a predetermined random order, with a different scenario for each resource type. Participants completed a reading quiz while taking reading notes, drew from memory their interpretation of relevant biological concepts from a prompt, and completed a think aloud interview. The output was coded using inductive and deductive methods for comparison between the treatments. Initial findings revealed that students spend less time answering reading questions from an OER textbook, while answering more questions correctly. This research will enrich the OER literature on usage, learning outcomes, and user perceptions. Evidence surrounding OER costs, outcomes, usages, and perceptions serves as a valuable incentive for faculty waiting for stronger evidence before considering an OER textbook intervention.

Poster #123 Writing impacts on self-efficacy and managing stress in an upper-level STEM lab course Beverly Smith-Keiling*, University of Minnesota; Sabrina Ratsamy, University of Minnesota; Kamilla Ruppman, University of Minnesota; Joanne Dehnbostel, University of Minnesota; Lidia Swanson, University of Minnesota; Melissa Seiberlich, University of Minnesota [abstract #259]

Stress is common among undergraduate students. When not managed, it may trigger individual feelings of helplessness and trigger Mental, Emotional and Behavioral Disorders (MEB-D). One in three students has a mental health diagnosis. Potential educational interventions in curriculum and policy changes can help reduce stress but also metacognitively help students manage stress. Using mixed-methods analysis, we compared baseline data from an initial course T0 to iterative T1, T2, T3 semester intervention outcomes from a writing-intensive, upper-division biochemistry lab student population within Social Cognitive Theory conceptual framework and self-efficacy influences within the Social Ecological Model. Writing-based curricular interventions of expressive, reflective, and a final post-course free response were used to increase meaning-based coping for managing stress. Other interventions aimed to decrease stress, increase self-efficacy, and build a metacognitive approach to manage stress. Others focused on advocating for policy changes through a stepwise process. Based on our hypothesis, students who wrote expressively or formulated reflective personal statements to critically think about their post-graduation futures would exhibit increased confidence, decreased stress and increased ability to manage stress. Early results suggested that certain expressive writing prompts could induce stress. However, options to write expressively as part of the personal statement writing process provoked more productive results. Descriptive demographics gender, age, ethnicity, English language learner (ELL), and first generation (FG) status were examined and analyzed. Student self-reported Likert scale mean comparisons of pre/post-surveys reported higher confidence in males (than non-males), higher stress levels amongst underrepresented groups, and potentially greater benefits of interventions for underrepresented students. Males, Asians, ELL, and FG students reported that writing personal statements “helped focus their futures” more compared to their counterparts. Quantitative coding with Pennebaker’s Linguistic Inquiry Word Count (LIWC) for semantic analysis of student expressive reflections, personal statements, and a post-course free response, measured several variables for cognitions and psychosocial patterns. Tracking student stress through course iterations using our own qualitative quasi-deductive, open-coding method identified reduction in some classroom and institutional sources of student stress. This exploratory ecologic study of iterative semesters supported some interventions increased confidence. Some reduced stress e.g. shifted deadlines for workload and time constraints. Some interventions may have increased metacognitive ability to manage stress, evidenced by writing, but still under development. Some interventions, such as personal statement writing, were suggested to be more beneficial to specific underrepresented demographics and are ongoing.

Poster #124 Utilizing document based questions (DBQs) in undergraduate biology courses Pablo Chialvo*, Lander University [abstract #2]

The ability to effectively communicate scientific information via writing is considered a critical skill to develop in students and has been promoted in modern educational initiatives as well as teaching organizations. Pedagogical research fully supports the inclusion of writing in science courses, as it can greatly enhance student learning. Thankfully for today's instructors, there are many types of writing assignments to use aside from traditional lab reports, including blogs, portfolios, and multi-genre research papers. One format that has not been widely utilized in the life sciences, however, is the Document-Based Question. The Document-Based Question (DBQ) is a standard component of the Advanced Placement (AP) history exams in which students are asked to write a cohesive essay using a variety of primary and secondary sources (e.g. quotes, maps, charts, etc.) pertaining to a specific time period or event. Students are required to evaluate the documents for potential bias, place them in the greater historical context, and provide additional background information in order to develop a robust argument. From a pedagogical viewpoint, the questions are an authentic assessment of critical thinking and interdisciplinary skills. In this study, I present a series of DBQs that have been tested over multiple semesters in a general biology course. The writing assignments cover a variety of major topics (e.g., cell biology, Mendelian genetics, evolution, and ecology) and utilize a variety of different documents (e.g., charts, article excerpts, data tables, etc). Furthermore, they have been specifically developed to emphasize core competencies such as the ability to apply the process science, quantitative reasoning, and effective communication. Initial feedback has been generally positive. Students enjoy the opportunity to apply lecture material in a more open-ended format than typical essays or reports. They have also noted that the DBQs are an effective tool for reviewing key concepts and preparing for exams.

Poster #125 Jigsaw Method Improves Learning and Performance for Observation-Based Undergraduate Biology Laboratory Activities Erica Baken*, Iowa State University; Michael Rentz, Iowa State University; Dean Adams, Iowa State University [abstract #8]

Some topics in biology do not easily lend themselves to experiment-based laboratory activities. This means topics such as comparative anatomy, evolution, and systematics are often taught as observation-based laboratories which can be un-engaging and passive. The Jigsaw method has been implemented in many biology experiment-based laboratory settings, but the utility of the Jigsaw method in improving of engagement and learning in observation-based laboratories has yet to be studied. We describe an instructional Jigsaw method for teaching observation-based biology laboratories by engaging students in interdependent learning. We report increased learning in experimental versus control sections, demonstrating the efficacy of the proposed Team-Based-Learning method in non-experimental biology laboratory activities.

Poster #126 The effect of required homework on student performances in flipped immunology class Ahrom Kim*, Michigan State University [abstract #24]

Many flipped classes are designed in a way that requires students to learn course materials prior to a class session. This allows for the class time to be used for active learning exercises. There are many different ways to introduce content to students, including utilizing textbooks and videos. In our course, we provided reading guides related to specific learning objectives that students were expected to complete before class. However, many students did not utilize these guides when points were not assigned. To determine whether assigning points to learning objectives is associated with increased performance, we compared and surveyed students from two different sections; one with graded homework and one without. The results indicated that greater than 80% of students completed the homework before class when one point was assigned. This additionally positively correlated with student engagement during in-class discussions and activities. These results suggest that as little as one point for pre-class homework may help students stay motivated and thus result in improved performances in class.

Poster #127 Creating Opportunities for Student Learning in Large Undergraduate STEM Courses by Making Use of an Effective Instructional Team Katelyn Southard*, University of Arizona; Jonathan Cox, University of Arizona; Young Ae Kim, University of Arizona ; Lisa Elfring, University of Arizona; Paul Blowers, University of Arizona; Vicente Talanquer, University of Arizona [abstract #32]

While overwhelming evidence in support of active learning has propelled many undergraduate courses toward transformation, instructors often encounter challenges in implementation in large enrollment STEM classrooms. Some of these challenges can include designing and implementing high quality tasks that demand high-level thinking, collecting evidence of student reasoning and using it responsively to make instructional decisions, juggling complex classroom management issues, and effectively using learning assistants. We have sought to address some of these challenges through an instructional team model (ITM) and supporting professional development (PD). The aim of this ITM is to help instructors create: 1) high-functioning instructional teams focused on student learning, 2) high-quality instructional tasks that maximize student learning, and 3) effective formative-assessment opportunities that provide information to improve instruction. In this model, the instructional team includes 1) a Lead Instructor, who plans and leads the implementation of the course, 2) a Learning Researcher, who engages in formative assessment of student thinking and provides feedback to the instructor, 2) an Instructional Manager, who helps manage the instructional team, and 3) a team of Learning Assistants who support student work during in-class tasks. We have piloted this ITM and supporting PD in 13 classrooms, across 8 STEM departments, with 16 instructors and their graduate/undergraduate teams. In our evaluation of the effectiveness of the ITM, data collection included clinical think-aloud pre-post interviews, focus groups, perspective surveys, daily in-class observations, and daily audio recordings of team members during in-class tasks. Ongoing analysis of the 13 pilot classrooms is focused on classroom evolution in the areas of 1) team building and communication, 2) task design and implementation, and 3) implementation of formative assessment to shape instructional decisions. Additional research includes a microgenetic analysis of one case: a pilot classroom that underwent large-scale, productive changes over the course of two semesters of adoption of the ITM and supporting PD. Results of preliminary analysis include common patterns in team evolution progression, the centrality of the instructor's beliefs and actions in the effectiveness of the team, the importance of "fit" in the Learning Researcher and Instructional Manager roles, and shared challenges among team members in moving from an evaluative to an interpretive perspective when observing student thinking during active-learning tasks. Overall, the aim of this presentation is twofold: 1) to address some of the challenges in adopting active learning in large enrollment undergrad STEM courses through the ITM and supporting PD and 2) to characterize successes and challenges in the evolution of transformed/transforming classrooms who have adopted the ITM from the perspective of the instructional team.

Poster #128 Augmented Reality as an Educational Tool for Teaching Macromolecular Structure and Function Rou-Jia Sung*, Carleton College [abstract #33]

Relating macromolecular "structure to function" is considered a foundational skill in biochemistry and molecular biology course curriculums. The molecular visualization skills necessary to interpret information in 3D models of biological macromolecules, however, are often lacking. Moreover, current technologies aimed at spanning this skills gap often require varying degrees of prior knowledge, training, and/or hardware requirements that can make implementation difficult. To address this we have developed a simple classroom activity using augmented reality technology that allows students to quickly and easily interact with high-resolution images of a 3D macromolecule. The activity was implemented in a junior/senior level biochemistry course as part of a class discussion on the structure and function of the potassium channel. The 3D images were integrated as an iPad application in which a 3D virtual image of the molecule would appear superimposed on the real world on the iPad screen when the iPad camera was directed towards a printed QR code. Students were able to rotate, translate, and zoom in on the molecule by physically moving either the iPad or the QR code sheet. The activity was also accompanied with worksheet questions aimed at developing an interpretation of the 3D structure. Student attitudes were assessed using a pre/post survey analysis. Preliminary results indicate increases in student confidence towards visualizing the 3D structures of biological macromolecules, as well as an increase in positive student perceptions of the helpfulness of looking at 3D structures for learning protein biochemistry.

Poster #129 Analyzing Short-Term and Long-Term Outcomes of a Life Science Gateway Course Susanne Jakob*, Harvard University; William Anderson, Harvard University [abstract #52]

As educators, we are constantly working on improving the courses we teach by introducing clear goals and objectives, as well as problem-based active learning that focuses on the student. At this point, no one doubts the positive impact of active learning elements and attention shifts towards understanding how active learning works. Studies have shown that the utilization of active learning elements and animations within a course increases long-term retention and deep learning. However, the vast majority of these studies focuses on the use of one specific pedagogical element and assesses retention only up until a few months after the original course. Our departmental gateway course (SCRB 10) focuses on the understanding of important embryological concepts, the ability to think critically, and ability to analyze and critique data. The sophomore-focused course has been taught since 2009 and has undergone substantial re-organization and improvement since its launch. In recent years, we have been adding more active learning elements to the course, including the use of Learning Catalytics software both inside and outside of the classroom, more animated slides to better visualize critical concepts, and hands-on section activities. We wanted to investigate how the changes that we incorporated in our course affected student opinion of their learning, their ease of thinking critically about a given scientific problem, and the long-term retention of this critical thinking ability. In this first part of our two-part study, we reached out to the students who took the course between 2009 and 2015 and sought to understand: 1) how the active learning activities they encountered in the course affected their learning, and 2) how students felt about the utilization of these educational tools in retrospect (e.g., after finishing college and starting a job). Overall, the majority of students agreed that the active learning exercises increased the value of our course and thought that it would not have been as effective without these elements. We are planning on using the data we gathered in this first study as a foundation for the second part of our study, which will be examining how long-term retention of course material and critical thinking skills is linked to the use of individual active learning techniques.

Poster #130 Analyzing the Effectiveness of a Modular Senior Thesis Writers Workshop Amie Holmes*, Harvard University; Susanne Jakob, Harvard University; William Anderson, Harvard University [abstract #58]

One of the main ways of communicating science is through writing scientific papers that are shared with a broader audience. While this manner of written communication is central to the scientific community, it is also based on a skill set that science education does not emphasize in teaching. This leads to a general frustration over a lack of writing skills in science-focused college students. Rising seniors in our department can elect to write a senior thesis, which gives the undergraduate students the opportunity to showcase their research interests and experimental experiences. It is a culmination of their scientific education and arguably the best way for students to learn how to think and write like a scientist. In the past, students have struggled with the process of scientific writing, especially with the idea of creating an interesting and convincing story based on their gathered data. To help our students improve their scientific writing skills, we developed a series of senior thesis writing workshops, encompassing a thesis proposal, introduction, and storyboarding workshop. The workshops were spaced logically through the academic year and were attended by the majority of senior thesis writers (79 - 97% depending on the specific workshop). The focus of each workshop module was on student-centered activities to teach students about scientific writing in general and the important components of a thesis (e.g., the logical flow of an introduction), as well as in class opportunities for the students to work on the respective parts of their own thesis followed by group discussions and constructive feedback. This year was the first iteration of our new senior thesis workshop series. All senior theses were submitted in March 2018 and we now plan on assessing the efficacy and student opinions on our teaching methods. Efficacy will be determined by comparing thesis grades between students who did not attend the workshops, students who attended previous iterations of the workshop, and students who attended the newly revamped workshops. Student perceptions of the thesis workshops and their activities will be assessed using a Likert-scale survey and free text responses. The aim of the survey is to determine which teaching activities were helpful for the senior thesis writers to improve their scientific writing skills.

Poster #131 SnapEd!: Accessing the benefits of popular social media for education.
Kelly Thomasson*, University of California at Santa Barbara [abstract #65]

The modern classroom has been described as fast paced and tech-infused while the modern student exhibits a decreased attention span and increased anxiety. The use of social media as a classroom technology has the benefits of student familiarity but the potential drawbacks of additional distraction. Additionally, these social media tools may increase content exposure and reduce text anxiety through gamification of assessment. I will discuss my experiences with social media as a teaching tool and its observed effects on test performance. Additionally I will highlight the effects of differring learning outcomes on the appropriateness of social media options.

Poster #132 Potential effects of course-based undergraduate research experiences on students' self-efficacy, research skills, and future goals Kelly Schmid*, Syracuse University; Jason Wiles, Syracuse University [abstract #66]

Initiatives to promote the use of active learning strategies in undergraduate STEM classrooms in place of traditional, lecture-style courses are increasing in light of growing evidence of their efficacy. In the sciences, mentored research within a faculty member's lab group has been considered by many to be the gold standard for undergraduate experience in STEM fields, as it allows students to directly engage in science; however, such opportunities are limited by the number of labs and faculty mentors. One way to expand the availability of undergraduate research experiences, and thereby make them more inclusive, is through course-based undergraduate research experiences (CUREs). CUREs are courses in which undergraduate students engage in authentic research throughout the semester, including aspects of scientific research such as experimental design, data collection, data analysis, scientific writing, and science communication. Such semester-long experiences have been shown to elicit increases in students' self-efficacy, science identity, research skills, science communication skills, and future goals. Improvements in these professional and personal factors through engaging in authentic scientific research will help students to become better scientists as they proceed with their education. We are currently in the process of assessing different types of CURES offered in the biology department at a private, northeastern, research-intensive university with regard to potential impacts on diversity and inclusion, students' self-efficacy, research skills, and future goals. Data were collected via an online survey and a paper-based constructed-response assessment tool administered at the beginning and end of an academic semester of CURE courses. We report on impacts on students' self- reported self-efficacy, as well as their measured scores on the research skills assessment. Additionally, we discuss the extent to which students may develop an interest in the pursuit of future research opportunities. Ultimately, this research will be a part of our broader project aimed toward development and assessment of different types of undergraduate research experiences across the university.

Poster #133 Do we really speak for the trees? Comparing instructional methods about phylogenetic tree diagrams in an introductory biology course for biology majors Edward Leone*, Oklahoma State University; Kristy Daniel, Texas State University [abstract #94]

Phylogenetic tree diagrams are often used to represent evolutionary relationships of organisms. The ability to accurately interpret and generate these diagrams is called tree-thinking. Unfortunately, this is a cognitively difficult task for students. Though many introductory biology courses incorporate tree-thinking instruction, few studies have identified which instructional methods provide the best learning gains for students. To measure tree-thinking learning gains, we gathered data from 294 introductory biology students majoring in biology using the recently developed Basic Evolutionary Tree Thinking Skills Inventory (BETTSI). Using a quasi-experimental design we measured tree-thinking differences across five sections of introductory biology, each offering a different instructional intervention method. After calculating paired differences, we performed a one-way ANOVA and a Scheffe's post hoc to determine significance among and between interventions. We found that students who experienced an active tree-thinking instructional approach had significantly higher tree-thinking learning gains than those who experienced a non-active approach. Our findings suggest instructors should go beyond the standard teaching methods regarding tree diagrams, preferably by including active learning in the classroom.

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Poster #134 Steady Glide or Wild Ride? A Study of the Ebb and Flow of Active Learning Implementation in STEM Classrooms Rebecca Reichenbach*, North Dakota State University; Lisa Montplaisir, North Dakota State University [abstract #97]

Instructional reforms in STEM Education have been called for on a national level. Little data about the transition of instruction exists. Common practices in classroom observational models include visiting courses once or twice at points close in time during the semester. Comparisons are often drawn between instructors whose observational data was collected at widely different semester time-points despite evidence that a single instructor can vary their instruction day-to-day by as much as 80%. This study explored the implementation of active learning practices by non-tenure and tenure track faculty over the course of a semester and addresses the research questions 1) How similar is implementation of active learning practices at time-points across a semester? 2) How closely do the active learning associated codes trend together? 3) Are there any practices more likely than others to be abandoned as indicated in observation codes? Faculty were introduced to evidence-based active learning pedagogy through three workshops of 2.5 – 3 days duration and faculty learning communities that met every three weeks for a semester. Their instructional practices within the following semesters were tracked through observations conducted using the Classroom Observation Protocol for Undergraduate STEM (COPUS). RM-ANOVA was conducted on the collapsed code groups typically identified as being most closely linked to active learning practices, Instructor Guiding (G) and Student Work (SW) A general downward trend in grouped codes was observed through the semester but was not found to be statistically significant at different time-points. A possible

Simpson's paradox was detected in both collapsed COPUS categories (G and SW) that may be interfering with broad interpretation. A statistically significant decrease in the SW code Independent Work (Ind) was masked by increases in other SW codes (F (1.3, 20) = 3.9; p = 0.05). While no statistically significant changed in individual G codes were detected, opposite trends are visible. Statistically significant decreases in DFW rates are linked to large increase in G (X2 (1, N = 1913) = 23.9, p < 0.0001) and SW (X2 (1, N = 1413) = 23.6, p < 0.0001) codes between semesters. Interviews were conducted to gain insight into reasons for instructional trends. Instructors expressed an expectation that implementation of active learning strategies would be highest at the beginning and lowest at the end of the semester due to time constraints, pressure to cover material, and general fatigue among both faculty and students. None felt they personally had completely abandoned any specific active learning practices. Recommendation is made to use care before interpreting collapsed COPUS categories. A focus on specific codes of interest is likely to be more fruitful as well as spacing of observations throughout the semester.

Poster #135 Asking students to draw in biology: a lesson-study of student attitudes and values in visual learning Natasha Morden, University of Calgary; Jessica Theodor, University of Calgary; Mindi Summers*, University of Calgary [abstract #103]

Drawing is an important tool for scientific observation and a learning strategy that fosters inquiry and creation of knowledge. The ability to visualize science and to translate between verbal and visual representations of data are also key skills for effective science communication. The literature on drawing-to-learn in science identifies student motivation as a critical yet understudied component of integrating drawing and visual literacy into biology courses. To investigate and add to understanding of student attitudes and values, an undergraduate student led the design of a lecture module that introduces students to visual learning. This module incorporated active-learning approaches such as TopHat questions with peer discussion, group worksheet activities, and whole class discussion to target and improve student attitudes, self-efficacy, interest, and values. Collaborative activities were also developed to promote inclusivity and reduce negative focus on artistic skill. These included instructor/student "quick-draws" and an ice-breaker activity where students drew animal-food combinations (e.g., octopine = octopus + pineapple; BEErito = bee + burrito). We used the Classroom Observation Protocol for STEM (COPUS) to objectively measure instructor and student behaviors. 43% of student codes reflected students working (individually and in groups on TopHat questions or worksheet activities) and 14% of codes reflected students talking to the class, while 55% of instructor codes were for guiding (posing questions, following up with students, moving and guiding, and working one on one with students). Analysis of student responses to worksheet questions recovered over 20 categories of how students viewed drawing as a professional skill. There were an equal number of ways that students found drawing useful as a learning and study technique, with approximately 60% of the value categories used to discuss both professional and learning practices. Further, when given specific scenarios, students showed interest in developing and using a variety of types of drawings in a classroom setting (e.g., observational, flow charts and concept maps, tables or graphs, and process or relational diagrams). These findings counter warnings in the literature as well as the instructors' initial perceptions of strong resistance to or lack of interest and value for drawing among biology students. In addition, we found students actively engaged through the lesson with over 90% of students stating that this activity increased their understanding of how drawings are used in the profession of biology and as a learning technique. This lesson can be incorporated into other biology courses to both increase student motivation and provide instructors with valuable evidence of their students' attitudes and values regarding scientific drawing and visualization.

Poster #136 Graduate student led science clubs: assessment of middle school student outcomes Jonathan Jackson*, Arizona State University; Bryan Henderson, Arizona State University [abstract #105]

STEM education in the middle school years is important in the development of children's interest in science and consideration of science as a possible career path. Unfortunately, most middle school teachers have little education or training in the sciences. Graduate students in STEM at our University run a science outreach program aimed at sharing their expertise in the sciences with middle school students. While this program is open to all science graduate students at our institution, over 90% of our volunteers come from the biology department. Volunteers take a 1 credit course in the fall during which they are trained in current pedagogical theory and evidence-based practices in STEM education. Particular emphasis is placed on training the graduate students in inquiry-based learning in which their students collect and interpret data. In the fall, during the course, graduate student volunteers are trained to use existing lessons as well as how to create and adapt new lessons. In the spring, graduate students implement their training in two types of middle school science clubs: beginner clubs and advanced clubs. Each club is run by two graduate students. For many of our graduate student volunteers this is their first time implementing a curricular plan of study of their own design. In the beginner clubs, volunteers are instructed to scaffold middle school students inquiry experiences; ideally working through confirmation, structured, guided, and open inquiry activities. In the advanced clubs, volunteers serve as coaches while middle school students conduct their own open inquiry investigations. It is our hope that by providing middle school students with early experiences conducting investigations that this will improve their interest and confidence in doing science, while also improving their understanding of the nature of science. Although this program has been operating for over a decade no formal evaluation of the program's effectiveness has been conducted. To test the effectiveness of this program we used previously published closed ended surveys and an open-ended probe to measure middle school students' science self-efficacy, continuing motivation to learn science, and views on the nature of how science is conducted. These measures were administered before and after the science club to students who were involved in the club as well as some students, schools permitting, who were not in the club. This will allow for a pre-post comparison as well as a comparison of students who did and did not attend the science club. These data were only very recently collected, so the quantitative survey results and comparisons will be completed by summer 2018. The analysis of the qualitative probe looking at views on how science is conducted may require additional time.

Poster #137 Fully Integrating Active Learning into Undergraduate Genetics Deborah Zies*, University of Mary Washington [abstract #112]

Evidence-based education research overwhelmingly supports the use of active learning to maximize student success. In the fall of 2017, I used sabbatical time to work with an active learning mentor on the goal of fully integrating active learning strategies into my genetics course. I am currently teaching the course I designed. In order to accomplish my goals, I implemented the following framework. I randomly assigned students to teams of four that worked together for the entire semester on active learning exercises in both lecture and laboratory. For each chapter I cover, students receive an ungraded but detailed reading guide that focuses their attention on sections and figures that emphasize my learning goals. Students demonstrate their understanding of the reading by completing an online homework assignment. Class time is planned as a mixture of lecture to clarify difficult concepts, short team exercises on making predictions and analyzing data from research experiments, and longer exercises for problem solving and construction their own content knowledge. Some class activities are being collected to monitor participation. Approximately weekly, student understanding of the reading and class material is being assessed with an individual quiz followed by the same quiz answered as a team. Performance on these quiz questions will be compared to the scores for students given identical questions in my lecture-based class last year. Additionally, four unit exams that consist of short and long answer questions that are primarily higher level Bloom questions are being taken by students individually. Overall course grades will also be compared to my previous course. Finally, to assess my use of active learning, I have video-recorded three class periods at different points in the semester and will analyze them using the COPUS observation instrument. The course is currently underway and therefore analysis of the data is not available at this time.

Poster #138 Implementation of Specifications-Based Grading in a Large General Chemistry Lecture Jacob Wainman*, University of Minnesota Duluth; Brian Gute, University of Minnesota Duluth [abstract #113]

Within the Chemistry and Biochemistry Department at the University of Minnesota Duluth, it was anecdotally observed that students leaving the first-year General Chemistry series had poor retention of basic chemical knowledge. To directly address this shortcoming, we implemented a specifications-based grading system in General Chemistry II during the 2017-2018 academic year (enrollment of 150-200 students each semester). We developed minimum criteria for satisfactory work on each of the assignments types (pre-class videos, online homework, and in-class groupwork) and established the minimum number of satisfactory grades necessary to earn each letter grade. A similar method was developed for the exams; each question on the mid-term exams were graded as satisfactory or unsatisfactory, and a minimum of 8 out of 10 questions was considered a satisfactory exam performance. “Second-chance” exams were developed so students could prove their competency on any problems graded as unsatisfactory on the first attempt. The use of this specifications-based grading approach had two specific aims: First, we aimed to the standard for demonstrating competency in General Chemistry to include the correct answer, not just a correct approach to a problem. Second, we aimed to provide students with additional opportunities to prove their competency. Preliminary data analysis shows little difference in student learning outcomes (as assessed by a standardized ACS General Chemistry II exam). However, it was clear from student responses to a survey that the “second-chance” exams did, in fact, drive students to review past material. In addition, while initially resistant, many students revealed that they learned to adapt to and succeed within the new grading scheme. The strategies used here to implement specifications-based grading in an introductory STEM course in such a large class has broad applicability to STEM disciplines outside chemistry.

Poster #139 Improving biochemistry education through computational modeling
Christine Booth*, University of Nebraska-Lincoln [abstract #141]

The ability to use modeling and simulation has been established as a core competency for life science education to adequately prepare biologists and biochemists for future careers. The goal of the current study is to foster student engagement and knowledge of the dynamics of complex biological systems through computational modeling while simultaneously gaining core biochemistry knowledge. When building and simulating computational models of a biological system, students are provided with an opportunity to engage deeply with the material, build their conceptual knowledge of the system, and draw on their critical thinking and problem solving capabilities. Computational modeling activities support student understanding of the interactive, dynamic and complex nature of biological systems. To achieve our goal, we are developing several computational learning modules focused on specific biochemical systems taught in various undergraduate life sciences courses. For each learning module, interactive modeling and simulation investigations are designed during which students are asked to build specific connections in the system and/or perform simulations to relate the interactions between specific components to the effects seen within the larger system. Students are frequently presented with peer-reviewed published data when asked to evaluate the systems. For each module, student learning is assessed using a pre and post assessment that is aligned with the learning objectives of the module (both systems-based and content-specific). Students are also asked to self-report on their learning using a short survey at module completion. A recently developed computational learning module on the topic of de novo purine biosynthesis has been implemented in an upper level biochemistry course (n=108). Comparing pre- and post-assessment scores, we found that students increased both systems and content knowledge. The average gain across the 9-question (36 item) assessment was 14% (range 6-28%) using matched-data. Initial analyses suggest that the module performs equally well with or without lecture support. Students self-reported a better understanding of the integration of metabolic pathways; increased understanding of the effect of feedback loops and mutations using simulations compared to static diagrams, and increased learning of the material overall after engaging with the computational learning module. Overall, our initial results suggest that the use of this computational module is effective in increasing students' understanding and reasoning about upper-level biochemistry concepts. Additional computational modules are currently under development to determine whether the results may be generalized to other topics.

Poster #140 Developing a theory of change for course-based undergraduate research experiences through the lens of self-determination theory and social cognitive theory

Isaura Gallegos*, Harvard Graduate School of Education ; Amie Holmes, Harvard University; Susanne Jakob, Harvard University; William Anderson, Harvard University [abstract #154]

National calls to reform biology education and incorporate more active-learning strategies have been addressed, in part, by the implementation of course-based undergraduate research experiences (CUREs). Although CUREs have been linked to a range of positive student outcomes such as improved science confidence, a higher sense of ownership in the laboratory, and higher persistence in science, the mechanisms by which these outcomes are reached are still not fully understood. In this study, we aim to expand on what is known about CUREs by drawing from self-determination theory and social cognitive theory to start to develop a theory of change that may help explain how CUREs lead to positive student outcomes. We hypothesize that student motivation and sense of self-efficacy play a key role in the implementation of an effective CURE in promoting student interest in science. To explore this hypothesis, we conducted in-depth, semi-structured interviews to investigate the development of students' sense of scientific competence, autonomy, relatedness and self-efficacy in a new CURE in a private not-for-profit R1 university. The research objective for the students taking the year-long CURE was to study DNA variants implicated in the development of amyotrophic lateral sclerosis (ALS) via disease modeling in both mice and stem cells, using CRISPR. The interviews were audio recorded and transcribed. Initially, we coded the interview transcripts for students' sense of autonomy, competence and self-efficacy, and sense of relatedness in the context of the CURE. We also included additional codes as they emerged. Preliminary results suggest that students perceived relationships and interactions with the instructional staff as a primary source of feelings of relatedness. Students often cited autonomy and novelty of the research as a source of motivation to perform beyond what was required in the course. Interestingly, whereas the majority of students reported that autonomy was a positive component of the CURE, other students reported feeling overwhelmed when faced with the prospect of designing and executing their own experiments. Furthermore, the framing of experimental failure emerged as a theme that could help explain whether students choose to pursue further undergraduate research experiences or not. Next, we plan to conduct a quantitative and longitudinal study to expand on a theory of change that can help explain how positive student outcomes are achieved through CUREs. In the long-term, we are interested in identifying what aspects of this CURE are most salient to students. Identifying salient aspects of CUREs can help us to start to distill the critical elements that lead to the efficacy of authentic research experiences. This in turn, can guide instructors about which elements can be modified and which elements are core elements of CUREs.

Poster #141 Despite similar course perceptions, non-traditional student status may negatively impact course performance in introductory biology and chemistry ERIN SHORTLIDGE*, PORTLAND STATE UNIVERSITY; Liz Griffith, Portland State University; Chloe Shelby, Portland State University; Gwen Shusterman, Portland State University; Jack Barbera, Portland State University [abstract #177]

Calls have been made to transform undergraduate classrooms into student-centered environments, and embedding active learning is a common mechanism for meeting these goals. Researchers have identified student benefits from active learning, yet these benefits may not be universal for all students. We sought to broadly identify how students at a non-traditional university perceive their introductory biology and chemistry courses, and if perceptions relate to course type, performance, or student-status. Here, we surveyed students (n = 1300) using open-ended prompts across one academic year regarding their perceptions of factors impacting their learning and interest, and how they felt about active learning strategies. Overall, we found that students did not generally differ in what influenced their learning other than postbaccalaureate students being more likely to report “In-Class Strategies” and “Professor” as influential, while most students reported similar factors influenced their interest in the subject. Students generally perceived active learning positively, particularly “clickers” (85%). There were significant performance differences among student groups - postbaccalaureates outperformed other student groups, and traditional-age undergraduates (18-22 years) outperformed older, non-traditional age undergraduate students. We found no correlation between student perceptions or attitudes of the classroom and their course performance (final grade). We conclude that although students generally perceive the classroom environment similarly, there are undetected factors that influence performance among student groups.

Poster #142 Increased Course Structure Enables Instructors to Increase Introductory Biology Exam Rigor Adriana LaGier*, Grand View University [abstract #188]

In courses with a heterogeneous student population, instructors are often challenged to balance successful course completion with rigor. This difficult task can be confounded in foundational, gateway courses, such as introductory biology, which serves a mix of freshman majors at various levels of preparedness. Research suggests that simple changes in course design, such as increasing course structure, can offer a solution. We hypothesize that increased course structure enables instructors to increase exam rigor without coincidentally increasing failure rates. Sixteen sections of general biology classes over the course of eight semesters were analyzed; eight sections had relatively low class structure (i.e. mostly Socratic learning and clickers), while eight sections had moderate structure (i.e. including class note summaries and practice exams). Class size and demographics data was collected. Weighted Bloom’s Index of 150 exam questions was used to facilitate comparisons between designs. The current study shows that increasing structure led to an increased index that indicates an increase in exam difficulty. Although exam rigor increased, student perception of the difficulty of the subject matter slightly decreased (IDEA diagnostic feedback student reaction to course 5 point scale; 4.2 ± 0.18 for low structure; 4.0 ± 0.19 for moderate structure) and failure rates did not increase. This study supports the use of increased course structure to balance student success and rigor. Additionally, it supports the use of Weighted Bloom’s Index as a method for assessing exam equivalence across institutions.

Poster #143 Peer Leaders as Potential Role Models and the Impact on Perceived Student Learning Gains Christina Winterton, Syracuse University; Ryan Dunk*, Syracuse University; Jason Wiles, Syracuse University [abstract #193]

Peer-led Team Learning (PLTL) is an active learning method that has been associated with a wide range of student benefits in various university settings across multiple science disciplines. The success of PLTL has been attributed to its fostering of peer interactions as students collaborate in small groups under the guidance of a peer leader who has recently completed the same course. Given the unique role of a peer leader, their interactions with students can influence the students' perceptions of the course. As peer leaders often develop close rapport with students, we would expect them to be well-attuned to students' learning gains and needs. In this study, students attending PLTL sessions associated with an introductory biology course were asked to fill out a modified version of the Student Assessment of Learning Gains (SALG) survey, which indicates their perceived learning gains. The peer leaders were also asked to fill out the SALG survey for each of their students to indicate their perceptions of the students' individual learning gains. A comparison of these results allowed us to identify students and leaders who were most aligned in their assessment of individual student learning gains. In addition to the SALG survey, students responded to an open-ended questionnaire regarding whether they viewed their peer leader as a role model, notable actions by the leader during sessions, and how the leader's style of communication has impacted their learning. The students who reported the highest perceived learning gains had SALG scores that aligned more closely with their peer leader's assessments than those that had low perceived learning gains (Welch's 2-sample t-test: $t = 7.63$; $df = 135.38$; $p \ll 0.001$). Additionally, students who view their peer leaders as a role model have significantly higher perceived learning gains than those who do not view their peer leader as a role model (two-way ANOVA: $F = 4.13$; $df= 1, 111$; $p = 0.044$). There is some support that this trend is stronger for students who have declared majors within a STEM program versus those who have not, but the interaction is not significant (two-way ANOVA: $F = 2.88$; $df = 1, 111$; $p = 0.092$). We also report qualitative analyses which provide insight into the behaviors, teaching methods, and attributes common to peer leaders who were viewed as role models by their students. These results can inform active learning strategies that involve peer leaders and mentors by giving peer leaders potential tools to becoming more aligned with their students and their learning needs, while students benefit from having an accessible role model in the STEM field.

Poster #144 Promoting Climate Change Literacy Using an Inquiry-based Classroom Activity Mary Williams*, Metropolitan State University; Deena Wassenberg, University of Minnesota [abstract #216]

Despite its strong scientific basis, climate change is a politically fraught topic in the United States. Although many states have adopted the scientific consensus of climate change as part of their education standards, many science teachers skim over the topic and do not assess whether students understand it. Through our experiences in teaching undergraduate science majors and non-majors, we have found that many students lack basic understanding the science of climate change. In response to the identified need to better educate students in this important area, we found and adapted a publicly available atmospheric carbon dioxide modeling activity to help teach climate change basics and to foster a deeper understanding and appreciation of climate change science in our students. This module helps students step through the development of a basic model of carbon flow between the land, the atmosphere, and the ocean. Students manipulate components of the model to optimize it based on real data. The students then use their developed model to make predictions for future atmospheric carbon dioxide under one or more student self-generated scenarios representing possible future conditions. To assess the effectiveness of the module, we combined quantitative and qualitative assessment methods. We used a pre- and post-questionnaire to assess learning, requested open-ended feedback from students in one of the activity questions, and collected anecdotal evidence through our observations and conversations with students. Assessments indicated that the students learned much about climate change and the climate change modeling process through this process. Interactions with students during the modules highlighted the usefulness of the modeling exercise to deepen thought processes and learning about researching climate change. Student discussions organically evolved to conversations about implications of climate change and policies needed to address specific components involved in the climate change processes. We found that this climate change teaching module provides a motivating and interesting means to teach both both biology majors and non-majors about basic climate change and the climate modeling process.

Poster #145 Do reading quizzes encourage students to effectively prepare for class? (Phase 1 of 2) Nadine Stecher*, Wentworth Institute of Technology [abstract #225]

Active learning is a learner-center approach that engages students in the learning process. This teaching practice is challenging for instructors because it relies on the students acquiring the basic knowledge beforehand, for example, through reading the textbook. How prepared a student is for class likely depends on the degree of self-motivation that student exhibits, which in turn is related to whether the student has a good incentive to make an effort. A study is being carried out in a non-biology-major Anatomy & Physiology I and II course sequence. The purpose of phase 1 (Fall 2017/Spring 2018) was to determine whether students prepare more effectively for class if their level of preparedness can be evaluated for each individual (test group) versus being measured anonymously (control group). In other words, the reason for effort being personal responsibility, or lack thereof. For every lecture, students received a list of relevant learning objectives for which to prepare. The level of preparedness was then determined using a reading quiz at the beginning of each class. Students submitted their answers via clickers to 5 multiple choice questions that were categorized as mostly Bloom's taxonomy level 1 but no higher than level 2. Each correct answer was scored as "1 point" whereas incorrect choices were scored as "0 points". The maximum possible quiz score was 5 points, which represents being fully prepared for class, and the lowest possible quiz score was 0 points, which represents being not at all prepared for class. Class average scores (all groups) and individual performance points (test groups only) for each quiz were reported to the individual students through weekly emails. However, the students were aware that the quiz scores did not factor into the course grade. Among the generally low to moderate level of preparedness, the students in the anonymous groups appeared to be least prepared. The pooled (18 quizzes in A&P I Fall 2017, 17 quizzes in A&P II Spring 2018) average quiz grade was lower in control group A (Fall 2017: avg = 2.99 points, stdev = 1.26, n = 230; Spring 2018: avg = 2.19 points, stdev = 1.24; n = 298) than in test group B (Fall 2017: avg = 2.82 points, stdev = 1.39, n = 169; Spring 2018: avg = 2.51 points, stdev = 1.20, n = 269) and test group C (Fall 2017: avg = 3.22, stdev = 1.26, n = 415; Spring 2018: avg = 2.63 points, stdev = 1.23, n = 210), although the differences were not significant (Fall 2017: $F = 6.5$, $F_{crit} = 3.0$, $p < 0.05$; Spring 2018: $F = 9.0$, $F_{crit} = 3.0$, $p < 0.05$). Based on these results, students are mildly motivated to prepare for class if it has no academic consequences, and even less so if the instructor does not track their individual performance. Phase 2 of the project (Fall 2018/Spring 2019) will measure whether students prepare more effectively for class if their level of preparedness affects their course grade (test group) or not (control group).

Poster #146 Graphing in Lecture: Infusing Evidence-Based Graphing Materials in an Upper-Division Animal Behavior Course to Teach Graph Choice, Construction, and

Interpretation. Emily Weigel, Georgia Institute of Technology; Aakanksha Angra*, Georgia Institute of Technology [abstract #232]

Graphing skills are important for the development of undergraduate students' knowledge on data construction and communication. Previous graphing literature expressed the need to improve graphing, specifically with graph construction and interpretation, but up until recently, published and validated graphing instructional and learning tools did not exist. The purpose of this study is twofold: to 1) determine whether published graphing materials can successfully be incorporated into a lecture course and 2) assess students' graphing skill progression by utilizing evidence-based graphing materials repeatedly across the semester. The context of this study is an upper-division animal behavior lecture course at a large R1 university in the Southeast (N=45). This course met three times a week and was taught in an active-learning format. The course had specific learning objectives targeted at graph interpretation, appropriate graph choice and construction of experimental data. In lecture each week, explicit effort was made to incorporate data and graphing into lecture. Graphing materials were introduced towards the beginning of the semester and students were given weekly practice using and applying the materials to various activities. Frequent instructor feedback was provided to gauge learning. A typical class consisted of a summary of graphing errors made by students in their pre-class homework, introduction of the day's topic, followed by individual or group work to interpret primary literature data and graphs, design hypothesis-driven experiments, and plot hypothetical data, with an emphasis on alignment between the research question, hypothesis, and methods as displayed by graph choice, data manipulation, and statistics. Student usage of the graphing materials was encouraged throughout the semester and was noted in the instructor's classroom observations. The effectiveness of the usage of graphing materials and students' graphing abilities was evaluated by: previously validated pre/post survey on graph knowledge, three multi-part graphing exams across the semester, and the attributes and quality of graph construction throughout the semester. Data from this preliminary study are promising, with students demonstrating overall improved graph choice and interpretation abilities by the end of the semester (GLMM, df=2, 62, t=4.00, $p<0.001$), interpreting the purpose of the graph (GLMM, df=2, 62, t=6.55, $p<0.0001$), interpreting the nature of data (GLMM, df=2, 62, t=4.75, $p<0.0001$) and relationships between independent and dependent variables (GLMM, df=2, 62, t=4.44, $p<0.001$), and interpreting the take-home message (GLMM, df=2, 62, t=2.87, $p<0.01$). These findings support and extend the utility of the graphing materials to a lecture course and illustrate the progression of student learning in graph choice, construction, and interpretation over the semester.

Poster #147 Analysis of higher order questions asked by Learning Assistants in their interactions with students Hannah Huvard*, University of Colorado Denver; Robert Talbot, University of Colorado Denver [abstract #239]

Learning Assistants (LAs) are uniquely situated within an active learning classroom as peer support for the students with whom they interact. LAs and students engage in collaborative interactions in which LAs directly ask questions to elicit student responses during in-class activities. The complexity of those questions and a more in-depth analysis of the specific discourse used by LAs when prompting student responses have not been fully explored. Sociocultural learning theory positions language as a powerful tool and carrier of higher level concepts that allows for collaborative learning experiences with the classroom Activity System. Based on this framework, we posit that the nature of LA-student interactions during an in-class activity depend largely on an LA's choice of semantics when posing questions to students. This study aims to use a discourse analysis of LA-student interactions to compare and contrast the levels and frequencies of higher order questions used by LAs to facilitate collaborative interactions with students in an introductory biology course. Due to the unique positionality of

LAs, they often use more informal language as a device to guide meaningful interactions. By examining the informal discourse of LA-student interactions, we can highlight the specific utterances used by LAs most often within the context of an active learning environment that construct these collaborative interactions. The interactions under examination were recorded using small, point of view cameras worn by LAs during six class sessions within a large introductory biology course. These videos were transcribed and LA utterances (specifically questions posed to students from the LA directly) were coded as one of the six cognitive domains described in the revised version of Bloom's taxonomy (remember, understand, apply, analyze, evaluate, or create). The frequencies of each cognitive domain code from these transcripts were tallied and synthesized into data tables to analyze which of these cognitive domains are most used by LAs when posing questions to students. Our initial analysis indicates that LAs most frequently pose questions to students within the cognitive domains of understand, apply, and analyze -- suggesting that LAs elicit multi-level thought processes rather than simply asking students to regurgitate memorized information (remember) during a collaborative interaction with students. The results of this work can inform the preparation of LAs for their unique positions within the classroom, specifically with respect to their choice of language when interacting with students.

Poster #148 Examining Student Perceptions of Active Learning in a Large-Lecture Biology Course Michelle Nugent*, NC State University; Miriam Ferzli, NC State University; Miles Engell, NC State University [abstract #244]

Research suggests that implementing active learning strategies in large-lecture introductory science courses has positive impacts on student achievement outcomes, as measured by final exam scores and final course grades. Despite these findings, some professors are reluctant to implement active learning strategies for various reasons. This study examines active learning at a granular level by using the student perspective to analyze which specific aspects of active learning activities are thought as most beneficial to learning. By identifying specific aspects of these activities, instructors may gain insight about how to best design and implement active learning in their classrooms to maximize student engagement. We collected data and analyzed student perceptions of various active learning tasks throughout the semester in a large-lecture introductory biology course for majors, wherein the instructor implements active learning pedagogies frequently. This report includes preliminary data. The research questions were as follows: 1) Which aspects of active learning tasks do students identify as most beneficial for learning? 2) Did the student-identified aspects of these tasks relate to behavioral, personal, or environmental factors? The latter question is framed within the context of the Social Cognitive Theory (SCT), which stipulates that behavioral, personal, and environmental factors all interact during the acquisition of knowledge. Immediately following in-class activities, students answered two open-ended prompts via a personal response platform, Top Hat: 1) Describe how this activity may have helped you learn the concept, and 2) List two or three aspects of the activity you found useful for learning this specific concept. Students were also asked to complete a demographic survey. Students in this course (n=247) were primarily undergraduate freshmen (81.4%), who are enrolled in science, technology, engineering, or mathematics (STEM) majors (90.5%). First round coding was completed via in vivo coding of student responses and resulted in 16 thematic codes. The coded responses were then assigned to one of four categories including the three factors from SCT and a fourth miscellaneous. The aspect of active learning most frequently cited by students as beneficial was working with peers, followed by various cognitive benefits, reviewing class notes, practicing real-world application of information learned, and learning how to study for the exam. These findings support aspects of the SCT of learning. Most students naturally identified behavioral, personal, and environmental factors as the most impactful aspects of in-class activities. This information, and future results from this study can be used by instructors to implement specific active learning tasks maximize student engagement and learning in large-lecture courses.

Poster #149 The effects of a writing assignment change on student perceptions and performance in an air pollution active learning laboratory activity. Katherine Barry*, University of Minnesota; Mary Williams, Metropolitan State University; Deena Wassenberg, University of Minnesota [abstract #253]

For our undergraduate, non-majors biology class in environmental science, we developed an active-learning laboratory activity in which students learn about environmental justice issues associated with air quality. As part of this lesson, students read about disproportionate exposure to air pollution based on racial and socio-economic factors and the health consequences of this exposure. They are then guided in asking their own questions about air quality variability over space and time based on topics of interest to them. The students are then challenged to mine publicly available data from the EPA AirData website to address their questions. The students perform a simple analysis of their data and present their results. In the first iteration of this project students' results were presented in the form of a scientific paper-style report of the activity. In Spring 2017, we surveyed 61 students upon completion of the Air Quality activity to assess learning and student impressions of the activity. Students most agreed with (ranking as "Agree" or "Strongly Agree") the statements "Air pollution is an important public health concern" (95% agreement) and "It is important for the EPA air quality data to be collected and made available to the public." (93% agreement). In open-ended questions, when asked what students did not like, or would suggest for improvement about the activity, student responses fell in three main categories; they didn't like data analysis (25%), they found the AirData website problematic (11%), they did not like writing the scientific paper-style report (20%). We hypothesized that providing an alternate way for students to present their findings in the form of an infographic would increase the students' enjoyment of the activity without diminishing the perceived importance of the activity or their learning endpoints. Students were instructed to develop an infographic (with supplementary materials and methods) to be part of a public health campaign to communicate the results of their analysis to the communities they studied. Our rationale was that this assignment connects better with the students' beliefs in the importance of public health and publicly available air quality data and will seem more relevant to the student. This new assignment was implemented in fall of 2017, revised and conducted again in spring of 2018. Students' perceptions of the activity will be assessed by survey questions and compared to that of students who did the activity with the scientific paper as an endpoint. In this poster we will present the results of the change in the assignment on student perceptions of the activity and the quality of student work. We will also discuss the place in the non-majors biology curriculum for scientific papers and other styles of science writing that may serve our non-majors population better.

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Poster #150 A course-embedded comparison of instructor-generated videos of either an instructor alone or an instructor and a student Katelyn Cooper*, Arizona State University; Lu Ding, Arizona State University; Michelle Stephens, Arizona State University; Michelene Chi, Arizona State University; Sara Brownell, Arizona State University [abstract #255]

Instructor-generated videos have become a popular way to engage students with material prior to a class, yet this is a relatively unexplored area of research. There is support for the use of videos where instructors tutor students, but few studies have been conducted in the context of a classroom. In this study, conducted in a large-enrollment college physiology course, we used a randomized crossover design to compare the impact of two types of instructor-generated videos that students watched as part of their pre-class assignments. We compared videos featuring only an instructor (Instructor Only videos) with videos featuring an instructor tutoring a student

(Instructor-Tutee videos). We analyzed student survey responses using essential elements of grounded theory to determine student-identified advantages and disadvantages of Instructor Only and Instructor-Tutee videos and which type of video students preferred and why. Using Wilcoxon signed-rank tests, we analyzed students' weekly physiology quiz scores and the extent to which they valued and enjoyed each type of video. We found that students preferred, enjoyed, and valued the Instructor Only videos significantly more than the Instructor-Tutee videos. In contrast to prior literature, students with a GPA below the median (3.49) performed significantly better on physiology quizzes after watching Instructor Only videos compared with Instructor-Tutee videos. Students with a GPA at or above the median performed equivalently on physiology quizzes after watching Instructor Only or Instructor-Tutee videos. We present this study as an example of bringing cognitive science studies into the context of a real physiology classroom.

Poster #151 Are we restricted to clicking? An investigation of question format in Peer Instruction Erika Offerdahl*, Washington State University; Jacob Woodbury, Washington State University; JESSIE ARNESON, Washington State University [abstract #265]

Peer instruction (PI) is a well-known, evidence-based instructional practice that has been implemented in range of institution types (both within the US and across the world) and disciplines, both STEM and non-STEM. While enactment may vary between instructors, the general sequence of events that defines PI is, (1) an instructor poses a question, (2) students given time to reflect on and answer the question, (3) students log individual answers which are reviewed by instructor, (4) students convince a nearby peer of an answer, (5) students commit to an individual answer again, (6) instructor reviews answers again and provides explanation of correct answer. An expansive collection of research elucidates many critical components of PI that are highly correlated with significant gains in student learning. For example, a number of studies suggest that the benefits of PI are greatest when higher-level questions are posed instead of lower-level comprehension or knowledge questions. These studies report using clicker questions, which require students to select from a list of choices. Ideally these choices should include common student misconceptions. While cognitive level of the question has been investigated in the literature, the format of the question (i.e. multiple choice versus constructed response) has not. Similarly, the literature articulates the need for the instructor to review student responses in order to craft further instruction. But the research is presently inconclusive as to whether or not the distribution of responses should be displayed to the students as well. In this poster, we report on the initial pilot stages of a project investigating of the role of (a) question format and (b) display of student responses on student learning through PI in a large-lecture, introductory biology course. In the first experiment, students generated a constructed response in Step 2 of PI before discussing with peers. After peer discussion, individuals then logged answers via a clicker question. We will report preliminary results of our experiments as compared with student performance in traditional implementation of PI.

Poster #152 Biodiversity Show and Tell: An accessible activity to encourage students to explore the tree of life. Sarah Stockwell*, University of California, San Diego; Jessica Davids, University of California, San Diego [abstract #267]

An appreciation of organismal diversity is a requirement for understanding evolution and ecology as well as serving a source of amazement and wonder that can inspire students to enjoy biology. However, biodiversity can be a challenging subject to teach; it often turns into a procession of facts and a disorienting sea of Latin names. There is little literature on more engaging ways to teach biodiversity at the undergraduate level. To help fill this gap, we describe an activity we developed in which students in a large-enrollment introductory biology course independently research living organisms and compete with their classmates to find the most interesting species. Students use the Internet to find and investigate a species of their choice, researching the answers to questions about the species' ecology and physical characteristics. In discussion sections of ~30 students, each student briefly presents what they have learned about their species. The species voted "most interesting" wins extra credit for the person who presented it. In anonymous clicker polls, students overwhelmingly reported that this activity taught them something new about life on earth (83%) and increased their interest in our planet's species (75%). Many students (47%) also reported that this activity caused them to talk to someone about biology outside of the class, suggesting that it helped them see the relevance of biology to their everyday lives. This activity can help enrich an introductory biology course of almost any size.