Abstract # 3  (Poster Fri # 12)
Assessment of a set of activities that teach the complexity of the nature and process of science
Kathryn Perez, University of Texas Rio Grande Valley; Rebecca Price*, University of Washington Bothell

A critical competency for students of science is understanding and practicing the means by which new scientific knowledge is created, a practice that is often incorrectly reduced to a linear, pre-determined recipe that does not reflect the complexity and iterative nature of scientific inquiry. In this study, we test the efficacy of a sequence of two activities for teaching undergraduates the nature and process of science in two courses about scientific practice at two different universities. First, students complete an already-published activity that models the process of science by using data to infer what is hidden on one side of a cube. They also make new puzzles on cubes for their peers to solve. They compare this simple activity to science through classroom discussion. Then, students learn about the “How Science Works Flowchart”. The Flowchart, available at the Understanding Science website, depicts scientific knowledge as accruing through a combination of Exploration and discovery; Testing ideas; Benefits and outcomes; and Community analysis and feedback, and smaller steps within each of these categories. The Flowchart highlights the dynamic interconnections among categories, presenting science as an unpredictable journey of discovery. We walk students through a case study on the Understanding Science website based on Walter Alvarez’s discovery of the asteroid impact that led to the Cretaceous-Tertiary Extinction. Throughout the case study we highlight iterative and non-linear aspects of the process of science, bouncing among the categories in the Flowchart. To evaluate the efficacy of combining these activities in teaching students about the complexity and variability in approaches to science, we compared how students depict the process of science before (n=18) and after (n=17) completing them. To assess the complexity of the students’ diagrams, we counted the number of times a step was repeated or bifurcated as measures of nonlinearity. We also counted the number of categories in the Flowchart that students included. After completing the activities, students showed an increase in their representation of the scientific process as nonlinear (unpaired t-test, p=0.01, t=2.73, df = 33). Moreover, students described more aspects of science after completing the activities: 65% noted interaction or feedback from the scientific community in the posttest, but none did in the pretest; 76% included many categories in the Flowchart in their posttest, but none did in the pretest. This pilot study suggests that this sequence of activities successfully improved students’ depiction of the nature and process of science as dynamic.

Abstract # 4  (Short Talk Sun )
Cognition at the Extremes: Understanding Undergraduate Biology Students' Concepts of Extreme Spatial Scales
Grant Gardner*, Middle Tennessee State University; M. Gail Jones, North Carolina St U; Martina Ramos, Middle Tennessee State University

Modern science continues to push boundaries of what can be explored in the natural world at both galactic and sub-atomic size scales. The need for K-12 science students to have learning experiences with scale is one of seven cross-cutting science concepts recognized by the Next Generation Science Standards (2013). In postsecondary biology, Vision and Change (2011) embeds the importance of scale conceptualizations in all five core concepts for biological literacy and undergraduate science student difficulties with scale are noted as a particularly common by NRC Discipline-Based Education Research (2012). Research has yet to explore undergraduate biology students’ conceptualizations of scale as they develop into content experts. Utilizing an analytical framework based in cognition and developed in previous studies this work examined the scale conceptions of early-career undergraduate biology majors (n =
242) at a large southeastern public university. The research questions were: R1: How accurate are undergraduate biology students' conceptualizations of spatial size of objects and distances over many orders of magnitude? R2: What scale boundary distinctions do undergraduate biology students cognitively hold with respect to size and scale? R3: How do undergraduate biology students reason through scale issues related to biology? An explanatory sequential mixed methods design was used with surveys, an in-person scale card sort and a semi-structured interview protocol. Data from the Scale of Anchoring Object Questionnaire (SAO, from Tretter et al., 2006a) section of the survey addressed R1. Data from the Scale of Objects Questionnaire and card sort (SOQ and Scale Card Sort both from Tretter et al., 2006b) addressed R2. A research-developed semi-structured interview protocol addressed R3. Percent estimation error from objects listed by participants on the SAO at a range of scales were calculated. Absolute and relative ranks of objects listed by participants within particular discrete size categories were calculated from the SOQ. Card sort data with a sub-sample (n = 29) were analyzed using multi-dimensional scaling methods. Interview results were analyzed inductively with question items as unit of analysis. Results demonstrate poor conceptual accuracy of participants at extreme size scales. Following instruction, participants showed little difference in cognitive distinction between large and small size scales. Explanations for these cognitive structures are elucidated through the interview data. This research suggest the need for explicit instruction in biological scale and the need for students to reflection on their reasoning around scales.

Abstract # 5 (Poster Fri # 13)

Modules as Preparation: An Investigation into an Online Meiosis Learning Module Developed For the Virtual Cell Animation Collection

Eric Goff*, University of South Carolina

Recent reports on the state of undergraduate biology education have placed an emphasis on student content interaction both inside and outside of a classroom setting (Brewer and Smith, 2011). As a result, many introductory biology courses have adopted a “flipped” design emphasizing active learning in the classroom (Freeman et al., 2014). Reports on such course designs suggest that the benefits often associated with active learning in the classroom relies heavily on how well the student prepares prior to attending class (Gross et al., 2015). In an attempt to focus on resources that aid in student preparation, the study presented here aims to test the learning outcomes of an online learning module developed as part of the Virtual Cell Animation Collection (McClean et al., 2005). Properly introducing students with content material outside of (prior to) class could provide a first step in the preparation needed to reap the benefits of active learning in the classroom. Accordingly, the meiosis learning module in this study functions as a stand-alone multimedia online learning resource with which students can interact in any environment, included as possible preparation for in class activities. Our approach selected students (n =534) from four sections of introductory biology that were presented the concepts of meiosis using one of two treatments. Treatment One consisted of a stand-alone animation-based learning module as the only form of conceptual introduction, while Treatment Two was a traditional lecture based session. The traditional setting was chosen as a comparison group in this study to provide confidence to instructors who are hesitant to rely on external resources as a means of conceptual introduction. Using pre/post assessment scores, student achievement was analyzed using calculated normalized gain scores. Students in this study who viewed the learning module as their only means of conceptual introduction scored (G = 0.47) significantly higher (d = 0.40, p < 0.001) than students in the traditional lecture comparison group (G = 0.34). In addition, multiple linear regression analysis showed no significant variation in these outcomes as a result of tested extraneous variables (multimedia learning preference, student gender, year in school, and ethnicity). Results show that the online learning module tested here effectively conveyed introductory concepts on the topic of meiosis.
to the students in our study. This, in turn, could provide confidence in its ability to support learning in an environment outside of the classroom.

Abstract # 6 (Round Table Fri )
**Open Data in Biology Education - What do we share and how do we share it?**
Erin Dolan*, University of Texas at Austin

Federal agencies and research journals alike are demanding sharing of raw educational data. As noted by the National Institutes of Health, data sharing benefits researchers and the public by: • “reinforcing open scientific inquiry • encouraging diversity of analysis and opinion, • promoting new research, testing of new or alternative hypotheses and methods of analysis • supporting studies on data collection methods and measurement • facilitating education of new researchers • enabling the exploration of topics not envisioned by the initial investigators • permitting the creation of new datasets by combining data from multiple sources.” (http://grants.nih.gov/grants/policy/data_sharing/data_sharing_faqs.htm#898) These priorities and demands present an opportunity to understand and learn from how data are currently shared in the biology education community, and to envision the future of data sharing in biology education. This roundtable discussion will address principles and practices of data sharing, such as: - What data repositories, if any, do biology education scholars currently use for data sharing? - What data sharing practices protect the privacy and confidentiality of human subjects? - What can biology education scholars learn from human subjects researchers in other disciplines (e.g., clinical geneticists, epidemiologists) about data sharing? - How can data be shared in ways that support future meta-analyses? - How can biology education scholars protect their intellectual property while meeting funder and publisher requirements for data sharing? Participants will be encouraged to share their own data management and sharing plans for the group to discuss. Data management and sharing plans from other disciplines will be presented briefly to spur discussion about data sharing strategies and principles that could be adapted or adopted by biology education scholars.

Abstract # 7 (Poster Sat # 53)
**Measuring Student Motivation in an Introductory Biology Class**
Brian Gibbens*, University of Minnesota

Student motivation is widely regarded as an essential prerequisite for learning and success. Motivated students have been shown exhibit higher levels of understanding, creativity, productivity, and achievement than their less motivated peers. Although motivation has been called “the single most important element of learning,” relatively few studies have focused on biology student motivation. Existing studies typically administer one of a variety of motivation instruments once during the semester; this makes it challenging to monitor motivation over time and to compare results between studies. To learn more about biology student motivation and how it changes over time, pre/post surveys were administered to students taking Foundations of Biology I and II (BIOL2002 and BIOL2003). Survey items were pulled from two established motivation instruments: the Intrinsic Motivation Inventory (IMI) and the Motivated Strategies for Learning Questionnaire (MSLQ). Several components of motivation examined by the IMI and MSLQ include intrinsic motivation, self-efficacy, value, and anxiety; MSLQ items also examined extrinsic motivation and control of learning beliefs. A total of 112 students in BIOL2002 and 79 students in BIOL2003 took the pre/posttests. Student scores on the IMI and MSLQ were remarkably similar, but significant differences were observed between the pre/posttest scores, between the two classes, and between high and low performing students. Baseline total motivation on the pretest was 76% and 73% in BIOL2002 and BIOL2003 respectively. Between the pre/posttests total motivation decreased by 11% in BIOL2002 and 4% in BIOL2003. Scores for intrinsic motivation, self-efficacy, value, and extrinsic motivation also decreased. Stratifying
the results between high, middle, and low performing students indicated that the low performers were typically less motivated and more prone to experience significant motivation drops than high or middle performers. The largest gaps were observed for self-efficacy scores where the difference between low and high performers was 21% in BIOL2002 and 23% for BIOL2003. Scores for all students were the highest on questions related to value and lowest on anxiety items, indicating that they cared deeply about the subject matter and that pressure/tension levels were manageable. Total motivation correlated with exam performance, the overall course score, and final grades. Intriguingly, several motivation differences were observed between different demographic groups. All of these results and their implications will be presented along with helpful tips for researchers and instructors wishing to increase student motivation in their classrooms.

Abstract # 8 (Short Talk Sun )

**Relationships among evangelical college students’ worldviews and their knowledge, beliefs, and acceptance of anthropogenic climate change.**

Joel Light*, University of Northwestern, St. Paul

Research has determined that the way people think about topics and how they learn, is very convoluted. Particularly, more research is warranted on how a student’s worldview influences how they interact with specific scientific topics. There is one current scientific topic that more worldview-focused research needs to be conducted, which is anthropogenic climate change. Anthropogenic climate change could be argued to be the one of the most pivotal and challenging environmental and social issues of the modern era. In the U.S., there is much controversy surrounding this topic with much resistance to climate change policy being implemented. Specifically, evangelicals have been found to be the most resistant group to accept the scientific evidence for human-induced climate change and, therefore, the most reluctant to engage in climate friendly action. There is limited understanding of where this strong resistance comes from and why some evangelicals accept anthropogenic climate change and why many do not. Research indicates that worldview may influence this phenomenon. This study investigates how an evangelical student’s worldview relates to his or her knowledge, belief, and acceptance of anthropogenic climate change. The study focused on the areas of belief that comprise a person’s worldview: environmental, religious, economic, political, and epistemological. Through detailed qualitative analysis of participant responses to the various instruments employed in the study, differences emerged between individuals along the continuum of anthropogenic climate change acceptance in the evangelical culture. These findings could provide the necessary tools for engaging this reluctant population in more meaningful climate change conversations.

Abstract # 9 (Poster Sat # 8)

**Randomized controlled trial captures conceptual change via a serious game and an interactive simulation in undergraduate molecular biology students**

Andrea Gauthier*, University of Toronto; Jodie Jenkinson, University of Toronto

Biology students have great difficulty understanding how randomness at the molecular level – a seemingly inefficient mechanism – can lead to perceptually efficient cellular systems, often misconceiving these emergent systems as directed in nature. These misconceptions are often robust and resistant to change, lasting throughout a student’s undergraduate career; a conceptual change is needed. In the past, interactive simulations have had some success in helping students understand emergent mechanisms. We propose that a serious (or educational) game may be equally or more effective at facilitating conceptual change with game design that enables instances of productive negativity – a player may attempt a challenge and fail under their current misconception, and then must re-evaluate their understanding in order to succeed.
We designed a serious game, MolWorlds, as well as a non-game interactive simulation (control), MolSandbox, to evaluate the effectiveness of additional game design elements in helping to resolve molecular misconceptions. We tested first- and second-year biology students’ misconceptions at the beginning and end of the Fall 2015 semester (n=485), a subset of whom played either the game (n=14) or control (n=14) for 30 minutes prior to the post-test. Data from third-year biology students is currently being collected and analyzed to determine if similar trends are observed in more advanced learners. We performed a repeated measures ANOVA to determine how educational level (first- or second-year biology) and intervention type (no intervention, simulation, or game) affected students’ molecular misconceptions over the course of a semester. While educational level did not have an effect on misconceptions, the intervention type did (p<.001). Post-hoc pairwise comparisons showed that participants who were not exposed to any intervention retained significantly more misconceptions in comparison to those exposed to the interactive simulation (p=.011) as well as those exposed to the game (p=.001). However, no significant difference was found between the simulation and the gaming groups (p=.528). That is, both interventions appeared to be equally effective at reducing misconceptions. This may be due to: 1) our sample size may have been too small to detect an effect; 2) the game is inherently more challenging than the simulation, resulting in several participants having insufficient time to finish the game, thus limiting its effect; 3) productive negativity was achieved through the simulation in an unforeseen manner. Gameplay data is currently being analyzed to investigate further. Future studies should ensure sufficient time for game players to experience the full game.

Abstract # 10  (Poster Sat # 21)
Development of a Professional Society Mentoring Program to Promote Active Learning and Teaching
Amy Prunuske*, University of Minnesota; Susan Wick, University of Minnesota; Mike Wolyniak, Hampden-Sydney College

Many current and future instructors have heard the call to develop more active learning, inquiry, and authentic research experience in undergraduate science courses, but the implementation of these types of experiences can be daunting. In addition, not all active learning experiences result in the desired critical thinking outcomes, which suggests a need for strategies to help support effective implementation of active learning. To address these challenges, we have developed the Mentoring in Active Learning and Teaching (MALT) Program through the American Society for Cell Biology (ASCB). At the K-12 level, long-term mentorship programs have been a successful strategy to build educators’ skills and confidence. Mentees in the program request to be paired with a mentor through the ASCB website. Most of the mentee applicants to the program have been postdoctoral fellows, interested in acquiring teaching experience. Using contacts on the ASCB Education Committee, we identified mentors who have experience in active learning and are geographically close to the mentee. A small subset of the mentoring pairs submitted proposals to receive funding to support travel, supplies, and a mentor stipend. To date, we have coordinated 26 partnerships and have collected data from surveys and interviews with the mentees and mentors. Individuals who received funding recorded an active learning session for assessment using the Classroom Observation Protocol in Undergraduate STEM. Mentees reported gains in writing learning objectives, implementing active learning, and using assessments to evaluate learning. Mentors reported benefits from their participation in the program in having the mentees bring in cutting edge cell biology techniques into their classrooms. Another advantage of the program is removing the hierarchical and confidentiality challenges that occur when mentoring pairs are both located at the same institution and the mentor may need to make promotion decisions about the mentee. We have implemented additional program milestones and guidelines based on mentor and
mentee feedback. Thus, mentoring programs like MALT can be an effective way to improve the quality of science education by supporting instructors in the translation of scientific research into the classroom.

Abstract # 11 (Short Talk Sat )
**Efficiently and effectively teaching genetic drift through hands on data analysis in a computer simulation**
Rebecca Price*, University of Washington Bothell; Denise Pope, SimBio; Joel Abraham, CSU Fullerton; Susan Maruca, SimBio; Eli Meir, SimBio

Evolution instruction typically focuses heavily on natural selection, but an approach that interleaves different processes of evolution may lead to a more scientifically accurate understanding of evolution. A challenge is for instructors to find materials that help students learn a variety of processes within the time frame allowed in already-packed curricula. In the simulation Genetic Drift and Bottlenecked Ferrets by SimBio (www.simbio.com) students learn genetic drift by exploring the effects of sampling error, inbreeding depression, and population size on the changes in allele frequency on a population of endangered black-footed ferrets. Students also have the opportunity to create a ferret reintroduction plan that is likely to maintain the genetic diversity of the newly founded wild population. The whole module takes one-to-two hours to complete. We tested the hypothesis that this interactive approach to teaching genetic drift improves students' understanding and reduces misconceptions relative to traditional methods. We compared the performance of students in 19 courses that used the simulation to the performance of students in five courses that did not. We used the Genetic Drift Inventory to measure students' understanding of key concepts and common misconceptions about genetic drift before and after instruction. We found that students in classes who completed the interactive module obtained a more sophisticated understanding of genetic drift. Moreover, students in the control courses performed significantly worse on the Genetic Drift Inventory after instruction. These results make two contributions to our understanding of how students learn genetic drift. First, having students consider data and test their predictions can help them understand key concepts and dispel misconceptions. Earlier research suggested that students need to distinguish among different mechanisms of evolution before they could develop an understanding of genetic drift, but students in this study seemed to learn both of these within the timeframe of pre/post testing. Second, students who are introduced to the concept of genetic drift but lack the opportunity to think

Abstract # 12 (Poster Fri # 50)
**Assessing the Impact of Course-Based Undergraduate Research Experiences on Novices' Attitudes and Motivation in the Biological Sciences: A Multi-Institutional Perspective on Historically Underrepresented Individuals in the STEM Disciplines**
Jeffrey Olimpo*, The University of Texas at El Paso; Denise Borja, The University of Texas at El Paso; Jesse Nelson, Washington State University; William Davis, Washington State University

Within the last decade, course-based undergraduate research experiences (CUREs) have emerged as a viable mechanism to promote novices’ development of scientific reasoning and process skills in the STEM disciplines. Recent evidence within the bioeducation literature suggests that student engagement in such opportunities not only increases their appreciation for, and interest in, scientific research, but also enhances their ability to “think like a scientist.” Despite these critical outcomes, few studies have objectively explored CURE vs. non-CURE students’ development of attitudes and motivation in the discipline, particularly among groups historically underrepresented in the STEM fields. To address these concerns, we adopted a mixed methods approach to evaluate the aforementioned outcomes following implementation of novel CUREs in three introductory cell/molecular biology courses across multiple, diverse
institutional contexts. Preliminary results indicate that CURE participants at each institution exhibited statistically significant gains on both attitudinal and motivational constructs relative to their non-CURE counterparts, including increases in self-efficacy, enjoyment, and problem-solving strategies (as measured via the CLASS-Bio and BMQ). Furthermore, descriptive interpretive analyses of end-of-term Student Perceptions of Learning (SPL) survey data suggest that structural features of the CUREs, such as increased student autonomy and peer-peer interaction, potentially mediate these gains. Collectively, this research provides novel insights into the benefits achieved as a result of CURE participation and can be utilized to guide future development and evaluation of authentic research opportunities in the domain.

Abstract # 13 (Poster Sat # 49)
Identification of Cognitive and Non-Cognitive Predictors of Hispanic Students’ Development of Scientific Process Skills in an Introductory Biology Course
Jeffrey Olimpo*, The University of Texas at El Paso; Dania Yin, The University of Texas at El Paso; Lynnsay Marsan, University of Texas at El Paso

In an effort to engage students in authentic aspects of scientific inquiry as well as to prepare them to be competitive in an increasingly globalized STEM workforce, recent efforts within the science education community have focused on the implementation and evaluation of curricula designed to enhance novices’ development of scientific process skills in the STEM domains. Despite these efforts, little remains known about the various factors that predict the development of these skills, particularly among students who self-identify as Hispanic. To address this concern, we adopted a quantitative approach to examine the extent to which various demographic, cognitive, and non-cognitive factors were predictive of novices’ abilities to design an experiment (E-EDAT) and analyze biologically relevant findings (Analysis Task)—two components identified as constituting scientific process skills development within the literature. Attitudinal and motivation data generated as a result of administration of the Colorado Learning Attitudes in Science Survey—Biology (CLASS-Bio), Biology Motivation Questionnaire II (BMQ), and Attitudes Toward Mathematics Inventory (ATMI), coupled with collected demographic data, were utilized as inputs within a series of multiple linear regression models. Results indicate that while problem-solving strategies ($\beta = 0.206; p = 0.016$), ability to recognize conceptual connections between phenomena ($\beta = 0.194; p = 0.023$), and highest biology course completed in high school ($\beta = 0.124; p = 0.048$) are unique, positive predictors of E-EDAT performance, mathematics self-efficacy ($\beta = 0.159; p = 0.013$) and GPA ($\beta = 0.170; p = 0.006$) uniquely predict student performance on the Analysis Task. Collectively, these data offer a foundation for guiding future curriculum development and teaching approaches in the biological sciences in a manner best designed to enhance novices’ development of scientific process skills in the domain.

Abstract # 14 (Poster Fri # 14)
Guided investigation using simulated computational models improves student thinking about cellular respiration system
Heather Bergan-Roller*, University of Nebraska Lincoln; Nicholas Galt, University of Nebraska-Lincoln; Tomas Helikar, University of Nebraska-Lincoln; Joe Dauer, University of Nebraska-Lincoln

Thinking about biological phenomena from a systems perspective has been defined as essential for undergraduate biology students. Unfortunately, it is difficult for learners new to thinking about systems to consider the components, relationships, and processes within a system. We have developed a learning approach where students learn about biological systems through guided investigations using simulated computational models. These learning activities have been purposefully designed with evidence-based best practices to facilitate conceptual understanding
and enhance systems thinking skills. In one activity, students investigate cellular respiration (CR), a biological system that is commonly difficult for students and ubiquitously taught in biology curriculum. We investigated how the guided investigation impacted student thinking about CR. We implemented the CR learning activity in the introductory biology laboratory course and assessed learning with pre and post conceptual models. Chronologically, the learning activity consisted of a pre-laboratory reading and reading comprehension assignment, a conceptual model of CR (Pre), the guided investigation, and a conceptual model of CR (Post). Students in half of the 40 sections of laboratory also engaged in a group conceptual modeling activity immediately after completing the Pre model. Students generated conceptual models in the box and arrow format informed by Structure-Behavior-Function theory to show the events of CR. We took a stratified random sample of student models based on laboratory sections (n=144) and analyzed the quantity and interconnectedness of structures and the quantity and quality of relationships on Pre and Post models. Additionally, we examined how the group modeling activity impacted models. Student who did the group modeling activity created conceptual models similar to students who did not do the group modeling activity (p > 0.05). From pre to post, students created larger models (p < 0.001) with 22% more structures (effect size = 0.65) and 30% more relationships (effect size = 0.69). Post models were 57% more interconnected (p < 0.001, effect size = 0.86) and 5% more accurate (p < 0.05, effect size = 0.21) than Pre models. These results suggest that the guided investigation is a useful activity to facilitate student learning of the CR system. We are continuing to research how guided investigations impact learning, specifically by looking at the local environment of structures, performance on CR exam questions, and association to mechanistic reasoning.

Abstract # 15 (Poster Fri # 15) Integrating Tree-Thinking into Plant Diversity Improves Student Understanding
Tyler Kummer*, BYU; Jamie Jensen, Brigham Young University

Tree-thinking is the ability to interpret, communicate with, and analyze evolutionary trees. Tree-thinking is an important component to understanding biological diversity and to biological literacy in general. Integrating tree-thinking into diversity courses is a natural connection because the evolution of the organisms is what gave rise to the diversity we see today. In addition to learning tree-thinking studying diversity via tree-thinking has the potential to enhance student learning of diversity content by reducing the cognitive load necessary to learn the traits that a given set of taxa have. To test the effectiveness of using tree-thinking as a tool to teach biological diversity by reducing cognitive load we conducted three studies. The first study was designed to test whether using an evolutionary tree to learn diversity could reduce cognitive load and increase learning of diversity. We randomly assigned students into two groups: one that studied characters using a matrix the other using evolutionary trees. We found that students using evolutionary trees performed significantly better on an assessment measuring the characters of a set of taxa. The final two studies were done to see if learning in this experimental setting translated to learning in actual courses. We used a control group and a tree-thinking group to test the learning of biological diversity at a unit level and a course level. The unit level was a one week survey of diversity in a non-majors course. Students were divided into groups with one group learning using trees and the other learning without them. We found that those in the tree group significantly outperformed their peers in the non-tree group on the unit assessment. The final study integrated tree-thinking on a course-level into two plant diversity courses. One course had tree-thinking integrated into the labs, lectures, and assessments. The other course did not emphasize tree-thinking but did use evolutionary trees as part of lectures and one lab. Measures included the BCI, an assessment of tree-thinking used to compare student understanding of tree-thinking at the end of the course, and an assessment of plant diversity content knowledge used to compare student understanding of
plant diversity. Students in the course with tree-thinking integration had statistically higher scores on both the assessment of tree-thinking and the assessment of plant diversity content knowledge. This study provides evidence that using tree-thinking as a course theme enhances student learning of biological diversity and should be integrated into diversity courses.

Abstract # 16 (Poster Fri #)
Do students view biology as nothing more than a vast collection of facts? An instrument to measure epistemic beliefs in biology (EBIB)

Steven Kalinowski*, Montana State University

Student beliefs regarding knowledge and learning—often called epistemic beliefs or personal epistemologies—are likely to influence how students learn science. For example, students who believe biology is nothing more than a vast collection of facts may fail to learn important concepts. Measuring epistemic beliefs is notoriously hard. The goal of the work presented here was to develop a new self-report instrument, the EBIB (Epistemic Beliefs in Biology), to measure three components of epistemic beliefs in college biology students. The development process of the EBIB was difficult and included 11 rounds of data collection. In particular, the research team struggled to find a reliable method to assess how students viewed the structure of biological knowledge. This led the team to redefine the traditional epistemological construct of “Simple Knowledge” in a way that is appropriate for biology and to find a new instrument format to measure student beliefs. The resulting instrument assesses three constructs: 1. The extent students believe there are important concepts in biology that explain many aspects of the living world, 2. The extent students believe different concepts in biology are related to each other, and 3. The extent students believe their performance in biology courses is influenced by innate abilities. Student interviews and psychometric analysis of student responses supported the reliability and validity of the EBIB. This instrument appears to provide more reliable estimates of its constructs than its predecessors. Administration of the EBIB to students in an introductory college biology course showed most students believed biology topics are highly related, and that most students believed they were smart enough to do well in biology, but that many students did not believe there are highly explanatory concepts in biology. All three constructs on the EBIB were correlated with conceptual change. Implications for instrument development and instruction will be discussed.

Abstract # 17 (Round Table Fri)
Scientific reasoning skill promotes conceptual change in college science students

Steven Kalinowski*, Montana State University

Students entering introductory college science courses frequently have misconceptions regarding the natural world. For example, biology students often believe species evolve because individuals adapt to their environment and pass these changes to their offspring. Many students retain these misunderstandings even when instruction is specifically designed to promote conceptual change. The goal of the work presented here was to identify characteristics of students that promote conceptual change in college science courses. The research team is studying the role of five variables: scientific reasoning skills, motivation, epistemology, study practices, and biology content knowledge. This presentation will focus on scientific reasoning. Data for this study consisted of pre- and post-instruction assessment of student understanding of natural selection and assessment of students’ scientific reasoning skills in an introductory biology course. The instruments used for this work were developed by the research team and validated using expert review, student interviews, and psychometric analysis. Structural equation modeling was used to quantify the relationship between scientific reasoning skill and conceptual change. The model incorporated several novel features that reduce bias and increase the power of the statistical analysis. Results showed a strong relationship between
scientific reasoning ability and conceptual change: students with more advanced scientific reasoning ability were more likely to correct misconceptions than their classmates. Over half of the variation in post-instruction test scores (assessing how well students understand natural selection) could be attributed to variation in scientific reasoning ability. Similar results were found in three other science courses, including physics and astronomy. These results have important implications for revising instruction: taking time to teach students' basic scientific reasoning skills could increase the amount of science content students learn.

Abstract # 18 (Poster Sat # 61)
**Exploring Increased Learning Gains in Student-Centered Learning Environments: A Qualitative Study Using Self-Determination Theory**
Kimberly Pigford, NC State University; Miriam Ferzli*, NC State University

Student-centered learning is a constructivist based approach to the classroom setting in which the student becomes an active participant in their own learning. While there is strong evidence that active learning works, there is a lack of research exploring what specific aspects of active learning result in higher student performance. Research on student motivation and its effects on performance could shed light on higher performance trends in classrooms utilizing active learning strategies. This study examined students’ perceived reasons for their motivation and performance in an introductory biology course taught using the SCALE-UP format (Student-Centered Active Learning Environments with Upside-down Pedagogies). Data was collected during two focus groups and coded a priori using self-determination theory as a theoretical perspective. Self-determination theory is an organismic-dialectic theory that posits that individuals are naturally driven to explore and grow as individuals when placed in a nurturing environment that provides for three basic needs: competence, autonomy, and relatedness. In an education setting, when these three needs are supported in the classroom, students are more likely to internalize their motivations leading to autonomous, self-regulated learning and higher performance. Results indicated students feel that SCALE-UP has positively affected their performance and motivation in regards to introductory biology. Data coding revealed that student’s comments conformed to self-determination theory with the psychological needs of relatedness and competency as the prominent emergent themes. The study suggests that active learning environments will be most effective when they are developed to meet students’ needs for autonomy, competence, and relatedness. • Key Words: Student affect: motivation, self-efficacy; Theoretical /Predictive Frames; Research on effective Instruction

Abstract # 19 (Poster Fri # 51)
**Implementation and Evaluation of a Course-Based Undergraduate Research Experience on Seafood Mislabeling for Biology Majors**
Blaire Steinwand*, UNC Chapel Hill; John Bruno, UNC Chapel Hill; Kelly Hogan, UNC Chapel Hill; Lisa Corwin, University of North Carolina Chapel Hill

Course-based undergraduate research experiences (CUREs) engage students in authentic, hypothesis driven research early in their college careers. CUREs increase self-efficacy, technical and analytical skills, content knowledge, and persistence in science. These positive outcomes can also result from a research internship or apprenticeship but students must seek these opportunities and self-select to enroll in them. CUREs make research experiences accessible to a greater diversity of students. At the University of North Carolina, approximately half of the undergraduates majoring in biology have the opportunity to conduct research during their college career. In effort to support more of our students and increase retention in the major, we developed and implemented a CURE called “Seafood Forensics.” In this CURE, students use genetic identification to determine the frequency of seafood mislabeling in their community. We are using different instruments to measure outcomes from this CURE and comparing results
from our CURE to a traditional laboratory course. Here we report the design, implementation, and results of our CURE.

Abstract # 20 (Short Talk Fri)
**Effect of Model Building and Model Investigation on Student Learning of Gene Regulatory Networks**
Joe Dauer*, University of Nebraska-Lincoln; Heather Bergan-Roller, University of Nebraska-Lincoln; Nicholas Galt, University of Nebraska-Lincoln; Tomas Helikar, University of Nebraska-Lincoln

The ability to use models and simulations are considered core competencies for undergraduate biology students. However, ‘use’ can involve a spectrum of skills from passive observation of graphs to creation and interpretation of models ranging from conceptual to computational. Biology instructors frequently incorporate models in their classrooms (e.g., graphs, figures, flow charts) and less frequently allow students the opportunity to practice modeling. Theoretically, model building should result in better conceptual knowledge and improved modeling skills compared to observing a pre-constructed model, but few have empirically tested this claim. We examined the changes in student conceptual knowledge for students investigating pre-constructed computational models compared to students building their own computational model. Students in the lab portion of introductory biology course simulated gene regulation in a computational modeling activity during a single lab period, using computational modeling software, (http://learn.cellcollective.org). Students read background information on gene regulation and specifically the lac and trp operons prior to the lab period. All students completed a conceptual model of gene regulation at the beginning of the class period and the same conceptual model at the end of the class period. Three self-selecting graduate TAs taught one section with students investigating (n=57) and one section with students building (n=32). We analyzed student Pre/Post conceptual models to determine changes in the quantity of structures included in student models and quality of the relationships among those structures. Conceptual Pre models were similar between Investigating and Building. Students included 8 structures in their model (9 were provided), connected these structures, on average, with 7.4 relationships, and used similarly low quality relationships (1.64 Building, 1.74 Investigating, scale from incorrect (1) to scientifically accurate (3)). On the Post models, Building students included fewer structures (avg: 8.5 to 9.1) and fewer relationships (avg: 7.5 to 8.3) than Investigating students. While Investigating students maintained their level of relationship quality, Building students improved their average relationship quality (1.84, p < 0.04, effect size=0.42). Despite the additional cognitive effort required to build a computational model from scratch, the iterative process of building and revising their own model allowed Building students to focus more intensely on how fewer structures were related within a gene regulatory network. As biology community looks to improve undergraduate students’ core competencies in modeling and simulation, it is important to consider the ways instructors can create opportunities for students to achieve mastery in these skills and improve conceptual knowledge.

Abstract # 21 (Poster Fri # 16)
**Supporting undergraduates’ science-informed decision-making about biofuels**
Jenny Dauer*, University of Nebraska-Lincoln

Science literacy, or knowledge of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity, is a shared goal for instructing postsecondary students (NRC, 1996). To foster science literacy in our classrooms we must foreground using science to support decision-making about challenging real-world issues. To confront this need, we developed a unique undergraduate general science course for that provides scaffolding for students’ science-informed decision-making about
complex socioscientific issues (Dauer & Forbes, submitted). In the course we ask students to use a six-step decision-making framework that asks students to be explicit about: 1) multiple potential choices for a solution to an issue, 2) scientific information that informs the outcome of a choice, 3) values that play a role in deliberation of choices 4) evaluation of tradeoffs of each choice based on values (Ratcliffe, 1997). We investigated if students’ classroom experiences using the six decision-making steps transferred to unscaffolded, open-ended reasoning about the issue. One of the units focused on biofuels—a crucial issue for our nation’s energy future. Specifically, we asked, “how do we find a renewable, energy dense fuel for transportation that doesn’t increase greenhouse gases?” During the six decision-making steps, students evaluated potential courses of action in solving that problem. We expected students’ unscaffolded opinions after the course to more fully connect to the problem, contain fewer misconceptions about biofuels and less emotive reasoning. To investigate students’ transfer of practices supported by the six decision-making steps to unscaffolded reasoning about biofuels, we compared students’ (n=53) open-ended opinions about corn ethanol biofuels at the beginning and end of the semester. Student answers were coded for an overall pro, con or neutral statement. Each supporting statement that a student gave was coded to describe the type and quality of argument according to the following: 1) scientific/functional connection to the purpose of biofuels, 2) non-functional and/or containing misconceptions, and 3) emotive (Kuhn, 1997). Overall, student responses showed some (not statistically significant) improvement with slightly more scientific arguments and less emotive arguments. We found that many students (42%) changed their overall position on use of corn ethanol, a sign of deeper reasoning and learning about the issue. However, students may need more support in developing high-quality, science-informed arguments. This work underscores the challenge in fosters students’ science-informed decision-making.

Abstract # 22 (Short Talk Sun )

Exploring the Impact of Jargon on Student Learning in Biology: Student Understanding, and Self-Perception of Understanding, of Technical Vocabulary
Lisa McDonnell*, University of California San Diego

The ability to communicate and collaborate is a core concept in biology education1, and includes mastery of both conceptual ideas as well as technical vocabulary. The “jargon load” is a particularly prominent hurdle in introductory biology courses, which are notorious for the vast quantity of new terms, often more than in a high school language course2. Previous research has shown that the jargon load can negatively impact learning3, 4. However, little work has been done to widely characterize student understanding of biology-specific jargon, and to distinguish between types of jargon and reasons why they may differently impede student learning. The purpose of this study was to assess students’ actual and self-perceived understanding of various biological terms presented in lower and upper division undergraduate biology courses in order to determine 1) the types of terms that students struggle with most, 2) the interaction between self-perceived and actual understanding, and 3) identify common errors in their understanding. In three large undergraduate biology classes, students were given an online survey about the specific terms they had seen in the course; the survey prompted them to assess their recognition and understanding of each term, as well as give definitions in their own words. This analysis includes a total of 93 vocabulary terms with over 2,400 student responses. The terms were grouped into thematic categories to facilitate analysis. Comparing self-perceived understanding, we found that students struggle the most with molecular terms (e.g. names of molecular structures). Interestingly, there was a significant difference between student’s self-perceived understanding and their actual understanding, and these differences vary between types of jargon. The least accurate self-assessment was found for the following categories: Information (describing information transfer processes), and Incompatible Ambiguity
(terms with precise scientific meanings that are used less precisely in everyday language). Analysis revealed that students often showed an overestimation of understanding; for example 83% of respondents claimed to understand the incompatible ambiguity terms, but only 27% percent provided correct definitions. The findings of this research provide insights about which technical vocabulary may indeed be jargon, and possibly create a barrier to developing deeper conceptual understanding. Additionally, our results shed light on the variation in types of jargon, and highlight a need to consider student understanding of different types of jargon to support learning and scientific literacy. 1 American Association for the Advancement of Science (AAAS). 2009. www.visionandchange.org. 2 Groves FH. 1995. School Science and Mathematics, 95, 231–235. 3 Brown BA, and Ryoo K. 2008. Journal of Research in Science Teaching, 45(5), 529–553. 4 McDonnell L, Barker MK, and Wieman C. 2015. Biochemistry and Molecular Biology Education.

Abstract # 23 (Round Table Sat )
Biology Education Research 2.0 Faculty Journal Club
David Matthes*, University of Minnesota, Twin Cities

The intense disciplinary training biology faculty receive prepares them to be content experts able to discern themes and trends in biology to share with their students. Their absence of significant training in "how" to teach, however, makes it likely that their approach to teaching will often center on the instructor as information source, focus class time on content-coverage, and rely on high-stakes testing for most of their student assessment. The major barrier to their adoption of a scientific teaching approach and skillful implementation of evidence-supported practices, in fact, is that they aren't familiar with – much less conversant with – biology education research (BER) that is deeply relevant to their work as instructors and guides to students in the classroom. In our department we have initiated a weekly journal club for interested faculty and staff to discuss the scholarship of teaching and learning focused on college STEM education. Our journal club has brought us together as colleagues, provided a regular opportunity to read and discuss articles that use methodological approaches distinct from those most of us are most familiar with, and begin to understand the evidence that can be gathered to assess teaching practices and student learning. In this way we become thoughtful and critical consumers of discipline-specific education research and better positioned to be practitioners informed by studies others have done and scholars who contribute work of our own to this new field. This poster will describe the literature on best practices for professional journal clubs that informed our journal club design, and some of the outcomes that we've seen after one academic year of weekly journal club meetings.

Abstract # 24 (Poster Sat # 50)
Characterizing student’s critical thinking and reflection in undergraduate biology laboratory courses
Lisa McDonnell*, University of California San Diego

A primary goal of undergraduate laboratory courses is to develop student’s scientific practices, which includes critical thinking skills. In the context of a biology laboratory research problem, critical thinking can involve (but is not limited to) reflecting upon and evaluating results, troubleshooting, and planning for iteration. Previous work, in various disciplines, has documented how novices struggle to (and often do not) engage in reflection, evaluation, and iteration1-4. To support student’s development of strong critical thinking skills we need to understand how students engage in these processes, and what pedagogical methods increase the likelihood that students will develop the desired skills. Although there is an emerging body of literature on the impact of course-based undergraduate research experiences on student’s perceptions of research and skills5, 6, there is a need to characterize and measuring student’s
critical thinking skills, such as reflection and evaluation, in biology laboratory courses. This project aims to characterize student’s critical thinking behaviours in two undergraduate lab courses, by measuring the frequency and quality of student reflections and evaluation of results, and plans for iteration. The data set consists of student lab note book entries from a lower division CURE (n=100) and upper division inquiry based lab course (n=150) and responses to surveys about scientific thinking. Preliminary analysis reveals that less than 50% of students include signs of evaluation and reflection in their work, and no plans for iteration. Analysis of student student’s perspectives of what it means to do scientific research and think scientifically reveal varied views, and a low proportion of students incorporating the need for evaluation and iteration. Student’s propensity to reflect, and the quality of reflections and evaluation, have also been evaluated after specific supports were imbedded in the course to encourage these ways of thinking. These small supports have resulted in a significant increase in the quality and frequency of reflection and evaluation, and increased awareness for the value of iteration. The results of this work are necessary to inform future lab course development, and better support students to develop scientific thinking skills. Cited Works: 1 Holmes. 2015. Thesis available at: http://circle.ubc.ca/handle/2429/51363; 2 McDonnell and Mullally. 2015. JCST, in press); 3 Schoenfeld. 1987. Cognitive science and mathematics education (pp. 189–215). Psychology Press; 4 Mayer. 1998. Instructional Science, 26(1-2), 49–63; 5 Corwin et al. 2015. CBE Life Sciences Education, 14(1); 6 Brownell et al. 2015. CBE Life Sciences Education, 14(2), 14.

Abstract # 25 (Short Talk Sun )

Integrating concepts in biology (ICB) approach increases learning: Assessment triangulation using concept inventory, card-sorting task, and MCAT, followed by longitudinal tracking

Douglas Luckie*, Michigan State University; Anne-Marie Hoskinson, Michigan State University; Caleigh Griffin, Michigan State University; Andrea Hess, Michigan State University; Katrina Price, Michigan State University; Alex Tawa, Michigan State University; Samantha Thacker, Michigan State University

A strong foundation gained in introductory biology can lead to success in upper-level STEM courses and beyond (Derting 2010). The purpose of this study was to look for evidence of impact of an intervention, a textbook, Integrating Concepts in Biology (ICB), when added to a year-long introductory biology course sequence already practicing reformed pedagogies. The ICB textbook rigorously implements “science practices” recommended by Vision and Change (AAAS 2011). Student learning was evaluated using three published instruments; the Biology Concept Inventory (BCI) (Klymkowsky 2008), Biology Card Sorting Task (Smith 2013), and a MCAT instrument (Luckie 2012). We hypothesized the ICB curriculum would boost conceptual expertise and longitudinal performance but perhaps negatively impact short-term gains in content knowledge. (1) The BCI concept inventory was selected because it probes depth of student mastery of fundamental concepts in both organismal and cellular topics when confronting strong distractors based on frequent misconceptions. On end-of-year post-tests, ICB students had significantly higher gains in all categories (Δ43% overall, p<0.01) than peers enrolled in comparable introductory biology courses using reformed pedagogies but traditionally content-focused textbooks. (2) The Biology Card Sorting Task is designed to assess whether students organize biological ideas superficially, as novices tend to, or based on deep concepts (evolution, energy and matter), as experts tend to do. In end-of-year post-tests, the frequency with which ICB students connected two deep concepts (a pair) were similar compared to peers, but generating triplets of deep concepts was higher, more indicative of expertise (59% vs 48% p<0.01). (3) A content-focused MCAT post-test, administered annually since 2000, was used to compare ICB student content knowledge to prior years. Historically, MCAT performance ranged from 53% to 64%, and the ICB cohort earned a 62%. In addition, longitudinal tracking into five
upper-level STEM courses revealed the ICB cohort as a whole statistically outperformed final course scores of peers in Physiology-310 (85% vs 80%, p<0.05) but no significant difference was found for other courses. Tracking a sub-cohort of “fully engaged” ICB students (removing students who rarely used the online ICB textbook) revealed the sub-cohort outperformed peers in all 5 upper-level courses, and gained significance for Biochemistry-401 (96% vs 71%, p<0.05). Overall our findings support those of Barsoum 2012, where performance of the ICB cohort also surpassed peers at end-of-year, and suggest the ICB approach may enable learning gains beyond those found in traditional or reformed courses using content-focused textbooks.

Abstract # 26 (Round Table Sat )

Broadening Participation in Biology Education Research (BER): Engaging Community College Students & Faculty

Lisa Corwin*, University of North Carolina Chapel Hill; Jeff Schinske, De Anza College; Linnea Fletcher, Austin Community College; Joe Gorga, Diablo Valley College; Jenny McFarland, Edmonds Community College; Anjali Misra, Florida SouthWestern State College; Apryl Nenortas, Clovis Community College; Matthew Tuthill, Kapiolani Community College

What would it mean for biology education research (BER) if the colleges enrolling half of all undergraduates were left unstudied? How would it complicate efforts to understand biology teaching and learning if these colleges enrolled the majority of underserved students in STEM? How might it impact initiatives in pedagogical transformation if the faculty teaching these students did not feel they could engage in BER? We will nucleate a discussion around these critical questions in a roundtable session on community college biology education research (CC BER). Community colleges (CCs) serve roughly half of all students receiving STEM degrees and enroll the majority of students from underserved/underprivileged groups (Tsapogas, 2004; AACC, 2016). For these reasons, CCs are broadly recognized for their potential to influence early undergraduate biology learning and broaden participation in STEM (National Academies, 2012). Despite this, a review of ten journals that regularly publish BER revealed that less than 3% of BER articles since 2012 include either a CC biology study context or a CC affiliated author. Further, the majority of individuals conducting CC BER appeared to be four-year faculty, with CC faculty representing only 49% of authors listed on existing CC BER articles. These findings raise two concerns: 1) As a BER community, we might be unaware of valuable teaching/learning strategies arising in CC biology contexts – particularly those advancing biology interest and learning among underserved populations. 2) As advocates of pedagogical transformation, the lack of CC faculty involvement in BER could hinder efforts in CC biology education reform. Faculty engagement in systematic evidence collection in their own teaching contexts is a key driver of change (Handelsman et al., 2007; Holme et al., 2010). Thus, a lack of CC involvement in BER represents a missed opportunity to promote change at CCs. During this roundtable, we will report on the recent, NSF-funded Building Capacity for Biology Education Research at Community Colleges Meeting, which sought to address these issues by characterizing the affordances and constraints of conducting CC BER. The meeting also gave rise to hypotheses about how to broaden participation of CCs and CC faculty in BER. We are interested in receiving feedback on the role of the SABER community in promoting and supporting future CC BER efforts and in discussing the feasibility of hypothesized next steps designed to increase representation of CC contexts and authors in the BER literature.
Abstract # 27  (Short Talk Sat )  
**Tree Thinking Meets Perceptual Psychology: Toward an Explanation of Students’ Difficulty Understanding Evolutionary Relatedness**  
Laura Novick*, Vanderbilt.edu

**Theoretical Background**  
Tree thinking—the ability to interpret and reason with the relational information depicted in evolutionary trees, particularly cladograms—is an important aspect of 21st-century science literacy (e.g., Novick & Catley, 2013; Thanukos, 2009). Unfortunately, many studies have documented students’ difficulty understanding how cladograms depict evolutionary relatedness among taxa (e.g., Author et al., 2016; Dees, Momsen, Niemi, & Montplaisir, 2014; Novick & Catley, 2013). Psychological research indicates that the Gestalt principles of grouping (e.g., proximity, similarity, connectedness) determine how diagrams and other visual stimuli are segmented into discrete parts (see Wagemans et al., 2012, for a review). Because these parts constitute experienced perceptual objects, which are the units of cognition, the Gestalt principles affect performance on a variety of tasks, including how spatial relations are represented and remembered (e.g., Coren & Girus, 1980; Maki, 1981; Stevens & Coupe, 1978). In two studies, I tested Author et al.’s (2016) hypothesis that students’ interpretations of evolutionary relatedness are influenced by how taxa are grouped visually.  

**Research Description**  
In the Comparison Study, 20 college students evaluated two pairs of cladograms. In the pair shown in Figure 1, duck is in a different group than platypus and kangaroo in Cladogram A, whereas all three taxa are in the same group in Cladogram B. As predicted, most students responded that Cladogram A provides stronger evidence for the scientist’s claim concerning the evolutionary relatedness of these three taxa (see Figure 1), chi^2(2) = 9.70, p < .01. In the Inference Study, 22 college students completed a set of inference problems (e.g., see Figure 2). I manipulated whether the taxon that provided the incorrect answer (the “adjacent taxon”) was in the same or a different visual group than the taxon for which the inference was to be made. As predicted, students made more correct inferences in the different group (M = 2.41 out of 3) than the same group (M = 0.68 out of 3) condition, F(1, 21) = 56.57, p < .001, h^2p = 0.73. These results provide initial evidence for the critical role played by general principles of perceptual cognition in students’ interpretations of evolutionary relatedness. Students’ explanations for their answers provide a richer understanding of their use of connectedness to inform judgments of evolutionary relatedness. Future research should investigate (a) the boundary conditions of grouping effects and (b) instructional strategies for overcoming these unwarranted perceptual influences on tree thinking.

Abstract # 28  (Short Talk Sat )  
**Survey of Teaching Beliefs and Practices for Undergraduates: A Novel Assessment Tool**  
Gili Marbach-Ad*, University of Maryland

We present a novel assessment tool for measuring biology students’ values and experiences across their undergraduate program. With universities transitioning to models of teaching that incorporate evidence-based teaching approaches, it is necessary to devise methods of assessment that can accurately measure the impact of changing teaching practices. Our Survey of Teaching Beliefs and Practices for Undergraduates (STEP-U) allows for assessment of how much students value skills needed for the workplace (e.g., ability to work in groups), as well as student experiences with teaching practices purported to promote such skills (e.g., groupwork). The survey was validated through factor analyses in a large sample of biology seniors (n=1389) and through response process analyses, in which we interviewed five biology students and assessed their understanding of items. The STEP-U skills items (14 items) were characterized by two underlying factors conceptually consistent with Mayer’s two major categories of learning: Retention (i.e., memorization and remembering information) and Transfer (i.e., more meaningful learning processes, such as applying material to novel situations). These factor scales showed
high internal consistency (.69-.89). Pearson’s correlations indicated that underrepresented students reported valuing Retention skills to a greater extent than non-underrepresented students. Students with lower GPAs valued Retention skills to a higher degree than students with higher GPAs. Gender did not differentiate students on either subscale. Multiple linear regression models (MLR) allowed us to examine specific relationships between classroom experiences, values, and student demographics. All MLR models showed that more experience with a teaching practice was associated with increased value for the corresponding skill. For example, being exposed to groupwork in class was associated with an increased value for groupwork. Regarding demographics, females valued real life examples more than males, and students who participated in a research experience placed a higher value on scientific writing and understanding the interdisciplinary nature of science than students without research experience. Students with lower GPAs valued groupwork more than those with higher GPAs. This study provides an easy-to-administer, valid survey, which when coupled with other measures, can be used by departments to evaluate the impact of adopting evidence-based teaching practices from the perspective of students. Future directions include exploring the use of the STEP-U in longitudinal analyses or in multiple disciplines (e.g., chemistry, physics). Initial analyses pertaining to the use of the STEP-U in these groups will be discussed.

Abstract # 29 (Poster Sat # 9)
Assessing the Subject Matter Knowledge of Beginning Biology Teachers: A Large-Scale, National Longitudinal Study
Kimberly Linenberger*, Kennesaw State University; Sarah Holcomb, McEachern High School; Gene Ray, Kennesaw State University; Gregory Rushton, SUNY StonyBrook

As part of a federally funded grant, we seek to answer fundamental questions regarding our nation’s ability to successfully recruit and prepare highly qualified secondary biology teachers for positions in public and private K-12 schools, as such empirical data is lacking. Using longitudinal data from content knowledge exams for beginning teachers, we will share outcomes regarding the trends in performance by the test-taking population demographics, such as undergraduate major, race, gender, self-reported undergraduate GPA, and years of teaching experience. Both aggregate and subscore analysis will be performed to indicate the extent to which beginning biology teachers have demonstrated competence in fundamental concepts such as molecular and cellular biology; genetics and evolution; diversity of life and organismal biology; and ecology. Implications for biology and biology education courses, curriculum, and assessment will be discussed.

Abstract # 30 (Round Table Sat )
The impact of pedagogical instruction and feedback on future faculty teaching beliefs
Jessica Stephens, University of Georgia; Cara Gormally, Gallaudet University; Peggy Brickman*, University of Georgia

Feedback can play an important role in motivating faculty to improve teaching practices and institutions are increasingly recognizing the importance of providing faculty with formative instructional feedback. While much research has focused on how to provide effective feedback for established faculty little is known about the impact of feedback for future faculty. Here, we look to examine the impact of instruction and formative feedback on future faculty teaching beliefs in two seminar courses designed to provide formal training to graduate teaching assistants. More specifically, we are interested in whether pedagogical feedback from peers and mentors with more similar teaching beliefs are attributed greater value than feedback from peers and mentors with differing teaching beliefs. In addition, how does formal pedagogical instruction influence teaching beliefs of future faculty? To assess these research aims, student teaching beliefs were evaluated pre, mid, and post instruction and both verbal and written feedback
among students and mentors was scored based on multiple qualitative categories. Results highlight factors responsible for a shift toward learner-centered teaching beliefs and increased ability to provide critical feedback. These findings help elucidate challenges in this apprenticeship-model program. We propose that the increased ability to provide critical feedback and pedagogical instruction may be a novel method to identify facility and confidence with evidence-based teaching practices.

Abstract # 31 (Short Talk Sun)
Assessing students’ motivations for actively learning.
Michael Moore*, Oklahoma State University; Jennifer Parrish, Middle Tennessee State University; Grant Gardner, Middle Tennessee State University; Donald French, Oklahoma State University

While the positive effects of active learning methods in undergraduate biology classes are well-supported by the literature, why and how they are most effective is still an area of speculation. As students’ persistence in biology majors and courses across the nation remains low, it is imperative that we as researchers and instructors understand exactly how the active learning methods we use directly affect our students’ meaningful engagement with the content. In this presentation, we will offer practical advice on the design and execution of several active learning techniques in large undergraduate biology courses, based on our research on their likelihood to motivate students. People have speculated that simply making students active participants in the classroom could be the driving factor behind increasing student performance; however, making students participate actively when they either do not want to or do not perceive a benefit can be detrimental to their learning. Students learn best when they are intrinsically motivated to do so. In light of this, we examined the hypothesis that active learning techniques achieve their effect by increasing student motivation. More specifically, we examined whether each of several active learning techniques met three basic needs that, according to self-determination theory, increase intrinsic motivation. Those three needs are autonomy (having a sense of choice), competency (knowing what you do and do not know) and relatedness (feeling connected to others). The active learning techniques employed were classroom response devices (clickers), small group work, whole class discussion, video lectures, Verso® (a web-based student response software), and exams. We examined students’ perceptions of how the instructional techniques used supported the three motivational needs. The samples were taken from introductory biology courses at two universities, using a modified version of the intrinsic motivation inventory. Students varied in their previous knowledge of and experiences with biology from no high school experience to a few college biology courses. Classes contained 50 to 120 honors, non-honors, majors or non-majors students ranging from freshman to seniors. We collected data from spring 2015 through spring 2016. We will report on similarities and differences among types of students and active learning techniques based on the findings of the research and discuss their implications for the active learning classroom.

Abstract # 32 (Poster Sat # 17)
Departmental teaching climate: A conceptual framework to guide research and reform efforts
Tessa Andrews*, University of Georgia; Erin Dolan, University of Texas at Austin; Evan Conaway, University of California--

Undergraduate biology instructors have been slow to adopt evidence-based teaching practices, despite high-profile calls for reform. Departments are a potentially important unit of change, because this level of organization most immediately affects faculty in institutions of higher education. Departments communicate expectations and performance standards to faculty and influence faculty recruitment, hiring, and evaluation. However, we currently lack theory about
how departments impact the adoption and sustained use of evidence-based teaching strategies. It is critical that institutional change efforts—which are now a target for funding agencies—are guided by prior research. We synthesized theoretical and empirical work from higher education, organizational and cultural studies, and other fields regarding “departmental teaching climate,” a useful conceptual framework to guide research and reform in undergraduate biology education. We define “reformed” climates as those that promote the adoption and effective use of evidence-based teaching strategies. The conceptual framework describes three dimensions of reformed departmental teaching climates: Dimension 1—teaching is viewed as an expertise to be developed and continuously improved, Dimension 2—teaching is viewed as an important element of what faculty do, and Dimension 3—evidence-based teaching is championed by leadership. Identifying these dimensions is insufficient, however, because they are not easily observed, nor is it obvious how to achieve them. Therefore, the conceptual framework also links specific departmental practices with one or more dimensions of a reformed climate. For example, faculty development professionals rank hiring practices that require demonstration of teaching ability among the top policies for contributing to improved teaching in a department. If teaching expertise must be developed just like research expertise, then a faculty interview should require demonstration of both research and teaching ability (Dimension 1). Requiring a teaching demonstration also communicates to interviewees and to departmental faculty that teaching is an important part of faculty work (Dimension 2), and therefore is part of the criteria used to select new faculty. Our primary aim in presenting a conceptual framework of departmental teaching climate is to guide future research on how departments affect teaching, and how departmental changes can promote education reform. Therefore, we report the strength of evidence supporting each departmental practice and highlight areas in need of additional research.

Abstract # 33 (Round Table Sat )
**Implementation, assessment and expansion of an interdepartmental Learning Assistant (LA) program**
Nadia Sellami*, UCLA; Kevin Eagan, UCLA; Shanna Shaked, UCLA; Erin Sanders, UCLA

In response to national calls to increase STEM student retention and restructure biology curricula, the UCLA Life Sciences Core Education Department is transforming its large-enrollment introductory Life Science courses into student-centered, highly structured, interactive learning environments. To facilitate the student-centered pedagogy and interactive learning environments, we have created a Learning Assistant (LA) program. LAs facilitate discussion sections, hold office hours, support in-class activities such as think-pair-share clicker questions and worksheets. LAs receive training to facilitate active learning pedagogy in the form of a highly active and reflective pedagogy seminar. It has been previously demonstrated that using LAs in Physics courses leads to increased student learning gains (Otero et al., 2010). The focus of our LA program is to 1) facilitate the transformation toward more student-centered classrooms and 2) improve student learning and retention in STEM majors. Our assessment strategy therefore includes concept inventories, self-reported measures of science identity and engagement, and student demographic data. To broaden the impact of the program, we are collaborating with the Physics and Chemistry departments at UCLA and have implemented LAs in select large-enrollment introductory classes in each of these departments. The LAs for courses in the different departments participate in the same pedagogy seminar, broadening the LAs’ exposure to diverse strategies and approaches to facilitating active learning. We will discuss our initial assessment of the effect of LAs on learning gains and self-reported measures of effectiveness, as well as our plans to expand the program to other courses and departments. We will also present our strategy to maximize LA effectiveness and how to use them to further facilitate the transition to student-centered pedagogies.
Using the Three-Dimensional Learning Assessment Protocol to Characterize Exams in Gateway Science Courses
Becky Matz*, Michigan State University

The 2012 National Research Council report, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, introduced the idea of three-dimensional learning as a guide to help students develop a robust understanding of science. Three-dimensional learning helps instructors to define what they want students to learn (core ideas), what they want students to do with their knowledge (scientific practices), and how students should connect their knowledge in one scientific discipline to another (crosscutting concepts). Multiple projects and activities at our institution have encouraged faculty to improve gateway courses by incorporating the three dimensions into their assessments and instruction. We developed the Three-Dimensional Learning Assessment Protocol (3D-LAP) as a tool for characterizing the potential for assessment tasks to elicit evidence of three-dimensional learning. Our goal is to identify whether change has occurred over three years by using the 3D-LAP to characterize the tasks on high-stakes exams from introductory courses. Three years of data will be presented, including approximately 4,000 assessment items from 90 sections of 8 biology, chemistry, and physics courses.

Scientist Spotlight Homework Assignments Shift Students' Stereotypes of Scientists and Enhance Science Identity in a Diverse Introductory Biology Class
Jeff Schinske*, De Anza College; Heather Perkins, North Carolina State University; Amanda Snyder, De Anza College; Mary Wyer, North Carolina State University

Research into science identity (Brickhouse 2000), stereotype threat (Steele 1997) and possible selves (Steinke 2009) suggests a lack of diverse representations of scientists could impede traditionally underserved students from persisting in science. However, faculty might refrain from adopting class activities directly addressing issues of diversity due to a lack of training on approaching the topic in class (Sue 2009) or due to concerns that such activities might impact grading time or content coverage (Austin 2011). We developed a series of metacognitive assignments (Scientist Spotlights) to feature counterstereotypical examples of scientists in an introductory biology class at a diverse community college. Each week students reviewed biographical information about and scientific contributions by diverse scientists matching course topics and responded to metacognitive prompts as homework. We used a mixed-methods, quasi-experimental approach to evaluate four null hypotheses surrounding implementation of Scientist Spotlights: 1) no correlation between completion of Scientist Spotlights and use of counterstereotypical descriptions of scientists, 2) no correlation between completion of Scientist Spotlights and ability to personally relate to scientists, and 3) no correlation between shifts in stereotypes/relatability and science interest or 4) course grades. Students completed beginning and end-of-course essays and quantitative surveys during each of five Scientist Spotlight (n=338 students) and two quasi-control (n=126 students) courses to assess scientist stereotypes, relatability, and science interest. Scientist Spotlight students additionally completed surveys six months after the courses as a longitudinal assessment. Reviewers coded essays to characterize scientist descriptions as stereotypical/counterstereotypical with reference to the literature and identified themes regarding scientist relatability. Quantitative data derived from coding essays were used to evaluate our hypotheses using Repeated-Measure ANCOVAs.
controlling for student demographics, course section, and science class experience. Students’ essays shifted from including 19% counterstereotypical descriptions of scientists to 54% after completing Scientist Spotlights (p<.001) and conveyed an enhanced ability to relate to scientists (from 2.1 to 3.0 mean relatability Likert ratings, p=.004). These shifts were not apparent in quasi-control settings, permitting rejection of Null Hypotheses 1-2. Longitudinal data suggested these shifts were maintained six months after class. We further observed positive correlations between these shifts, interest in science, and course grades, permitting rejection of Null Hypotheses 3-4. As Scientist Spotlights require little class time and complement existing curricula, they represent a promising tool for enhancing science identity, shifting stereotypes, and connecting content to issues of equity and diversity in a broad range of science classrooms.

Abstract # 36 (Poster Sat # 40)
Implementation and Impact of Student-Centered Pedagogy in Large Biology Courses
Nadia Sellami*, UCLA; Liz Roth-Johnson, UCLA

In an effort to address the nationally recognized STEM retention problem at UCLA, we are implementing a more student-centered pedagogy in the introductory biology curriculum. Because these courses serve approximately 2,000 undergraduate students each year, changing the way they are taught stands to impact a broad swathe of potential STEM majors. By creating more active, student-centered classroom environments, we hope to increase STEM retention and improve student learning in these courses. Here we describe our strategy to roll out and assess this curricular reform. This strategy includes a faculty mentoring plan to overcome possible implementation barriers such as resistance to change and fear of increased time commitments. Specifically, faculty work in team with dedicated Discipline-Based Education Research (DBER) Fellow postdocs to incorporate new technology and transition lecture-based courses to highly structured, interactive (“flipped”) classrooms. To determine whether our curricular changes are having the desired effect, we are implementing a mixed-method assessment plan devised to evaluate the new curriculum’s impact on both students and faculty stakeholders. Our preliminary findings include measures of student learning as well as affective measures such as self-reported academic ability and sense of belonging in traditional versus flipped classrooms.

Abstract # 37 (Poster Fri # 41)
How can we help students understand the primary literature? Insights into the approaches that allow students to better comprehend research articles.
Miriam Segura-Totten*, University of North Georgia; Kristen Howard, University of North Georgia; Emma Thomaswick, University of North Georgia; April Nelms, University of North Georgia

Reading and analyzing the primary literature increases critical thinking, scientific literacy, and student confidence. However, students often struggle with understanding primary research articles, especially in introductory and lower level courses. We are interested in determining the hurdles that students face when trying to understand a research article. We hypothesized that these obstacles will differ between under- and upperclassmen. Our long-term goal is to use the knowledge we gain from this initial study to design strategies for analyzing the literature that are well suited for students at different levels of the college experience. To examine differences in reading the scientific literature, and to determine how these differences may prevent students from understanding an article, we conducted individual “think aloud” sessions with upper- and underclass biology majors. During these sessions, students would think aloud as they read a research article. To elicit metacognition, we designed a set of questions about the article that students had to answer orally as part of the exercise. These were interspersed throughout the article. We transcribed, coded, and qualitatively analyzed these interviews. We found that both
under- and upperclassmen encountered unfamiliar jargon in the article. However, upperclassmen utilized more tools than underclassmen to better comprehend the text, such as: re-reading, underlining, note-taking, and summarizing the text in their own words. Upperclassmen also looked up unfamiliar words more often than underclassmen. We are currently analyzing what tools students who correctly answered the in-text questions used, so we can determine the specific approaches that allowed students to better comprehend the material. While upperclassmen showed greater scientific literacy and critical thinking skills than underclassmen, they still encountered difficulties with understanding statistical analyses, as well as with synthesizing and analyzing information. Our data suggest techniques that students can utilize to better understand a research article, as well as skills that faculty can develop within courses to aid students in the understanding of primary literature.

Abstract # 38 (Short Talk Sun)

Using multiple-true/false clicker questions to identify and correct student misconceptions
Joanna Hubbard*, University of Nebraska-Lincoln; Brian Couch, University of Nebraska-Lincoln

In-class response systems, or clickers, are useful formative assessment tools that support learning by providing real-time feedback that can be used to correct misconceptions through peer discussion and instructor guidance. Questions are typically asked in a multiple-choice (MC) format in which students identify one preferred answer; however, this format cannot identify students with mixed conceptions, where they simultaneously hold correct and incorrect ideas. Conversely, multiple-true/false (MTF) questions, which challenge students to separately evaluate each answer option, have the potential to identify mixed conceptions. To determine the effectiveness of MTF clicker questions for identifying mixed conceptions, we designed an experiment in which students in two sections of introductory biology taught by the same instructor were asked the same clicker question in either MC or MTF format. In both sections, students answered individually, discussed with an assigned group, re-voted, and were provided an explanation by the instructor. While, on average, only 35% of students selected distractors in the MC format on the first vote, more than 80% of students demonstrated incomplete understanding of the corresponding MTF questions. Furthermore, clicker pedagogy recommends skipping peer discussion if more than 70% of students initially answer correctly; six of 16 experimental questions met this cut-off when presented as MC. However, when asked as MTF in the other section, 73% of students selected incorrect statements in addition to the correct statement, demonstrating that many students hold mixed conceptions that would be left unaddressed in the MC format. To test whether clicker question format influences later performance, we used a full factorial design in which students in each section answered exam questions that were isomorphic to in-class clicker questions in either the same or opposite format. We found no effect of clicker question format on exam performance; however, our ability to detect an effect may have been limited as both sections were encouraged to discuss every answer option regardless of question format and received the same instructor explanation. MTF clicker questions are an effective formative assessment tool for identifying mixed conceptions among students and offer instructors an alternative method for implementing clicker pedagogy. More work is needed to understand how clicker pedagogy can best be implemented to effectively correct misconceptions.

Abstract # 39 (Poster Sat # 54)

Changes in Confidence and Judgement Accuracy for Non-majors Students
Andrea Nicholas*, UCI

This study investigates how perceptions of confidence and judgement accuracy change for students during large non-majors biology courses. Students were asked to report confidence
ratings while answering test questions that were presented in either a multiple choice or a multi-choice format. Judgment accuracy measures show students' ability to predict correct or incorrect answers during the exam. As expected, improvement in confidence and judgement accuracy following exposure to test taking over the quarter was observed, but not for all students. Influence of question content, task difficulty, gender and URM status on confidence and judgement accuracy in non-majors will be presented.

Abstract # 40 (Short Talk Sat)
Implementation and Evaluation of the MUET Curriculum in an Introductory Organismal Biology Course
Yi Kong*, The University of Texas at El Paso; Jennifer Apodaca, The University of Texas at El Paso; Jeffrey Olimpo, The University of Texas at El Paso

Within the last decade, various educational interventions have been implemented in an effort to improve novices’ tree-thinking abilities within introductory biology contexts. Although select interventions have been found to be effective at accomplishing this goal, research indicates that these interventions are often integrated into existent curricula as “single purpose” (e.g., construction of trees) modules and, as such, might therefore fail to promote students’ acquisition of expert-level tree-thinking abilities. To address these concerns, we developed a two-session curricular module based on the Model of the Use of Evolutionary Trees (MUET), a conceptual model that details the essential knowledge and skills employed by professional biologists when they utilize evolutionary trees in the context of conducting scientific research (e.g., using evolutionary trees to show chronology, homology, and homoplasy). Individuals enrolled in nine sections of an introductory organismal biology laboratory course (n = 164) at a mid-size, doctoral degree-granting institution in the Spring 2016 semester participated in this research. Using a quantitative, pre-/post-intervention study design, participants’ tree-thinking abilities were assessed using the MUET survey, a validated diagnostic consisting of items selected from previously published assessments. These assessments included, for instance, Baum et al.’s (2005) Tree-Thinking Quiz I and Naegle’s (2009) Tree Thinking Concept Inventory (TTCI). Participants’ self-reported knowledge, experience, and confidence in utilizing tree-thinking skills was furthermore evaluated. Results of a Mann-Whitney U test demonstrated that students who self-reported that they had received prior instruction about evolutionary trees were more confident in their tree-thinking abilities than those students who had not (U = 2646.5, p = 0.046). Furthermore, students (n = 99) who had prior experience with evolutionary trees performed significantly better on the pre-MUET survey (M = 6.46, SD = 1.75) than students (n = 65) who did not (M = 5.66, SD = 2.01) (t(162) = -2.708, p = 0.008). Paired t-test data indicated a statistically significant improvement in student performance following participation in the MUET curriculum (t(163) = -7.587, p <.0005). Collectively, these results suggest that the MUET curriculum can be used in introductory biology contexts as an effective approach to assist students in developing expert-level tree-thinking abilities.

Abstract # 41 (Poster Fri # 1)
PowerPoint Use in the Undergraduate Biology Classroom: Perceptions and Impacts on Student Learning
Emily Smith*, Middle Tennessee State University; Grant Gardner, Middle Tennessee State University; Ryan Otter, Middle Tennessee State University

Biology Education Research is now entering a new phase; it has moved from trying to discover what methods are effective to why those methods are effective and how those methods can be implemented in a classroom setting. This study focuses on the use of and perceptions that biology students and faculty hold about PowerPoint in undergraduate introductory biology classes in an attempt to understand how PowerPoint composition can best promote student
learning when used as an advanced organizer. PowerPoint has been used almost ubiquitously across college classrooms in the last fifteen years. Best practice advice for slide construction usually suggests images along with bullet points or short textual explanations. However, Dual Coding Theory suggests that using words on PowerPoint slides in association with instructor reading of the material may cause unnecessary overload of the learner’s visual channel. This research utilized a Likert survey taken by Bio 1 (first semester biology course) (n = 427), Bio 2 (second semester biology course) (n = 86), and Senior Bio students (n = 41) as well as faculty participants (n = 29) at a large Southeastern university. Student grades from two PowerPoint construction treatments were also compared as a data source. Our research demonstrates that while all levels of students and professors agree that images on PowerPoint slides are beneficial to learning (F(3,581)=0.15, p=0.927), students perceive text on slides is beneficial while professors remained neutral (F(3,580)=6.85, p<0.001). While all levels of survey-takers found PowerPoint to be useful and effective, Bio 1 and Bio 2 students found it more effective than Senior Bio students who found it more effective than faculty; faculty responses were significant from all other categories (F(3,571)=21.71, p<0.001). When test scores were looked at from two different PowerPoint construction treatments over multiple semesters of an introductory Biology course (enrollment per semester 87 ± 7 students), taught by the same instructor, visual only slides were far superior to visual and text slides in promoting student learning as measured by course assessments; an average increase in test score of 5.73% was seen (t(1871)= -5.04, p<0.001). Perhaps most interesting is that students traditionally struggling in the class, those below the 75th quartile, saw the most significant gains in semester averages. With calls from AAAS to improve student learning in classes with traditionally high drop out rates, our data indicate that simple adjustments may help increase student learning for groups who customarily struggle with the content.

Abstract # 42 (Poster Sat # 51)
What Students Don’t Know: Analyzing Students’ Questions About Experimental Research and Primary Literature
Brian Rybarczyk*, UNC Chapel Hill; Amanda Raimer, UNC Chapel Hill

The role of student-generated questions in educational discourse and the knowledge construction process is important to investigate in the context of how students develop scientific thinking skills. However, instructors typically provide few opportunities for students to pose questions about scientific experimentation in the context of reading primary literature. This study aimed to: 1) identify the types of questions students ask while reading primary literature 2) determine differences in the types of questions posed based on gender and 3) determine how the types of questions changed over time. We hypothesized that all students would ask more complex questions at the end of the semester indicating more expert-like scientific thinking. Data were collected from 4 semesters of an upper-level undergraduate biology course focused on disease mechanisms. Students (n=117, 67.5% female, 33.5% male) were all senior biology majors. Students were asked to read articles prior to in-class discussion and respond to the prompt “what was confusing/unclear to you about the article?” Students’ statements/questions (n=150) were collected in response to the first article in the course and the last article in the course (n=116). An established hierarchical scheme for classifying questions was used to analyze the statements and was modified to accommodate the context of reading primary literature. Students’ questions were coded with primary codes: properties, comparisons, and causal relationships. Secondary codes were used to further characterize students’ confusions (factual information, explanation, methodology, visual interpretation, and prediction). Application of the coding scheme resulted in interrater-reliability of alpha=0.83 for primary code assignment and alpha=0.82 for secondary code assignment. Inter-rater disagreements were discussed until consensus was achieved. Only 2 statements were discarded after initial analysis since a code
assignment could not be determined. The majority of the students’ questions (60%) were coded as properties, suggesting that students were primarily challenged with lower order aspects while reading journal articles. Students posed more questions at higher levels (comparison or relationships) in response to the last article in the course as compared to the first article (chi-square=8.19, p<0.05). Results also showed that students’ questions focused on explanations (43%), methods (38%), and visual interpretations (13%) with similar distributions between the first and last articles. There were no significant differences in the distribution of the types of questions based on gender (chi-square, n.s.). This study provides an approach to uncover students’ metacognitive skills, identifies students’ challenges with reading primary literature and helps inform the design of future educational interventions to support students’ scientific thinking.

Abstract # 43 (Poster Fri # 17)
**What’s in a prerequisite? A mixed-methods approach to identifying the impact of a prerequisite course.**
Usman Alam, UC Irvine; Jennifer Dang, UC Irvine; Amanda Lee, UC Irvine; Samantha Dacanay, UC Irvine; Brian Sato*, UC Irvine

The very existence and commonality of prerequisites in undergraduate STEM education is built upon the assumption that they enhance student learning in subsequent courses. We have previously established a tool for evaluating the efficacy of prerequisites via “familiarity”, which highlights the degree to which a tested concept was covered in a prerequisite (very familiar (VF) – students should be able to answer the question based on the prerequisite, familiar (F) – the concept was touched upon in the prerequisite, not familiar (NF) – the concept was not discussed in the prerequisite) (Shaffer et al. 2016). We apply this same scale in the present study focusing on a microbiology lab course with a suggested, but not required, prerequisite microbiology lecture course. Consequently, we were able to compare performance on microbiology lab exam questions in the context of content familiarity (designated by prerequisite lecture slides and course instructors) for two populations of students, those who had taken or had not taken the suggested prerequisite. Data from two quarters of the microbiology lab course found that students who had taken the prerequisite lecture course did no better on VF or F exam questions relative to students who did not. We followed up these results with a qualitative study examining student perceptions of the value of prerequisites, for both the microbiology lecture/lab series and in general. From these results, we identified a majority of individuals who believed that the lecture course was not necessary for success in the lab, mirroring our familiarity analysis. While students highlighted a number of other examples in which they believed a prerequisite course was beneficial, many also expressed that they spent little time thinking about prerequisites when preparing for a new quarter and often viewed them mainly as an impediment for course enrollment and degree completion. Together, these results highlight the need to routinely assess the value of specific prerequisite courses, especially in light of their prevalence in higher education.

Abstract # 44 (opening Thurs)
**A familiar(ity) problem: A novel system for assessing the impact of prerequisite courses**
Brian Sato*, UC Irvine; Justin Shaffer, "University of California, Irvine"; Pavan Kadandale, "University of California, Irvine"

Prerequisites are ubiquitous in STEM curricula. However, the success of prerequisites in preparing students for later courses is rarely assessed. When they are, the most common methods involve identifying correlations in student performance between a prerequisite and a later course, or comparing the performance of students who have completed a prerequisite to those who have not. But these methods of assessment have inherent flaws or are difficult to implement in many curricula. In order to overcome these limitations, we have developed a novel
familiarity scale to determine whether concepts presented in a prerequisite course improve student learning in a later course. The core of our method involves classifying exam questions in the later courses into three categories (very familiar - VF, familiar - F and not familiar - NF) based on the degree to which the tested concept had been taught in the prerequisite. If content familiarity is important, exam scores on topics covered in the prerequisite (VF and F) should be higher than scores on new (NF) topics. We implemented this familiarity scale in two large enrollment biology courses at an R01 institution in the western US. Using multiple regression models and controlling for the Bloom’s level of each question, we found that scores for VF questions were greater than scores for NF questions in some cases. However, scores for concepts taught only briefly in the prerequisite (F) were indistinguishable from performance on topics that were only taught in the later course (NF). These results imply that superficially “covering” topics in a prerequisite does not result in improved future performance. Analysis of short essay answers indicates that while students retain and use knowledge from previous courses, the appropriateness of the usage was widely variable. Building on these results, we have transformed two large introductory biology courses taught by multiple instructors. Converting these courses to a student-centered, high structure format, at the expense of decreased content “coverage”, produced increased learning gains on a cumulative end-of-quarter assessment in all of the transformed courses. With the prominent role that prerequisites play in undergraduate STEM education, it is vital that their alignment to later courses is properly assessed. It is our hope that our assessment tool, which can be widely implemented, can help nucleate conversations amongst faculty teaching linked courses, and potentially lead to institutional change.

Abstract # 45 (Poster Fri # 18)
Assessing Assessments: Does Success Equal Learning?
Brian Sato*, UC Irvine; Cynthia Hill, Tufts University

Course grades in STEM curricula are heavily dependent on the assumption that our exams reward students based on their understanding of the material, and that high performing students are those that have mastered the course learning objectives. Despite the enormous impact that course exams have on students’ futures and the far-reaching consequences of these achievements on society post-graduation, there is little time spent validating exam performance in the same manner as one approaches the construction of a concept inventory. At a more basic level, we have little knowledge as to whether exam questions require complete understanding of the tested phenomenon to produce the instructor-accepted answer. To investigate the relationship between exam performance and understanding, we performed a series of modified think-aloud written or verbal interviews. Twenty-two students were presented with previously utilized exam questions and were instructed to present their complete train of thought in writing as they attempted to answer each question. Half of the students then participated in a think-aloud to better elucidate their thought process. We coded the written and interview responses based on an instructor-generated rubric to establish the exam-like performance for each student. Using this as a baseline, we assessed students’ work for their understanding of the concept or phenomenon. Taken together, we could identify students with the rubric-based “right” or “wrong” answer, and examine whether their understanding matched these scores. From this analysis, it is clear that there is a discrepancy between the ability of a student to correctly answer a question and the entirety of their understanding of the tested material. We observed cases where students were able to produce an answer that would result in full credit on an exam, yet there were clear flaws in their reasoning, and conversely where students incorrectly answered the question, yet had some understanding of the material. These results highlight the need to potentially re-evaluate our course assessments, to question what those assessments value as ‘learning’. While there are legitimate impediments that constrict the manner in which we can
assess our students, especially in large enrollment lecture courses, we think it is essential that students earn their grades based on their understanding of the material, as opposed to being more adept at foreseeing an answer key. Additionally, our work highlights the potential use of exams as tasks to enhance student learning, as student reflection of their answer choices can lead to improved understanding.

Abstract # 46 (Short Talk Sat )
The Scientific Teaching Practices Survey: A tool to measure the frequencies of Scientific Teaching practices in undergraduate science courses
Mary Durham*, University of Nebraska-Lincoln; Jenny Knight, MCDB; Brian Couch, University of Nebraska-Lincoln

The Scientific Teaching (ST) pedagogical framework aims to make teaching science more closely emulate how science is practiced by using data to inform teaching practices and by actively and inclusively engaging students in their learning. The core elements and supporting practices of ST have been previously defined in a taxonomy of practices called the Scientific Teaching Taxonomy, but as yet, no measure specific to this pedagogy is available. To address this need, we developed a survey derived from the ST Taxonomy to gauge the frequencies of ST practices in undergraduate science courses. To develop the survey, we drafted statements aligned with the taxonomy, and then interviewed ST experts, evaluators, instructors, and students to make iterative revisions to each statement. The completed online survey consists of 49 questions, primarily with Likert-like scales that capture the frequency of specific ST practices. We administered the survey in the Fall 2015 semester to both students and instructors in 64 courses at 9 institutions. On average, students and instructors completed the survey in less than 13 minutes. Internal reliability analysis showed an acceptable alpha of 0.92 for students and 0.89 for instructors. We also use factor analyses, combining a data-driven approach and a theory-driven approach based on the ST literature, to delineate 8 subscales. The 8 subscales that can be measured with the ST Practices Survey are Active Learning Strategies, Learning Goal Use and Implementation, Inclusivity, Instructor Awareness, Experimental Design, Data Analysis and Interpretation, Cognitive Skills, and Reflection. Although the ST Practices Survey was designed as a research tool, it can also be used as a development tool by individuals, departments, and programs to quantify and track changes in ST practices. For example, individuals can use the survey to identify frequent and infrequent practices, and to track changes in the frequencies of those practices from semester to semester. Departments and programs can thus identify heavily-used practices and tailor instructional development seminars and workshops to educate on and encourage the use of lesser-used practices. Furthermore, faculty development programs can use the survey to understand how participants’ practices change as a result of program participation.

Abstract # 47 (Round Table Fri )
Exploring Note Taking Strategies to Enhance Student Performance, Comprehension, and Recall in an Introductory Level Biology Course
Erin Duckett*, University of West Georgia

Most undergraduate students take a science course during their first two years in college. Many will likely attend a science class in a big lecture hall with more than one hundred students. One of the challenges of teaching an introductory science course is the reality that many undergraduate students are not prepared to be self-directed learners. Many students expect to earn a grade of A or B just like in high school. However, the failing results of the first exam can be a shocker to the students. Not only do the students not know the science content they studied, they had difficulties retaining and recalling the information. Patrick (2011) discussed how concept mapping helps students in their courses. Interviews with students reported that the
use of concept mapping facilitated students’ ability to determine relationships among concepts, sharpen understandings, and demonstrate an increase in critical thinking. Patrick concluded that high retention rates of learning had been observed when using concept mapping in studying for biology tests. Other researchers (Nesbit & Adesope, 2006) described the concept mapping method as a tool for enhancing teaching quality in higher education. They argued that the use of concept mapping could facilitate the transformation of abstract knowledge and understanding into concrete visual representations. It can be used to identify prior knowledge (and prior-knowledge structure) among the students as well as provide evidence of the integration of student prior knowledge and conceptual understanding. The concept mapping method also presents new material in ways that facilitate meaningful learning. This presentation will describe and discuss research that explores concept and visual mapping as a strategy in improving students’ performance, comprehension, and recall within a principles of biology I lecture course. It will engage interested audiences through the sharing of experiences based on data collected during a 14-week term. The changes and challenges experienced from data collection and analysis will also be discussed.

Abstract # 48 (Poster Sat # 35)  
**Using the cognitive clinical interview to identify instructional scaffolds in physiology**  
Matthew Lira*, Purdue University; Stephanie Gardner, Purdue University

Biology education researchers now seek to transition from a “what works” approach to understanding how instructional designs and learning mechanisms operate. We embrace this transition by exploring the cognitive clinical interview as a methodology utilized infrequently in undergraduate-focused biology education research. Leveraging this methodology, we designed a research protocol that aimed to identify how students engaged in mechanistic reasoning and systems thinking. The protocol extended the past efforts of others by (a) improving our knowledge of student cognition in one domain—neuroscience and (b) refining one analytic lens—the Structures-Behaviors-Functions framework. This framework describes systems in terms of their parts, their mechanisms, and their purpose, respectively. The framework therefore guides analysis of students’ conceptual understanding of a system by operationalizing the construct. Moreover, the framework holds pedagogical value because prior applications demonstrate that students’ conceptual understanding improves when instructors scaffold student learning with the framework. We embedded these and other learning opportunities for students based upon design principles identified by prior theoretical and empirical work on learning environments and the clinical interviewing method itself. Our protocol consisted of four broad tasks—defining terms, explaining phenomena and solving problems, drawing and comparing structures, and interpreting diagrams—that allowed us to contrast evidence from each task to identify instructional scaffolds. We used the context of these tasks to accomplish four instructional aims: frame the interview, activate prior knowledge, generate conceptual conflict, and guide attention and learning. We present a comparative scaffold analysis of how each of the four tasks enacts principled interviewing techniques as well as illustrate how features of the protocol’s design embedded scaffolds. In particular, we emphasize how students’ unsupported reasoning differs from their supported reasoning when students were introduced to the instructional diagram. Here, we theorized that when provided with the accurate structural information, students would shift towards more expert-like understandings that coordinated structures, behaviors, and functions. Preliminary findings from interviews show such learning events but only for students who demonstrated certain requisite knowledge of critical structures. In light of these findings, we discuss alternative instructional and research strategies for supporting students with lower content knowledge.
Abstract # 50 (Short Talk Sun)

**Using the Structures-Behaviors-Functions framework to assess students’ conceptual understandings in neuroscience**
Matthew Lira*, Purdue University; Stephanie Gardner, Purdue University

The complexity of biological systems emerges from interactions between many simple sub-units. Put another way, biological function (i.e. a life-sustaining purpose) emerges from interactive behaviors (i.e. mechanisms) between biological structures (i.e. the parts of the system). To develop literacy in biology, students should understand the concept of structure and function relations. Prior research in the Learning Sciences developed and applied the Structure-Behavior-Function (SBF) framework to account for students’ conceptual understandings. These studies demonstrate that when middle school students reason about systems, such as aquariums, they attend selectively to structures more so than behaviors or functions. In contrast, more expert-like populations coordinate the three ideas. At present, we know little about how the framework applies to other domains and populations. Neuroscience offers a practical extension because the domain examines wide varieties of neuronal structures that support wide arrays of corresponding functions through many signaling mechanisms. We therefore sought to (1) assess how the SBF framework accounted for undergraduate neuroscience students’ conceptual understandings of neural systems and (2) identify finer-grained knowledge constructs that appeared when students reasoned about these systems. We recruited upper division physiology students (n= 10) learning about neural circuits. Using cognitive clinical interviews in a laboratory setting (i.e. outside of the students’ classroom), we asked students to explain by talking and drawing how the knee-jerk response happens. We found that the SBF framework provides a generative tool for assessing students’ understandings because, like less experienced students, these students emphasize structures over behaviors and functions when describing neural circuits. Moreover, our finer-grain constant-comparative analysis revealed that when students reasoned about neural circuits, they (1) identified features and relations within and between structures, (2) specified initial conditions, mechanisms of action, and final conditions for behaviors, and (3) coordinated proximate (i.e. physico-chemical) and ultimate (i.e. evolutionary) explanations for functions. The frequency of these reasoning patterns, however, varied depending upon students’ prior course work—students with more neuroscience course work tended to describe the knee-jerk response in terms of its neural circuitry whereas other students tended to describe the response as a unidirectional cause-effect relation. We interpret these results as evidence that students’ conceptual understandings of neural circuits build upon knowledge of structure but we caution against linear teaching and learning progressions that first teach structures divorced from the behaviors and functions of a neural system.

Abstract # 51 (Poster Fri # 56)

**Differential student motivation on online, low-stakes, pre- and post-test assessments**
Justin Shaffer*, "University of California, Irvine"; Ethan Luong, University of California, Irvine; Kristen Yabuno, University of California, Irvine

Pre- and post-tests are used ubiquitously by education researchers to assess student learning gains during a course. Most often, these tests are implemented with no- or low-stakes, meaning that students are given little incentive for completing the tests. This may lead to decreased student motivation when completing the assessment, resulting in potential reduced performance (versus if the same assessment was given in a high-stakes situation, such as a final exam). Moreover, student motivation may be further affected when these low-stakes assessments are given in an online format versus in-class. To investigate the effects of student motivation on low-stakes course assessments, we analyzed student behavior on online pre- and post-tests in large enrollment (100+) majors and non-majors biology courses at a large research university taught in the quarter system (10-week courses). Behaviors including pre- and post-test
participation rate, time spent on the test, percentage of students exhibiting rapid-guessing behavior, students' ability to read the test carefully, and students' self-reported effort were compared in matched student samples from the pre-test to the post-test in ten courses. In the majority of cases, significant declines in these metrics related to student motivation were observed on the post-test compared to the pre-test. These data suggest that students are less motivated to complete online, low-stakes post-tests compared to pre-tests given in the same conditions. The bias in lower student motivation on post-tests may therefore underestimate post-test scores and thus may result in smaller learning gains. This hypothesis was only partially supported by this data set however, as when the "low-motivation" students were removed from the analysis, pre- and post-test scores only marginally changed in some of the courses. While differential student behavior and motivation did not have resounding effects on the learning gains on our pre-post tests, these data raise a critical issue regarding the efficacy of pre-post-testing and suggest that student behavior needs to be at least taken into consideration when using online, low-stakes pre- and post-tests to assess student learning.

Abstract # 52 (Short Talk Sat)

Using pre-class reading guides to improve student performance in introductory biology
Justin Shaffer*, "University of California, Irvine"; Rebekah Lieu, University of California, Irvine; Ashley Wong, University of California, Irvine; Anahita Asefirad, University of California, Irvine

Flipped courses and mid-to-high structure courses require students to obtain course content prior to class so that class time can be used for active learning exercises. While textbooks are used ubiquitously in college biology courses for content dissemination, studies have shown that students frequently do not read the textbook or have a difficult time understanding the content within. To address these issues, we created course-specific reading guides that provided students with a way to actively engage with the required reading for each day of class. The reading guides directed students to read specific textbook passages and to define terms, explain concepts in their own words, summarize information with tables and drawings, and answer in-chapter questions. To test our hypothesis that completing reading guides prior to class results in increased learning, we assessed the use of reading guides in two sections of a large-enrollment (400+ students) introductory biology course taught in the quarter system (10-week courses) at a large research university in the western United States. Reading guides were made available as word documents on the course website at least one week prior to each day of class, and while students were urged to complete them while reading the textbook prior to attempting graded online pre-class assignments, no course points or other incentives were given for completion of the reading guides. At the beginning of each day of class, students were asked to self-report their use of the reading guide associated with that day of class via a “clicker” question. Student reading guide use was correlated with midterm and final exam scores using multiple linear regression models controlling for SAT scores and pre-class assignment scores. Full completion of the reading guides prior to each day of class was significantly correlated with exam scores: for each reading guide that a student fully

Abstract # 53 (Short Talk Sun)

Group Type Affects Student Learning and Attitude in a Student-Centered Biology Class
Georganne Connell, Western Washington University; Deborah Donovan*, Western Washington University; Daniel Grunspan, University of Washington

The use of group work in university classrooms is recognized as important for implementing student-centered strategies. However, there is little evidence as to how groups should be formed in higher education. We examined the impacts of group composition on learning gains and student attitudes by testing three methods of group formation in a flipped, large-enrollment Biology course. For all three experiments, we used a pre/post content assessment to measure
content knowledge and the Student Attitudes towards Group Environments (SAGE) to measure attitudes about working in groups. In the first experiment, we administered a pre-assessment on the first day of class and used scores to classify students as low-, mid-, or high-aptitude (LowA, MidA, HighA). We randomly assigned students to groups such that half the groups were composed of students with the same aptitude (LIKE) and half had students with different aptitudes (MIXED). Using hierarchical linear models (HLM) to account for the non-independence between students in the same groups, we found that LowA students in MIXED groups had significantly greater content knowledge gains and better attitudes about their work compared to LowA students in LIKE groups. There were no significant differences between HighA or MidA students in different group types, suggesting that group composition is most important for LowA students. We next allowed students to self-select into groups. No groups of only LowA students formed. Thus, we investigated whether experiences differed between LowA students who worked in a group with a HighA student (18 students) or didn’t (29 students). Results from HLMs show no significant differences in content knowledge gains between LowA students in groups with at least one HighA student and groups without. While there was no direct effect of working with a HighA student on attitudes towards group work, there was a significant crossover interaction between the learning gains of LowA students and whether or not they worked in a group with a HighA student. LowA students working without a HighA student responded more positively about group work the worse they did, but LowA students with HighA students responded more positively about group work the better they did. Our final experiment is underway; we assigned students to groups using demographic data, focusing on GPA, previous science classes, race, and gender. After pre-assessment, we found that the demographic assignment resulted in 58% MIXED groups, 33% of groups containing only MidA and LowA students, and no groups with only LowA students. GPA was significantly correlated with pre-assessment score, suggesting its use as a factor when assigning students to groups. We are currently collecting post-assessment and SAGE data from this study. Together, these experiments show that group composition is particularly important for both the achievement and experience of students who are most at risk of failing.

Abstract # 54 (Short Talk Sun)

**Students’ choice of post-undergraduate career goal influences their opinions regarding usefulness of undergraduate upper level scientific laboratory assignments and course content.**

Lynne Gardner*, Iowa State University; Sydney Steinauer, Iowa State University; Claudia Lemper, Iowa State University

Recent research suggests that undergraduate science students gain an understanding of real-world scientific research when they are required to complete critical thinking exercises, such as reading of primary literature and completion of research projects. To address this need, we redeveloped Medical Microbiology Laboratory, a one-credit upper-level laboratory course required for microbiology majors, to include critical thinking and scientific writing assignments. Previous versions of the course relied upon “cookbook” experiments with known outcomes that provided little understanding of the realities of conducting laboratory research. Students enrolled in the course (n = 93) consisted of a variety of primarily science majors. Students completed surveys at the end of the Fall 2014 and 2015 semesters which asked them to rate the benefits of the course overall, an epidemiology project, an antibiotic discovery project, and weekly written case study assignments on a Likert Scale of 1 (Strongly Disagree) to 5 (Strongly Agree). Our study objectives were to examine whether career goals influenced students’ perceived benefits from the course overall, the research projects, and aspects of the course aligned with course learning outcomes. Students were placed into one of three groups based on post-undergraduate career goals (professional medical school (n=36), graduate degree in biological
sciences (n=38), or other/undecided (n=19)), and differences in opinions were examined among the three groups using paired t-tests for differences between mean Likert Scale ratings. We used one-sided t-tests to determine whether or not, on average, students in each category perceived selected parts of the course as beneficial (e.g., a mean Likert Scale rating ≥ 3.5). To test for significant differences in means between post-baccalaureate goal categories, we used Analysis of Variance and Tukey’s Honestly Significant Difference for multiple comparisons of mean Likert Scale ratings. In general, students in the other/undecided category ranked all aspects of the course of significantly lower benefit than those in the graduate and professional school categories. When examining specific learning outcomes of the course, students in the other/undecided category perceived reasoning skills, writing skills, basic research skills, and the ability to apply what they learned to courses both within and outside of science of neutral benefit, whereas students in the other two professional goal categories perceived these aspects of the course as beneficial. Therefore, post-baccalaureate career goals have a significant influence on perceived benefits from assignments designed to enhance critical thinking and technical writing skills in the classroom. This information is important when considering scientific laboratory course design and the impact of specific types of activities on both professional scientific and non-professional career oriented undergraduate students.

Abstract # 55 (Short Talk Sun )

Does question format matter? A comparison of number right elimination testing to free response questions.
Pavan Kadandale*, "University of California, Irvine”; KT Ho-Nguyen, University of California, Irvine; Garrett Long, University of California, Irvine; Fred Han, University of California, Irvine; Sabina Nussipov, University of California, Irvine

The assessment of learning, especially in large classes, is an ongoing challenge. Although most educators agree that free response (FR) questions are a better mode of assessment, the workload associated with grading them makes multiple choice (MC) exams the preferred choice in most large classes. Numerous studies have addressed the differences between the two formats, and highlighted several shortcomings of the multiple choice format, with one major issue being the prevalence of guessing. The Number Right Elimination Testing (NRET- which uses negative points to penalize wrong answers) modification to the traditional MC format has been shown to reduce guessing, and is a promising alternative to the traditional MC format. However, it has not been compared to the FR format. In this study, we directly compared student performance on identical questions in either the NRET or FR format in a large enrollment (400+ students) lower division biochemistry class at a RO1 university in the western US. For each of the three midterm exams and final, we created different versions of exams, each of which had a subset of identical questions in either the FR or MC format. We then compared student performance on these identical questions to study whether question format impacted student performance. Using multiple regression models to control for GPA, gender and ethnicity, we find that students somehow adapt to the NRET format. Early in the class, students perform better in the FR version of a question, but later in the class, perform better on the NRET version of a question. This effect is seen across all Bloom’s levels, although there is a large variation in the difference seen for individual questions. This large question-to-question variation, irrespective of Bloom’s level, leads us to conclude that whether students perform better at the NRET or FR formats of a question depends on some as-yet unidentified qualities of individual questions (or MC answer choices). Interestingly, despite the higher performance on the NRET version, the negative points associated with this format makes students almost universally detest it, as gauged by student responses in an end-of-class survey. We will discuss the implications of our findings in the context of assessing learning in large classes, and our
plans for identifying question characteristics that might impact student performance in the
NRET/MC formats.

Abstract # 56 (Short Talk Sun )
Scientific Process Flowchart Assessment (SPFA): An Interdisciplinary Method for
Evaluating Changes in Understanding and Visualization of the Scientific Process
Kristy Wilson*, Marian university

Assessing the scientific process and nature of science is difficult with methods that rely on
Likert scale or multiple-choice questions. We hypothesized that the evaluation of student-
created visual representations, that we termed flowcharts, would be more informative as they
demonstrate declarative knowledge, how the knowledge is organized, and relationships
between topics. Visualizations can represent student’s cognitive structures and mental models
and thus are important tools in assessment of student understanding. The methodology,
Scientific Process Flowchart Assessment (SPFA), consisted of a prompt and rubric that was
designed to assess student’s understanding of the scientific process. Flowcharts from
interdisciplinary group without intervention (n=40) and summer research program with pre and
post instruction (n=26) were evaluated over five dimensions. Each flowchart is ranked in each
dimension as 1- naïve, 2- novice, 3- intermediate, 4- proficient, or 5- expert. The dimensions
experimental design, reasons for doing science, and nature of science are evaluated based on
rubric guidelines concerning item counts within the flowcharts. The rater using rubric-suggested
criteria evaluates the connection and interconnectivity dimensions. For example the
interconnectivity dimension measures overall layout of items. A naïve rating is given if the
flowchart is linear or a list, and an expert rating if the flowchart is very interconnected with no
specific start. Inter-rater reliability demonstrated that the rubric is reliable. Focus group
assessments and the interdisciplinary sample supported the applicability of SPFA to multiple
disciplines. Pre to post instruction/experience flowcharts from the summer research
program showed a statistically significant improvement (Wilcoxon matched-pairs signed rank
test) in the number of items per flowchart from 13 ± 1 to 21 ± 2. Similarly, the average rating
score per flowchart shows a statistically significant improvement from 8.7 ± 0.5 to 14 ± 1
indicating a change from a novice rating to an intermediate rating over the 5 dimensions. The
greatest improvements were in the interconnectivity and nature of science dimensions.
Additionally, analysis of terms used and connections between terms were also evaluated to
reveal a more nuanced understanding of the scientific process. This was shown especially in
the communication with the scientific community and connection to society. We propose that
this method can be used in a variety of circumstances including in the determination of what
curriculum or interventions would be useful in a course/program, in determining misconceptions
held about the scientific process, in the assessment of curriculum, or in the evaluation of
students performing research projects.

Abstract # 57 (Round Table Fri )
Development of a survey instrument to assess course-based undergraduate research
experiences in an upper-division molecular pathophysiology course
Kristen Walton*, Missouri Western State University

There is a general consensus in the national biology education community that undergraduate
biology majors benefit from exposure to the scientific method through reading primary literature
and through participating in research projects. While out-of-class independent research projects
offer an in-depth experience, limitations in faculty time, lab space, and funding can restrict those
experiences to fewer students than would like to participate. One way to give a larger
proportion of students an authentic research experience is a course-based undergraduate
research experience (CURE). In my upper division majors course, Molecular Basis of Disease,
students spend the first 10 weeks of the semester learning techniques including histopathology, western blotting, immunofluorescent staining, ELISA, and DNA laddering analysis. In the last 5 weeks of the semester, they work in small groups of 3-4 students to design and complete a research project using at least two of the assays that they had previously used in the class. Informal feedback from the past 3 course offerings has suggested that this group project is well-liked by the students and a useful introduction to the process of cell and molecular biology research. I am in the process of developing a survey instrument to assess whether students’ attitudes towards research, understanding of the scientific process, and data analysis skills are improved by this CURE project. Feedback on the draft survey instrument will be solicited as part of the validation process for this instrument.

Abstract # 58 (Short Talk Sat )
Using the Knowledge in Pieces framework to design innovative learning environments that meet the needs of undergraduate physiology students
Matthew Lira*, Purdue University

Two essays on conceptual change appeared recently in CBE—Life Sciences Education. These essays presented alternative perspectives regarding how the biology education research community should characterize students’ incorrect ideas. From this dialogue a distinction between the theoretical constructs called misconceptions and intuitions emerged. Misconceptions refer to large-grained, stable, theory-like ideas. In contrast, intuitions refer to fine-grained, fragmented knowledge structures that are not stable or theory-like. I sought to identify students’ fragmented knowledge as described by diSessa’s (1993) Knowledge in Pieces (KiP) theory. I will present an unprecedented account that shows how to apply knowledge analysis to video data of undergraduate biology students explaining quantified phenomena. Because the KiP framework developed vis-à-vis classical mechanics, I sought to extend this framework into a domain that integrates concepts from physics and math—cellular physiology. I conducted two studies that aimed to (1) assess how undergraduate physiology students’ coordinate their knowledge of math and physics concepts, and (2) identify mechanisms responsible for how students develop new conceptual knowledge. First, to assess students’ (n=10) knowledge, I conducted cognitive clinical interviews that tasked students with explaining dynamic equilibrium and interpreting equations that described this phenomenon. Second, to understand students’ (n=30) conceptual change, I conducted a pre-/post-study that included a novel multi-representational learning environment as part of an intervention. Using knowledge analysis, I first identified that when students explained dynamic equilibrium they coordinated the disciplinary concept with their intuitions that systems just have a point of stability and that two influences just happen to balance. In contrast, when students interpreted equations of dynamic equilibrium they cued their intuition that one variable depends upon or is the same as another. Using eye-tracking and protocol analysis, I next identified that during the intervention students shifted from seeing dynamic equilibrium as just a point of stability to seeing it as two influences that just balance. This shift co-occurred with students’ demonstrating significant improvement across measurement occasions. This application of the KiP framework demonstrates that biology students, like physics students, leverage their intuitions and learning resources to shift from recognizing one influence to recognizing two in dynamic equilibrium. This conceptual shift re-frames students’ interpretations of equations as students shift from understanding two variables as the same physical quantity to distinguishing them as two different influences. With increased emphasis on infusing math into biology, these results suggest that during learning tasks instructors should allocate time for students to not only relate but also distinguish between physical quantities.
Revealing metarepresentational competence with graph choice and construction in expert and novice biologists
Aakanksha Angra*, Purdue University; Stephanie Gardner, Purdue University

The undergraduate education reform in the biological sciences suggests engaging students in the practices of expert scientists including: scientific inquiry, experimentation, and data communication. Graphs are ubiquitous among science practices, and creating effective graphical representations involve understanding and incorporating disciplinary knowledge and quantitative concepts and skills. Past studies have revealed student difficulties with graphing in the context of the classroom or national assessments, where student reasoning behind graphing choices was not evaluated. As part of a larger graphing project, the purpose of our work is to reveal differences associated with reasoning during the graphing process between undergraduate biology students and professors in a think-aloud, pen-and-paper task to graph data from a biological experiment. Here we (a) reveal the thought processes and reasoning associated with graph choice, and construction, and (b) describe the attributes of graphs constructed. This research study is guided by two frameworks: meta-representational competence (MRC) emphasizes a reflective approach to representation construction, and expert-novice comparison to understand how professors and students reasoning processes and strategy selections differ when they graph data. Under an approved IRB protocol, participants were recruited and divided into three groups: undergraduate students with no research experience (n=5), undergraduate with some research experience (n=4), and professors (n=5). We divided the process of graph construction into three phases (planning, construction, and reflection) based on Polya’s work and used this analytic decision to segment the transcript for coding. Each transcript was coded using inductive and deductive methods to identify patterns and categories that emerged from the think-aloud interview data. Inter-rater reliability was obtained and findings reveal that undergraduate students without research experience did not spontaneously provide insight into their thought process regarding data, variables, and graph choice during graph construction. In contrast, professors exhibited certain qualities such as: automatically reflecting and elaborating on their data and graph decisions, and aligning their final graph to the research question. When comparing graph quality between undergraduates’ and professors’ graphs, undergraduates included more mechanical components (i.e. title, axes labels, units, scale, and key), but professors overall plotted computational forms of data (i.e. averages with error bars and sums). These differences in the reasoning and strategies taken with graph choice and construction corroborate and extend previously reported findings. This work also informed the development of several graphing learning tools aimed at improving undergraduate student reasoning with graph choice and construction.

Blended Learning in a Flipped Undergraduate Genetics Class
Yunqiu Wang*, University of Miami, Florida

The most essential aspect of active learning is students’ intellectual engagement and investment in the learning process. To involve students into in-depth discussion and reflection of study topics in the classroom with large enrollment has always been a major challenge in almost all disciplines. Recent studies reported that blended learning model might hold the key to resolve this problem. Blended learning combines face-to-face classes with online learning modules, which makes it possible to enjoy the advantages of both teaching methods. In the past two years, I have applied the blended learning model in an undergraduate genetics class. To implement this model, I created and developed an online portion of the genetics course, comprising self-recorded video lectures, online animations, and Youtube videos that cover all
key theories, concepts, and processes in genetics. The online study material was arranged in a series of study units that correlate with the in-class lecture schedule. Students were required to watch the online course delivery and complete online interactive assessments for the assigned study unit before each in-class lesson. The in-class lesson is primarily reserved for students to engage in hands-on learning, collaborating with their peers and evaluating their progress. During the in-class lesson, I provide questions and problems to initiate discussions among students. Occasionally, I would give a short lecture explaining somewhat challenging concepts during the discussion. Throughout the semester, students were required to sit in assigned seats, and were strategically placed in ten study groups with eight students per group to encourage group learning. The blending of online learning and face-to-face classes makes it possible to transform the traditional instructor-centered, lecturing only classroom into a student-centered, discussion and problem solving learning environment. The effectiveness of instruction using the blended learning model, compared with the traditional lecturing mode, was measured with the 25-question Genetics Competency Assessment (GCA). Promising results and the challenges of designing effective online video lectures and motivating students to participate in the online learning and in-class discussion will be discussed in this presentation.

Abstract # 61 (Round Table Sat)
Building Excellence with Scientific Teaching (BEST): Novel Program for Undergraduate Teaching Assistants
Jonathan Andicoechea*, University of Minnesota; Jessamina Bloom, University of Minnesota; Julie Brown, University of Minnesota; Sehoya Cotner, University of Minnesota; Elizabeth Ring, University of Minnesota; Seth Thompson, University of Minnesota; Gillian Roehrig, University of Minnesota

Most undergraduate Biology departments rely on teaching assistants (TAs) to lead laboratory sections (Hughes & Ellefson, 2013). Although these TAs understand discipline-specific content (i.e. curricular knowledge), they rarely have the teaching expertise (i.e. pedagogical knowledge) needed to teach effectively (Hughes & Ellefson, 2013). To address this deficiency, we plan to develop a one-year course called Building Excellence with Scientific Teaching (BEST), designed to provide biology TAs with the training and experience they need to succeed as instructors. Development of this program is in its early stages and therefore we hope to engage the SABER community in a substantive discussion on scientific teaching, in general, and the development of TA training programs, in particular. First, we briefly describe the structure of the proposed BEST Program. The course will be divided into an initial summer training session, followed up by weekly, one-hour training sessions during the fall and spring semesters. These additional training sessions will serve three roles: (i) to provide TAs with an opportunity to critically engage with active learning, assessment, and inclusive teaching; (ii) to address issues of diversity and equity in science education using Culturally-Relevant Pedagogy (CRP) as a guiding principle (Gay, 2002; Ladson-Billings, 1995; 2000); and (iii) to develop relationships between novice TAs and experienced biology instructors. At the end of the year, TAs will be encouraged to participate in educational conferences, which will provide a forum where they can refine their scientific teaching skills. We estimate BEST will enroll between 25-30 undergraduate biology TAs each year—all of whom will be concurrently assigned to lead inquiry-based laboratory sections. We expect TAs who complete the BEST Program will demonstrate increased knowledge of scientific teaching (specifically the core concepts of active learning, assessment, and diversity); increased confidence in their own science skills; and improvement in science-process skills. Likewise, we envision students enrolled in lab sections taught by program participants will also benefit from scientific teaching methods, with increases in student engagement (Hunter, Laursen, & Seymour, 2007), long-term learning (Seymour, Hunter, Laursen, & DeAntoni, 2004), and interest in science as a career (Russell, Hancock, &
McCullough, 2007). We thus welcome a discussion on the theoretical framework and methodology behind the BEST program, with an emphasis on alignment between our program structure and desired learning outcomes.

Abstract # 62 (Poster Sat # 46)
**Undergraduate Research at a Two-Year College: Understanding Perceptions of Faculty and Creating Opportunity for Students**
Heather Wilkins*, University of Cincinnati

Understanding faculty perceptions of undergraduate research at a two-year college can inform and focus efforts to increase support and opportunities for students. Undergraduate research opportunities allow students to explore topics in more depth, think critically about a question, deepen relationships with faculty, and gain experience easily transferable to multiple careers upon graduation. Students who are engaged in a research experience are more academically successful, as shown by increased GPA (Fechheimer et al. 2011), and more likely to pursue graduate programs (Hathaway et al. 2002). The University of Cincinnati Blue Ash College (UCBA) is a two-year college of approximately 5,000 students. Most departments enroll students who complete an associate’s degree or transition to another UC campus to complete a bachelor’s degree. Some faculty members, including some in the sciences, engage in mentoring undergraduate research students. In order to collect information from a diverse mixture of faculty members, a college-wide survey was administered to study perceptions of undergraduate research on campus, resource availability, administrative support, and personal experiences with mentees. The survey was a mixture of Likert items and free-response questions. Here we present preliminary conclusions from an initial cohort of participants (N=44). Faculty state: 1) undergraduate research is relevant to students’ field of study and has clear benefits to students, 2) faculty benefit from mentored undergraduate research experiences by increasing their scholarship pursuits and contributing to the academic growth of exceptional students, 3) both financial and non-financial (e.g. course release, RPT consideration) support are insufficient, and 4) faculty are neutral about accessibility of opportunities for students. The results from this survey have highlighted a need to enhance resources for both faculty and students. Other two-year schools have successfully established programs (e.g., Langley 2015) that provide student research opportunities. The hope is to model details from successful programs and use the information collected from faculty to facilitate research experiences between students and faculty. A commitment of internal funding to support both faculty and student research experiences has been obtained, and a faculty learning community has established an undergraduate research resource guide. Ongoing efforts to support both faculty and students as they explore and collaborate on research questions will result in increased student exposure to research and, ultimately, student success.

Abstract # 63 (Poster Fri # 42)
**Differences in Context: Revealing Expert-Novice Graph Knowledge in Biology**
Mozhu Li*, Purdue University; Stephanie Gardner, Purdue University

In response to recommendations for undergraduate biology education, more students are engaging in the practices of science, including data analysis and representation. However, previous literature has shown that undergraduate students have difficulties interpreting and constructing graphs. Graph construction is a reflective process and involves the application of four, inter-related concepts and skills: 1) knowledge of the scientific discipline and associated inquiry, 2) knowledge of statistics, 3) visuo-spatial skills, and 4) graph knowledge. Graph knowledge is defined as any knowledge a person knows about a type of graph including its function, data that can be displayed with it, affordances and limitations. Operating under the expert-novice and meta-representational competence frameworks, we aimed to study the differences in graph knowledge among biology undergraduate students (novices), biology
graduate students (intermediates), and biology professors (experts). We used think-aloud interviews with questions designed to reveal subjects’ knowledge on five, unlabeled graphs: a bar graph, a scatterplot, two types of line graphs, and a histogram. These five graphs were chosen by 12 biology professors based on their classroom practices and goals for every undergraduate student to master. Participants were recruited from a biology department at a large Midwestern research university, and they were biology professors (n=8), biology graduate students (n=13), upper-level undergraduate students (n=13) and lower-level undergraduate students (n=24). We used deductive and inductive coding to reveal and organize the data into three main categories: 1) Graph Description (basic description of the graph without further interpretation), 2) Graph and Data Interpretation (local or global interpretation of the graph), and 3) Instantiation (concepts and reasoning that subjects engage in while populating a graph with data). Inter-rater reliability of coding was conducted afterward among three researchers and the degree of agreement reached 80%. We did not observe a difference in the proportion of codes that fell into the three categories between the three subject groups. However, the frequency and identity of the ideas and concepts that comprised the codes were often distinct. The most striking observation was that, within Instantiation category, experts spent more time talking about Experimental Design and Graph Construction than novices. Experts also tended to draw from their personal research and knowledge of experiments, while novices rarely situated their examples in the context of experiments. Further, the frequency and identity of codes varied by graph type. Based on our findings, we suggest that the linkage between experimentation, data, and graphs be emphasized as part of teaching students the practices of science.

Abstract # 64 (Poster Sat # 30)
Contextualized Science Information Literacy in Introductory Biology Laboratories
Linda Fuselier*, University of Louisville Biology Department

As evidenced by a number of studies conducted at multiple institutions, college students are often unprepared for the complexities of academic research and experience many challenges finding and evaluating information sources. We contribute to ongoing research on the pedagogy of science information literacy; this poster describes the contextualization of instruction within a consequential biology-related public health issue and the assessment of its impact on student learning. Our research question was: Is the combination of contextualized information literacy learning modules and laboratory instruction effective for teaching science information literacy in a large-enrollment general education lab course? We used six information literacy “threshold concepts,” proposed by the Association of College and Research Libraries to design lessons and assessments to answer our guiding question. A biology faculty member and two librarians developed in-class and online science information literacy lessons as part of a general education biology lab course. The lessons were assessed through a comparison of the information literacy skills of students enrolled in the lab and lecture versus those enrolled in the lecture only. Student learning and improvements in student information literacy skills were measured in formative assessments that emphasized source and credibility evaluations. Results from surveys and assignment responses indicated that students in the lab had greater perceived confidence in their information skills and improved information seeking methods, relative to lecture-only students who did not receive the contextualized information literacy content. The lessons were effective in teaching about the quality and credibility of scientific sources. Participation in a one semester general education biology lab course with embedded library instruction and writing assignments improved science information literacy among undergraduate students.
Comparison of student engagement and learning outcomes among three commonly used active learning approaches
Cassie Dresser*, University of Tennessee; Jennifer Brigati, Maryville College; Beth Schussler, "University of Tennessee, Knoxville"

Substantial evidence supports the use of active learning over traditional lecturing to facilitate cognitive student engagement and learning, yet few studies have compared the relative effectiveness of individual active learning approaches. We compared three commonly used active learning approaches (verbal questions, clicker questions, and worksheet questions) and asked which method promotes the highest student engagement and highest assessment performance. We minimized instructor effect by using the same guest instructor in three different introductory biology lecture courses (N = 216 students each), controlled for confounding variables by presenting identical information and visuals via PowerPoint, and implemented best practices in all treatment groups (e.g. discussion before answering questions). We varied only the manner in which students responded to posed questions: verbally, using clickers, or on a worksheet. To assess student engagement, we issued an anonymous paper survey immediately after the lecture and to assess student learning, all students completed identical multiple choice and short answer assessment questions for the presented topic on their final exam. While it might be expected that verbal questioning would result in reduced engagement because only one peer at a time provides an answer, we did not observe any significant differences in student engagement among the three approaches (Kruskal Wallis, H = 0.231, p = 0.894). Verbal questioning, however, did result in significantly lower assessment scores for multiple choice exam questions relative to worksheet questioning (ANOVA, F = 3.316, p = 0.037; Verbal-Worksheet, p = 0.028). Previous studies show mixed results regarding the influence of clicker questioning on academic performance; however, some studies have shown that the use of clickers increases student engagement. In our study, clicker questioning resulted in significantly higher scores on short answer exam questions relative to worksheets (ANOVA, F = 3.127, p = 0.045; Worksheet-Clicker, p = 0.047) without significantly increasing student engagement. Thus, surprisingly, worksheet questions in lecture enhanced multiple-choice performance on exams, while clicker questions enhanced short answer performance, but neither approach influenced student engagement. Our results suggest that, for the topic, classes, and assessments used in this study, the type of active learning approach does not result in differential student engagement, but does influence student performance on specific types of assessments. We feel that studies comparing active learning methods could refine how instructional approaches are chosen, directing instructors toward active learning methods most appropriate for their future learning assessments.

Using a threshold concept framework to examine the dimensions of student explanations about variation within species.
Elise Walck-Shannon, University of Wisconsin-Madison; Janet Batzli*, University of Wisconsin-Madison; Emily Jobe, University of Wisconsin-Madison

The concept of variation is challenging yet fundamental to disciplinary understanding of evolution. Understanding variation is troublesome because it requires nuanced language, integration of biological scales (molecules to organisms to populations) as well as an understanding of statistics, and time and experiences to wrestle within a liminal space—where stakes are low but feedback is high. We are using these characteristics of variation as a threshold concept to analyze students' progress through a 'variation-enhanced' inquiry-based laboratory curriculum. The aim of this project is to 1.) examine how students explain variation (the biological, scientific and statistical reasoning surrounding variation), 2.) examine how
student explanations of variation progress over time within our curriculum, and 3.) explore the utility of threshold concept framework to analyze student explanations. In order to capture many dimensions in student thinking, we conducted semi-structured think-aloud interviews of 29 students in a cross-sectional design: before, during and after experiencing our curriculum. The interviews were conducted outside of class in an informal setting and asked students to measure, analyze, interpret, and explain the variation among ten preserved Sturnus vulgaris (Common Starling) specimens. Initially, we will use a grounded approach to develop coding schemes that capture patterns in interview transcripts. Then, we will overlay a threshold concept framework to examine the following aspects of their explanations of variation: the troublesome nature of variation, the use of disciplinary language, the capacity to integrate variation (e.g., biological variation across scales as well as statistical variation), and evidence of liminality (e.g., level of disorientation, openness to explore ideas, tolerance to uncertainty, confidence). Preliminarily, we have noticed differences in students’ capacity to integrate variation across biological scales, from genetic to organismal. We recognize different levels of comfort and conflicting or disoriented reasoning as students attempt to explain how variation within a species arises and changes over time. Additionally, we have noticed differences in disciplinary language use and the scale at which students associate with biological variation: some focus on the origins, while others focus on the outcome (“raw material for evolution”). We hope to engage SABER in a dialog about teaching and learning the concept of variation; the dimensions of variation as a threshold concept; and use of other theoretical frameworks for examining challenging concepts such as variation, randomness, scale, uncertainty and probability. Lastly, we plan to describe next steps for development of free response prompts that accurately reflect students’ understanding of variation.

Abstract # 67 (Poster Sat # 55)
"Science isn’t my thing": Exploring non-science majors’ science identities
Cara Gormally*, Gallaudet University; Amber Marchut, Gallaudet University

When students arrive at college, most see themselves as either a “science person” or “not a science person.” Their science identities may be based on years of patterns of participation, attitudes, and expectations about science learning. Students’ conceptions of scientists may also influence their science identities. We asked whether participation in inquiry-based biology laboratory classes impacted students’ science identity and conceptions of scientists. Our study focused on Deaf, hard-of-hearing, and hearing non-science majors in visual bilingual (American Sign Language and English) learning environments. This is important because non-science majors have fewer formal learning opportunities that may positively influence their science identity, in contrast to science majors. We used a mixed methods approach, including videotaped interviews, reflection statements, and demographic surveys. We collected data from traditional (1 semester) and inquiry-based (2 semesters) biology laboratories. Study findings suggest a few possible impacts on participants’ science identities, including: stereotypes of scientists portrayed in popular media; and a preference for careers involving working with people, specifically with the Deaf community. Applied research is needed to challenge stereotypes, and to identify connections between science and the Deaf community, with the goal of both improving students’ science identities and increasing student involvement in science careers.

Abstract # 68 (Poster Sat # 36)
Cell Collective - Learn: An Interactive simulation platform for learning and teaching about biological processes.
David Tichy, University of Nebraska-Lincoln; Bryan Kowal, University of Nebraska-Lincoln; Nicholas Galt, University of Nebraska-Lincoln; Heather Bergan-Roller, University of Nebraska-
Lincoln; Joe Dauer, University of Nebraska-Lincoln; Tomas Helikar*, University of Nebraska-Lincoln

Computer simulations have the potential to improve the way life sciences students learn and understand dynamic biological processes. However, many instructors are unsure how to integrate computational modeling into their classroom. Furthermore, many existing software tools are limited in the ability of students to directly manipulate the models. To address these challenges, we have developed an on-line modeling software platform, Cell Collective (http://learn.cellcollective.org). The platform enables students to learn about biological processes using a full range of computational modeling that spans from simulations of pre-fabricated models to construction and simulation of new computational models. Construction of computational model has been designed in such a way that it does not require the input or editing of mathematical equations; instead, the user defines the relationships between model components (regulatory mechanism) in biological terms, and the mathematical representation of the regulatory mechanism is constructed in the background. This makes the modeling platform and model construction accessible to students with any mathematical modeling experience. This has proven key for our group to be able to deploy the platform in introductory biology courses where students’ knowledge in mathematics is variable. Along with the software, we have developed and deployed various computational learning modules, including ones about cell respiration, regulation of gene expression, cell cycle, regulatory feedback loops, food web. Each module is grounded in a set of learning objectives, and consists of brief background information, a pre-fabricated computational model and activities to investigate its dynamical properties, or an activity to develop a new computational model, and assessment-driven questions and investigations. The modules are designed to be deployable in various settings (in-class, homework assignment, lab activity) by instructors at various universities in an independent fashion. We are currently extending the software to also provide instructors with a flexible environment to modify existing and develop new computational learning modules directly in the platform. While anyone, including instructors, can already build any computational model in Cell Collective, the new “instructor view” will allow content developers (instructors, teaching assistants, etc) to build computational learning modules with integrated modeling activities, assessments (with correct answers), etc. This will also enable instructors to easily assess and grade student responses and activities. We strive to make this platform easily accessible to instructors at any university, whereby they can customize any existing learning modules, and/or develop new modules that fit their specific needs.

Abstract # 69 (Poster Fri # 61)
**Affect matters: The role of belonging on academic performance in STEM classrooms**
Bryan Dewsbury*, University of Rhode Island

The attrition of underrepresented minorities (URMs) from STEM disciplines has been a point of concern for institutions of higher education for a considerable time. Many approaches to address this include increasing and improving the institutional structural support provided to these groups, transformation of the in-class pedagogy, and increased selectivity of the students who enter these disciplines in the first place. The education psychology literature have identified broadly defined ‘identity contingencies’ as a potential limiting phenomenon for URMs, and have suggested multiple interventions to address this in college classrooms. In this study we measured multiple factors that have traditionally been assumed or shown to affect academic performance in STEM classrooms. We incorporated into the classroom multiple measures to determine students’ sense of belonging both to the classroom and to the campus at large. Some of the affect interventions were drawn from the literature and implemented because of their reported positive effect on the social navigation of college by URMs. These included having students produce written reflections on their first year of college and separate reflections on
career choice and mindset. Using thematic analysis we dissected these reflections to determine the most common themes that students espoused, across demographic lines, relating to their social navigation. Using a hierarchical linear model, we determined which of the affect and academic variables were the strongest predictors of student success in each course. Where active learning was used, sense of belonging as measured by the Classroom Community Scale was the second strongest predictor of student success after only high school GPA. Where active learning was not used, high school GPA was still the strongest predictor but was typically followed by SAT scores, race and income-level. Our results indicate that when active learning is used, the sense of community created by this approach can mitigate for the potential effects of race and class. Our results strongly suggest that for URMs, instructors who are intentional about incorporating these strategies in their classrooms are likely to promote retention of this group.

Abstract # 71 (Poster Sat # 65)
Arrows in Biology Drawings: Missing the Point of the Figure
Jordan Cardenas*, Rochester Institute of Technology; Dina Newman, RIT; Kate Wright, Rochester Institute of Technology

Biology textbooks rely on representations such as figures and diagrams to communicate concepts to students, though these representations often do not achieve their goal of clarifying these concepts for students. There is a clear difference in novice and expert views of the same image, and instructors may not always understand this difference. While an instructor may be able to sort through a figure with ease, a student may find it visually overwhelming or vague. One aspect of these representations that contributes to their ambiguity is the arrows that are used. Arrows are often used liberally in biology, and, in contrast to fields such as chemistry, the shape and style of arrow rarely corresponds to a particular meaning. To quantify this observation, every arrow in an introductory biology textbook was coded. Of all of the figures in a single book, about 52% contained arrows (636 out of 1214, including some in all major topics). We identified 47 different styles with 67 different meanings. To check for accuracy of coding, these 67 meanings were used by two researchers to code a random subset of 55 figures from a new version of the same book, yielding 96.9% agreement between the researchers. In these figures, it was found that of the meanings that appeared more than once in the set, only 5 had only one arrow type associated with them. Of the arrow types that appeared more than once, only 3 were consistently used for a single meaning. Seven figures were selected from multiple introductory textbooks, and interviews of biology students of varying experience were conducted to determine the way the arrows in each figure were interpreted by the primary audience of these books. We observed that the inconsistency in arrow use carries over to interpretation, as students did not agree on the meaning of many of the arrows within the interviews. While more experienced students generally could identify the concept, they often either disagreed over the meaning of an arrow or incorrectly described its use based on their previous experience with that arrow type. A card sorting task is now being developed to determine whether students make assumptions about a figure based on the type of arrow that is presented to them. Overall, our data suggests that the random, overuse of arrows in biology leads to confusion and thus may be a barrier to learning. Future work will attempt to derive rules for biologists and textbook illustrators to use in their visual communication techniques that provide greater clarity.
Abstract # 72 (Poster Fri # 44)
The Scientific Teaching Practices Survey: Measuring agreement between faculty, students, and observers.
Jenny Knight*, MCDB; Lauren Crisma, University of Colorado; Mary Durham, University of Nebraska-Lincoln; Alex Paine, University of Colorado; Brian Couch, University of Nebraska-Lincoln

The Scientific Teaching Practices Survey is designed to measure the frequency of specific classroom teaching practices that are aligned with the Scientific Teaching pedagogy. This survey can be used by faculty and students to report frequencies of teaching practices in a course. Since survey responses may be biased, we sought to determine how faculty and student ratings compare to an outside observer. This pilot study reports on the correlations between three sets of raters (students, faculty, and outside observers) on seven courses from one university. To determine the correlation between raters, we collected faculty and student ratings on each survey item, and then used video recordings of class periods from each course to establish a set of observer ratings. Two observers watched videos of three consecutive class periods for each course, and obtained artifacts such as syllabi and learning objectives, when available. In general, observers were able to score 33 out of 49 survey items; the unobservable items tended to be about practices that were executed outside of class (such as alignment of homework assignments to learning objectives). To calculate the agreement of students, faculty, and observers, we used a “match score”: the difference between ratings from two groups normalized to the scale of the question. A higher match score indicates higher agreement between the two groups being compared. Over all seven courses, students and faculty had a relatively high average match score across the survey items (.81). On average, observers tended to agree about equally with faculty (.78) and students (.77), although this varied widely by item and course. For observer-faculty comparisons, 18 individual survey items had a match score above .8, but some items had very high or very low match scores. Additional comparisons between the two observers, as well as questions for which all parties (observers, students, and faculty) tend to be in high or low agreement, will be presented, along with statistical analyses of agreement on individual items and across courses. Ultimately, the comparisons of outside observer ratings to student and faculty ratings will allow us to consider the potential for using this instrument as an observation tool, and the correlation between how students and faculty view the same course.

Abstract # 73 (long talk Fri)
Prevailing questions and methods in biology education research: An analysis of SABER abstracts
Brian Sato, UC Irvine; Stanley Lo*, University of California, San Diego

Biology education research (BER) is a growing field, with increasing attendance at annual SABER meetings. To facilitate a reflective discussion on how research at SABER has matured, this study aims to determine the scope of work presented in 2011-2015. Analyzing abstracts, we identified existing research areas and methodologies, as well as potential gaps for new exploration. We examined all 688 abstracts from 2011-2015 in relation to seven parameters: nature of research, type of research questions, stage in research pipeline, topic, methodology, data, and study population. Abstracts were blinded to remove identifying information: authors, year, and presentation format. Data analysis took a combination of deductive and inductive approaches. For the first three parameters, external frameworks were used as coding schemes (NRC 2002, IES/NSF 2013). For other parameters, codes were generated from data using thematic analysis. Subset of abstracts (18%) was analyzed by two independent researchers, with inter-rater agreement of 85%. After coding, contingency and correspondence analyses were used to determine statistical relationships among parameters. Vast majority of abstracts...
are empirical (96%), with most focusing on interventions-based work (70%). Research questions emphasize causal relationships (66%), and stage in research pipeline favors efficacy of interventions (64%). Skew in these distributions suggests underexplored areas of BER, e.g. descriptive or exploratory investigations not based on interventions, large-scale effectiveness studies, examination of mechanistic explanations, and theoretical work. For research topic, many abstracts emphasize student learning (77%), including assessment of active learning or laboratory education, examination of conceptual understanding, and development of tools. Few abstracts deal with diversity, metacognition, or science and society. Data collected largely focus on cognitive domain (64%), with little emphasis on affect, behavior, or persistence. Majority of abstracts are either quantitative or mixed-methods that are also predominantly quantitative (72%), with relatively less emphasis on qualitative methodologies. For study population, most abstracts focus on undergraduates (70%), but few examine community college students (1%). Only two abstracts compare different populations or examine pathways between populations. The small proportion of abstracts that study faculty, postdoctoral fellows, and graduate students nearly all focus on their professional development as educators but not as researchers. Overall, we identified a predominant area of research at SABER: causal studies that examine efficacy of interventions on undergraduate cognitive learning measured by quantitative methods. This trend has not changed over time, as year has no correlation to any parameter in statistical analyses. Our results also suggest areas of BER that may be currently underexplored by the SABER community.

Abstract # 74 (Short Talk Sat)

Navigating from vision to change: The development of an ecology and evolution assessment that measures student learning across the major
Mindi Summers*, University of Maine; Michelle Smith, University of Maine

The Vision and Change report outlines a set of core concepts and competencies for undergraduate biology majors. Departments seeking to measure student progress towards these goals must know the extent to which undergraduates understand these core concepts as they progress through their degree. To assist departments in this process, the BioMAPS project is currently developing a suite of tools specifically aimed at measuring conceptual understanding at multiple points during undergraduate study. One of these assessments, known as EcoEvo-MAPS, is aligned to the general concepts outlined in Vision and Change as well as a set of core principles and learning outcomes specific to ecology and evolution. EcoEvo-MAPS includes nine question stems and approximately 5-8 statements under each question stem that students rate as being “likely” or “unlikely.” The nine question stems are focused on different scenarios not typically included in standard textbooks and therefore are intended to explore student’s ability to transfer and apply conceptual understanding. These questions were iteratively developed through extensive feedback in the form of individual review and focus groups from over 100 Ph.D.-level experts. The final version of each question was response-validated by more than 15 faculty with over 93% of experts rating the statements as accurate and over 73% of experts rating the statements as clear. All statements were also response-validated through more than 80 student interviews. Student thinking matched their correct or incorrect answers over 80% of the time for 53 of the 63 likely/unlikely statements. EcoEvo-MAPS was piloted at 36 institutions (including community colleges, primarily undergraduate institutions, and research-intensive universities) and over 3000 students have taken the assessment to date. Pilot data was analyzed using classical test and item response theory to determine difficulty and discrimination. Quantitative pilot data and associated student thinking from interviews demonstrate that the assessment addresses concepts that undergraduate students know when they enter a program, learn during their introductory courses, develop in upper division courses, or continue to struggle with throughout the major. Through surveying
student understand of concepts that span ecology and evolution, this assessment provides departments with a new tool for conducting programmatic assessment: a longitudinal measure for how well novice undergraduate learners are being transformed into adaptive experts in ecology and evolution.

Abstract # 75 (Round Table Sat )
**How do educators begin to collaborate and learn together about problems of biology teaching and learning in higher education?**
Anuschka Neuwald*, University of Wisconsin-Madison

The Vision and Change reports (American Association for the Advancement of Science, 2011, 2013) have identified a need for change in undergraduate biology education, emphasizing student learning of content knowledge and competencies. Missing from this report and larger efforts to improve undergraduate education (Brainard, 2007; Henderson et al., 2011; Sunal et al., 2001) are guidelines for how to support instructors’ professional learning to change teaching practices. I am exploring one possible support structure by studying a collaborative professional learning group. This study employs the Lesson Study model (Lewis, 2006) to engage seven biology instructors in iterative cycles of collaborative course development, implementation, analysis and reflection on their teaching and students’ learning. The intervention occurs over two semesters at a weekly general biology instructor’s meeting. The purpose of this qualitative case study is to examine the micro-processes of this collaboration and how these micro-processes afford, limit, and challenge the ability to change one’s teaching practices. Wenger’s (1998) concept of “community of practice” provides a theoretical framework for data analysis. I view learning as social and situated in a combination of experiences and social practice. Therefore, learning involves negotiating new meanings, boundaries, identity transformation, and participation as part of an on-going collaboration. Preliminary data analysis shows inquiry-based collaborative professional learning can be difficult to implement in higher education settings where teaching, problems of practice, and long-term engagement with professional learning activities are not the norm. Wenger’s framework allows me to attend to what is actually happening in the micro-processes when the concept of “communities of practice” is enacted. This collaborative process appears to create an environment that challenges instructors conceptually, culturally, and professionally to various degrees. Therefore, this collaborative process could be a provocative context for spurring questions about how science teaching is done and how science learning is viewed in higher education. These findings will be important for identifying parameters that could support or impede collaboration and instructional improvement among science educators in higher education, as such activity is not the norm in these settings. Furthermore, the results will help reevaluate teaching and learning at the undergraduate level in hopes of building a continuum from the K-12 to college level. To further my understanding of change in higher education, it would be fruitful to receive feedback about others’ experiences with collaboration as it relates to the larger context of improving teaching and learning in biology at the undergraduate level. (398 words)
Abstract # 76 (Round Table Sat)
**An Analytical Framework for Domain-Specific Problem Solving**
Cheryl Sensibaugh*, University of Georgia; Paula Lemons, University of Georgia

The proposed roundtable discussion addresses the research question: How can students’ solutions to well-defined biology problems be analyzed for content knowledge and strategic knowledge? This research question derives from the theoretical framework of domain-specific problem solving (Chi et al., 1981; Pressley et al., 1987; Smith, 1988; Alexander et al., 1998; Bodner, 2015). According to domain-specific problem solving, successful problem solving depends upon a well-developed knowledge base that includes content knowledge, knowledge of strategies, and the awareness of how to apply that knowledge to the problem at hand. Our rationale is that a novel analytical framework is necessary – one that quantitatively accounts for a continuum of conceptions, from accurate to inaccurate content, and from supportive to unsupportive strategies. Currently, this work is non-empirical. The ideology of our analytical framework is that successful domain-specific problem solving requires blending content with strategies (AAAS, 2011; NRC, 2003, 2011). We first established a structure of an overall score with sub-scores, for a more complete view of student understanding (NRC, 2014). Specifically, an overall score of domain-specific problem solving can be considered alongside sub-scores for (a) content knowledge, (b) strategic knowledge, and (c) interactions between content and strategy. We drew upon a model offered by Nehm and Reilly’s natural selection performance quotient (2007), as well as a suggestion to consider both correct and incorrect responses, which emerged from pilot studies conducted by Haertel and colleagues (2012). We propose a simple algorithm that normalizes scores for the number of knowledge statements within a solution, producing scores that range from -1 to +1. We intend to test this analytical framework within our BioSTEPS project (Biology Student Thoughts Explaining Problem Solving), which investigates biology-specific problem solving among undergraduates. The problems relate to three threshold concepts: the physical basis of interactions, thermodynamics of macromolecular structure formation, and biochemical pathway dynamics and regulation (Loertscher et al., 2014). We have collected data from think-aloud interviews (27 students, 21 experts) and written administrations (780 students). We particularly request critique and feedback on the following questions: To what extent is this framework sound and appropriate? How widespread is the need for and utility of the proposed analytical framework? What additional literature should be considered? We anticipate this discussion to connect to other research contexts represented at SABER, including conceptual understanding and change, assessment of student learning, science process skills, visual thinking, and theoretical and predictive frames.

Abstract # 77 (Round Table Sat)
**Warning: Active learning may cause anxiety**
Ben England*, The University of Tennessee; Beth Schussler, "University of Tennessee, Knoxville"; Jennifer Brigati, Maryville College

In fall 2015, students at a large public research university attending a course in the introductory Biology sequence (Biodiversity and Cell Biology) were surveyed about active learning and engagement, and the results revealed differential feelings of anxiety based on the instructor’s active learning practices. Given that anxiety may impact participation and thus course success, for spring 2016, the data collection was expanded to allow students to report anxiety levels, what classroom practices made them anxious, and why these practices made them anxious. By collecting these data, the researchers addressed the following overarching research question: What are the causes and implications of differing levels of anxiety in introductory Biology classes that use active learning? One month into the spring 2016 semester, student anxiety levels were measured with a validated general anxiety instrument, then analyzed using one-way ANOVA followed by post-hoc analysis. The anxiety instrument revealed significant differences
among course sections; cell biology courses (the second semester course) had students with the highest anxiety scores (p < 0.05). To determine instructional sources of this anxiety, students were asked on subsequent surveys to report what classroom practices made them anxious. The most commonly cited practices included the use of clickers (40% of comments), group work (21% of comments), and cold calling (when students are randomly called on to answer a question, 15% of comments). Students reported clickers made them anxious when there was inadequate time to respond, when the question covered material from the reading not yet discussed in class, or when the question was worth points for answering correctly rather than for participation. Cold calling and group work were anxiety-inducing mostly due to peer pressure (knowing the correct answer and not being embarrassed). To assess the potential implications of anxiety-inducing practices, spring 2016 student anxiety levels were analyzed with students’ fall 2015 instructors as the independent variable, using one-way ANOVA followed by post-hoc. One of the professor’s students showed significantly higher anxiety scores than all the others (p < 0.05). Interestingly, this professor had significantly higher engagement scores than four of the five other professors in fall 2015 (p < 0.05, one-way ANOVA with post-hoc). This suggests a potential engagement-anxiety carry-over effect between semesters. These findings show that an instructor’s use of active learning or transitions between courses with different instructional practices may drive differential student experiences in introductory biology. Current research is exploring how this anxiety impacts student engagement and/or learning.

Abstract # 78 (Poster Sat # 62)

**Linking performance and participation in the flipped classroom**

Michael Moore*, Oklahoma State University; Donald French, Oklahoma State University; Evan Davis, Oklahoma State University

The rationale behind implementing a flipped classroom is that pushing lecture outside class allows more time for students to practice recalling information in-class learned previously out of class (Abeysekera & Dawson, 2015), typically through active learning techniques, because of the evidence that they improve student performance in STEM classes (Freeman et al., 2014). Two unanswered questions about the flipped-actively learning techniques are: Is there a relationship between the amount of participation in active learning experiences and course performance (grades) and the oft-asked (flippedclassroom.org) “How do I get my students to watch the lecture videos?”, a common method for content delivery. Do students need simply to “attend” flipped and active learning sessions to gain a performance benefit or must they actively participate to see a difference? If student participation is important, how predictive is their choice to participate of their course performance? To answer these questions, we conducted a study in a “flipped” large (N = 120), section of a mixed-major, introductory biology course at a large land-grant university in the Midwest in Spring 2015 and in a smaller honors section (N = 76) in Fall 2015. We were tracked student use of lecture videos (frequency and time spent playing) and measured active student participation using clickers, which the instructor used on a daily basis for formative assessment and student engagement. Both components (videos and clickers) are the trackable participation components of the classroom that we have looked at and compared to first and total exam performance. No grades were associated with actively participating in either environment (online or in-class) to encourage intrinsic motivation to participate as opposed to extrinsically motivating students by offering participation points (Cameron & Pierce, 1994, 2002). Using linear regression we found that actively participating in-class and online was a significant predictor of performance for both the first (p<.001) and total (p<.001) exam scores. When looking at effect size, active participation is more predictive of total exam score (R2=.33) than for the first exam (R2=.44). The strengthening of the predictability from the first to the total exam score may have to do with the material covered initially, the cumulative nature of the exams, the additional practice the students had in the technique, or attrition. This study provides
research support that can be used to advise and motivate students in flipped classes to carefully consider their decisions about participating in class.

Abstract # 79  (Poster Fri # 19)
**Does procedural scaffolding of technological skills improve concept learning in a non-majors biology class?**
Jack Suss*, Philadelphia University; Jeffrey Klemens, Philadelphia University

Having students manipulate and construct models of complex systems is a powerful method for teaching science skills and concepts. Many technological tools exist to support this pedagogy, but the approach comes with a potential pitfall: the effectiveness of a particular tool for learning skills and concepts depends on the degree to which students are able to master the underlying technology. While instructors select tools from a position of mastery of the underlying material, students are exposed to the tool and the concept simultaneously. Because of this interdependence, care must be taken to ensure that evaluation and assessment of student performance is measuring understanding of the learning outcomes and not measuring technological proficiency. Procedural scaffolding enables students to explore technological tools and concept learning to make connections on their own. At Philadelphia University, we have been teaching Design, Engineering, and Commerce (DEC) students biology with a systems modelling approach using Vensim as our primary model-building tool. To accomplish this, we dedicated significant class time to instructor-assisted Vensim usage prior to the first time we used it for concept learning. The concept learning outcomes involve interpreting the graphical output of model simulation. Unfortunately, in order to run simulations, students needed to first download and install Vensim, orient to the user-interface, and learn the mechanics of model construction. In order to scaffold the technological model building and graphical concept learning, we converted models to a web-based format in Forio, where students could interact with graphical output from a simulation without these preceding steps. In Fall 2015 and Spring 2016 we used this scaffolding to introduce exponential and logistic population growth models prior to having students construct those models in Vensim: 8 class sections (treatment group), while using the integrated approach without the scaffolding: 16 sections (control group). In the treatment sections we compared student metacognition of the application technology through survey. Analysis revealed that students recognized Forio as a tool to understand system behaviors and Vensim as a tool for model construction (Chi-squared= 5.6076, df = 1, p-value = 0.01788). Analysis of student Vensim model submission is forthcoming for all sections (treatment and non-treatment).

Abstract # 80  (Poster Fri # 2)
**Attitudes of Instructors Towards the Importance and Necessity of Alignment of Topics in Lecture and Lab in Introductory Microbiology and Biology Courses**
Andrea Rediske*, University of Central Florida; Morgan McAfee, University of Central Florida; Heidi Eisenreich, University of Central Florida; Stephen Sivo, University of Central Florida; Malcolm Butler, University of Central Florida

Laboratory activities are a vital component of college-level introductory biology and microbiology courses, and the attitudes of instructors teaching the laboratory section of introductory biology courses can have a significant effect on not only the structure of the course, but student outcomes and experiences. Kolb’s experiential learning cycle suggests student understanding of complex scientific topics progresses from abstract conceptualization, to active experimentation, to concrete experience, and finally reflective observation. Alignment of topics between the lecture and lab may assist students in making meaningful connections between abstract concepts studied in lecture and their concrete experience in the laboratory. Instructor attitudes toward the importance or necessity of alignment may influence not only the alignment
of topics, but completion of the experiential learning cycle as well. The hypotheses for this study were: (1) Instructors at smaller institutions such as liberal arts college and community colleges are more likely to agree that alignment of topics is important and necessary (2) Instructors with a focus on teaching are more likely agree that alignment is important and necessary. Ninety-two introductory biology, microbiology, cell biology, environmental biology, and other biology instructors from various institution types were surveyed to determine the degree of alignment between lecture topics and lab activities in their courses. A chi-square test of association on self-reported attitudes of introductory biology instructors towards the importance and necessity of alignment of topics indicates a significant effect of institution type (Importance: \( \chi^2=9.51, \text{df}=4, p=0.049 \)) and (Necessity: \( \chi^2=15.76, \text{df}=4, p=0.003 \)). A chi-square test of association on self-reported attitudes indicated a significant effect of instructor type with respect to the importance (\( \chi^2=13.09, \text{df}=6, p=0.042 \)), but not necessity (\( \chi^2=10.46, \text{df}=6, p=0.107 \)) of topic alignment. Results of this study may have implications for development of more effective curriculum practices at a variety of institutions and with various instructor types that may assist students in completing the experiential learning cycle that may lead to improved student learning outcomes and retention of students in biology and microbiology courses.

Abstract #81 (Short Talk Sat )

**Biology Identity and Persistence Survey (BIPS): An instrument for assessing students’ biology identities and aspirations in biology**

Feng Li*, Florida International University; Zahra Hazari, Florida International University

Identity has been part of science educational research for over a decade as a lens to explore students’ relationship with science fields. The definition of identity in educational research was clarified by Gee as what “certain kind of person in a given context” people think they are. Science identity was described as who people think they are in terms of their relationship with science. Previous studies have demonstrated the influences of science identity on students’ persistence in science. Increasing emphasis on science identity has made it necessary to explore not only science identity in general but also identity in specific science disciplines in terms of its development, fluctuation, and influence on students’ learning. Knowledge of distinctions between different science disciplinary identities can contribute to better understanding of how science disciplinary identity mediates the fluctuation of students’ aspirations for a career in a specific science field. The Biology Identity and Persistence Survey (BIPS) is in development as a research instrument for collecting data on students’ biology identities and aspirations in biology. BIPS utilizes an identity conceptual framework drawn from the work of Carlone and Johnson, and Hazari, Sonnert, Sadler and Shanahan, which includes a four component disciplinary identity: interest, recognition, performance, and competence. BIPS was designed for use with high school biology students. Thus, the BIPS was validated through expert reviews and cognitive interviews with high school students. Quantitative data also provided statistical evidence of the validity and reliability of BIPS from a test-retest study in high school science classes. The survey items were reviewed by an expert in science/biology identity to provide face and content validity for what they are supposed to measure. Confirmatory factor analysis was employed to statistically validate survey items in measuring each specific construct. Students’ responses in the test-retest were analyzed using a t-test about the consistency of measures from one test to the next. Cronbach’s alpha was employed to assess the internal consistency of items in the same category in measuring the same construct. The analysis provides evidence that the final BIPS instrument is reliable and valid for measuring the biology identity and aspirations in biology of high school students.
Abstract # 82 (Poster Fri # 3)

Longitudinal Impacts of the Prairie Science Classroom

Cedar Walters*, North Dakota State University; Lisa Montplaisir, North Dakota State University

Environmental Education (EE) has a long history in the United States and in other countries around the world. Fostering awareness of environmental issues, providing access to knowledge and skills needed to protect the environment, and creating behavioral change toward the environment have been identified as goals critical to creating an environmentally responsible citizenry. For some children, a field trip or other school-related activity may be one of their only experiences with nature. The literature on connectedness to nature indicates a correlation between childhood experiences in nature and a stronger connection to nature in adults. The human connection to nature is thought to be a significant predictor of ecological behavior, and is critical to this study. The Prairie Science Classroom (PSC) is a formal educational partnership between the U.S. Fish and Wildlife Service (FWS) and a school district in West-Central Minnesota. This partnership is unique in our region in that it provides a year-long, half-day program to 4th and 5th grade students with an outdoor educational experience using the Prairie Pothole ecosystem at a waterfowl production area managed by the FWS as an integrated learning context. During this year-long program, students go through their science, writing and math curriculum in an interdisciplinary context that provides hands-on experiences in nature on a consistent basis. Teachers and EE specialists at the PWLC have developed a framework to ground curriculum development called The Compass – four guiding principles that help students connect to nature in the outdoor classroom: 1) Phenology – the study of seasonal cycles in nature, 2) Place-based learning – get to know the place you live, 3) Nature Journaling – record and track your observations, and 4) Writings of Naturalists – use the work of naturalists to become a naturalist. Although this educational partnership has been evaluated in the past, durability of the program outcomes have never been assessed. The goals of the current research are to 1) assess the durability of the original program outcomes using original program evaluation tools and 2) assess the program’s impact on connectedness to nature using a validated Connectedness to Nature Scale. A representative sample (n=50) of the graduating class of 2017 (n = 138) were surveyed; 64% of our sample participated in the PSC during either their 4th, 5th, or both grade years. The results of this preliminary data will inform future decisions regarding this educational partnership. Keywords: Assessment as related to beliefs, attitudes, and expectations; assessment of student learning and instructional innovation; research on effective instruction; environmental education; project evaluation

Abstract # 83 (Poster Fri # 20)

Using Comparison to Frame Conditional Knowledge in Biochemistry Problem-Solving

Stephanie Halmo*, University of Georgia; Cheryl Sensibaugh, University of Georgia; Laura Novick, Vanderbilt.edu; Paula Lemons, University of Georgia

The strategic use of contrasting comparisons to improve learning has been used successfully within the problem-solving domains of mathematics (Rittle-Johnson and Star, 2007 & 2009) and contract negotiations in business (Gentner, Loewenstein, & Thompson, 2003), but has not been well studied in biology. The goal of this study is to determine if the strategic use of comparison also improves student learning of biochemistry threshold concepts, specifically the physical basis of interactions and the thermodynamics of macromolecular structure formation, which are concepts critical to the domain of biochemistry that students routinely have difficulty learning (Loertscher et al., 2014). This research is grounded in the theoretical framework of domain-specific problem solving and strategy use (Chi et al., 1981; Smith, 1988; Alexander et al., 1998; Bodner, 2015). According to domain-specific problem solving, successful problem solving depends upon a well-developed knowledge base that includes content knowledge, procedural knowledge or strategy use, and conditional knowledge, which is the awareness of how to apply
that knowledge to the problem at hand (Alexander, 1988). We hypothesize that using similar and contrasting comparisons will improve student problem-solving performance by helping students frame their use of conditional knowledge. To investigate our research question, we conducted an empirical study in which roughly 400 students from introductory biology and biochemistry classes at a large research institution were asked to solve similar and contrasting comparison problems using the online survey platform Qualtrics. Participants were randomly assigned to control groups, a similar comparison group, and a contrasting comparison group. For example, in the contrasting comparison condition, students were asked to compare the properties of two different amino acids like glutamic acid and phenylalanine, predict the effect of amino acid substitutions on the folding of a protein, and transfer what they learned to an amino acid categorization task. Our preliminary analyses, which will be conducted this spring, will involve the use of qualitative content analysis to generate problem-solving scores for each student. Problem-solving performance will be compared among student groups using standard statistical methods to test our stated hypothesis. If our hypothesis is indeed supported, we will design educational applications, including online problem-solving tutorials and in-class curricula that utilize the strategy of contrasting comparisons to improve student learning of biochemistry threshold concepts. For example, we anticipate that explicitly asking students to compare the properties of amino acids in a folded protein may help them determine the impacts of substitutions to residues within that protein.

Abstract # 84 (Poster Sat # 22)
**Can You Hear Me Now? GOOD!: How Graduate Students Learn to Communicate Science to the Public**
Caitlin Ishibashi*, University of Georgia; Kathrin Stanger-Hall, University of Georgia

Being able to effectively describe one’s research interests to a broad audience is an incredibly important skill that students in the sciences often lack. This is because many students rarely have the opportunity to receive formal training to become an advocate for their subject of interest. We were interested in determining whether formal training in science communication helped graduate students improve their confidence and proficiency in communicating their dissertation research to a general audience. In Fall 2015, we designed and taught a new graduate-level course called “Communicating Science,” in which students learned different techniques to convey their research to a general audience using a variety of different methods (including elevator speeches, press releases, and social media). This course culminated with a “Student Science Series” night, a free event open to the local community in which students delivered short presentations on their research and fielded questions from the audience. We conducted a survey with students from a wide range of life science disciplines, including those who had taken our science communication course. In the survey, we asked students to respond to a series of prompts that assessed their ability to communicate scientific concepts to a lay audience (use of jargon, clear delivery of messages, appropriate analogies, etc.). We analyzed responses to measure if our former students showed an increased aptitude for communicating science when compared to students who did not enroll in our class. While this survey showed that students exhibited a wide range in proficiency for communicating science, we confirmed that our former students strongly felt that their enrollment in our course was largely helpful in improving their ability to communicate with the public. We therefore conclude that providing formal training in science communication can be extremely useful for graduate students’ professional development.
Abstract # 85 (Short Talk Sat)

Decibel Analysis for Research on Teaching (DART): Measuring Classroom Decibel Levels to Quantify Active Learning
Shannon Seidel, Pacific Lutheran University; Melinda Owens*, San Francisco State University; Mike Wong, San Francisco State University; Jeff Schinske, De Anza College; Kimberly Tanner, San Francisco State University

Although evidence supports using active teaching strategies in university classrooms, measuring the extent these strategies are used remains difficult. Currently available classroom observation tools provide detailed descriptions of pedagogies instructors use but are difficult to deploy at large scales, so often only a handful of class sessions per course are analyzed. To fill the need for a method that can efficiently assess whether large numbers of faculty consistently use non-lecture strategies, we created Decibel Analysis for Research on Teaching (DART). We hypothesized we could measure deviations from lecture by analyzing patterns in the decibel levels of classroom noise associated with lecture and non-lecture teaching strategies. To develop DART, over 50 hours of classroom recording were annotated and compared to the corresponding classroom decibel levels, showing a high correlation between certain decibel patterns and teaching strategies such as pair-discussion and minute papers. These human-curated annotations were used to train a computer algorithm, DART, to distinguish Single-Voice (e.g., lecture), Multi-Voice (e.g., pair-discussion), and No-Voice (e.g., minute paper) events. By comparing human- and computer-generated annotations, we found DART correctly determined the type of activity 89.5% of the time, estimated using 10-fold stratified cross-validation. To what extent can DART reveal differences in patterns of active learning across large numbers of courses? In collaboration with 58 biology instructors from 15 community colleges and a public comprehensive university, DART was applied to over 1800 hours of recordings of 78 entire courses, ranging in size from 4-287 students. We quantified the percentage of time spent on Single-Voice, Multi-Voice, and No-Voice events as well as the number of each event type. We found that >77% of class sessions (n=1560) included non-Single-Voice events, with the average per-course time spent on non-Single-Voice activities being 10.8%±1.0% (n=78). Courses taught by different instructors varied considerably, with per-course non-Single-Voice percentages ranging from 0-25%, demonstrating DART can identify differences in non-lecture teaching strategy use. Furthermore, some instructors had high variability between class sessions: one instructor ranged from 9.5-33 events per hour in different class sessions, emphasizing the need for an instrument that can analyze each session of an entire course. While DART cannot assess the quality of active learning, our results demonstrate that DART is valuable for high-throughput, cost-effective, and comprehensive analyses of the extent of non-lecture pedagogies in biology courses. Future DART studies may be able to inventory the presence of non-lecture activities across courses, departments, or even entire universities over time.

Abstract # 86 (Short Talk Sat)

Development of a new Theoretical Framework and its application to learning Meiosis
Kate Wright*, Rochester Institute of Technology; Dina Newman, Rochester Institute of Technology

Although instruction on meiosis, an important biology and genetics topic, is repeated numerous times during the undergraduate curriculum, many students show poor comprehension even as upper-level biology majors. Guided by the literature and confirmed by survey data obtained from 50 biology experts about what is important for meiosis understanding, a 15-question open response concept test was created and given to first and second year biology students (N=149) to learn how they think about this process. Results demonstrated that students had particular difficulties realizing that DNA sequence is the basis of the concept of homology as well as mechanism of homologous pairing (crossing-over). For a comparison we surveyed a different
set of biology faculty to gather data on how experts describe homology and homologous chromosome pairing. We discovered that less than 5% of biology students (N=149) mentioned DNA sequence in any explanation of homologous chromosomes or pairing and 10% referred to genetic information. On the other hand, 44% of biology experts (24/55) discussed DNA sequence and 80% referred to genetic information in their explanation of homologous chromosomes. To investigate why students fail to think about DNA sequence as the basis for homology and homologous pairing we analyzed 174 passages about meiosis from a total of 17 commonly-used biology textbooks. Using a deductive coding strategy we found only 16/104 (15.4%) of textbook passages describing “homology” or “homologous” make an explicit link with DNA sequence; these 16 passages were found in only 9 of the 17 textbooks. Fewer passages about homologous pairing mechanisms were found but analysis revealed that only 2/28 (7.1%) of passages described DNA sequence as being important for homologous chromosome pairing during meiosis. Building off ideas of the Threshold Concepts Framework (TCF) by Meyers and Land we propose a new theoretical framework that highlights threshold links for teaching and learning meiosis. We hypothesize that students do not grasp meiosis because typical instruction and classroom resources do not help students make and build upon important connections between key ideas: DNA sequence and genetic information are inextricably linked with each other and those concepts are linked to our understanding of homology, which in turn explains the mechanism of homologous pairing during meiosis. Preliminary data indicates that making the threshold links explicit to students improves long-term retention of knowledge about meiosis. This model may be useful to others in the community for investigating student learning of other complex topics.

Abstract # 87 (Round Table Sat )
Development of the CDCI-SHiNE Web Application for analysis of data generated by a Multiple Select Assessment Instrument
Kate Wright*, Rochester Institute of Technology; Dina Newman, Rochester Institute of Technology; Christopher Snyder, Rochester Institute of Technology; J. Nick Fisk, Rochester Institute of Technology; Katie Lewis, Rochester Institute of Technology

Central Dogma of Molecular Biology states that information flows from DNA to RNA to protein in an organism. Although the concept is straightforward, biology students of all levels have difficulty with many key Central Dogma concepts. The Central Dogma Concept Inventory (CDCI) is a multiple-select assessment tool that can be used to analyze the effectiveness of Central Dogma related pedagogy. The multiple select nature of the tool is a double-edged sword; while the tool provides greater insight than a traditional forced choice assessment, it is more difficult to analyze the results and make meaningful inferences. Currently CDCI results have been analyzed using ad-hoc programs written in R by undergraduate bioinformatics students at RIT, but this is an inefficient approach which is not transferrable to other instructors or researchers. In order to extend the usability of this assessment instrument we are developing a web-based application for the analysis of CDCI results called CDCI-SHiNE which uses the Rshiny framework for building web applications produced by RStudio. This tool will allow users to upload CDCI data for analysis and return to them statistical and graphical representations about class knowledge on specific concepts and possibly on how groups may compare (i.e. pre/post data comparisons). Feedback is needed from the Biology Education Research community about what is needed to create a useful and user-friendly online tool.
Investigating How Science Students and Faculty Organize Their Science Knowledge
John Rodriguez*, San Francisco State University; Kimberly Tanner, San Francisco State University

Given the need for interdisciplinary thinking, there are few to no measures that assess the extent to which students make connections across science disciplines. To address this, we created the Interdisciplinary Card Sorting Task (ICST), which asks participants to group 9 science textbook problems, each embedded with both a disciplinary context (i.e., biology, chemistry, or physics) that is a surface feature and a fundamental scientific principle (i.e., energy transformations, types of equilibrium, or structure-function) that is a deep feature. Participants, which included advanced science students (n=222) and science faculty (n=21) from biology, chemistry, physics, and environmental studies, sorted these 9 cards in three separate task conditions: First, in a 1st unframed task condition, participants were tasked to sort cards into groups that shared similar fundamental scientific principles and create group names. Second, in a 2nd unframed task condition, participants were charged to produce another organization, different from their first sort. Two unframed conditions were necessary because we hypothesized that most participants would initially sort by disciplinary surface features; a second unframed sort provided an opportunity for participants to sort based on deep features. After each unframed condition, participants wrote rationales for their sorts. Third, in a framed condition, participants sorted the cards under 3 deep feature group names provided by the researchers. We hypothesized that students and faculty would organize their science knowledge by surface features and deep features, respectively. Quantitatively, we examined the frequency at which participants paired cards based on deep features versus surface features (percent card pairings). Qualitatively, we examined group names and written rationales for evidence of surface or deep feature sorting. Here we present 4 key findings: 1) faculty made statistically more deep feature card pairs 43+7% compared to students 24+1% in the unframed conditions (p<0.02); 2) 52% of faculty created the group name “energy transformations” compared to 13% of students (p<0.001); 3) 71% of faculty provided deep feature rationales compared to 13% of students (p<0.001); and 4) faculty made statistically more deep feature card pairs 71+6% compared to students 50+2% (p<0.02). Based on the metrics examined, the ICST appears to be able to distinguish between advanced science students and science faculty using multiple measures. However, faculty produced an unexpectedly large proportion of surface feature pairs and low proportion of deep feature group names in the unframed sorts. Overall, we believe the ICST may be a valuable tool to measure interdisciplinary scientific thinking.

Developing Learning Progressions in Undergraduate Physiology (LeaP UP)
Jennifer Doherty*, University of Washington; Mark Urban-Lurain, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University; Jenny McFarland, Edmonds Community College; Mary Pat Wenderoth, University of Washington

To gain expertise in a field is to recognize, understand and be able to effectively use underlying disciplinary principles. If faculty are to help students not only understand but master the unifying principles, it is first necessary to investigate the paths students take to mastery. A learning progression helps us understand how students’ mental models of key principles are refined and strengthened over a curriculum and learning progression-based assessments provide a more fine-grained measure of students’ progress towards a goal, rather than a binary right/wrong verdict. Our goal is to develop a learning progression framework and associated assessments to describe how students’ reason about the physiological principles of flux (i.e., movement of substances described by Ohm’s, Fick’s, Poiseuille’s Laws) and mass balance (i.e., Conservation
of Mass) as this set of basic principles apply to and explain the mechanisms of a wide variety of physiological systems. We developed a semi-structured interview protocol to solicit explanations and predictions in four contexts (two on Flux—ion movement in electrophysiology, oxygen movement during ventilation and gas exchange and two on Mass Balance—calcium levels in cardiac muscle contraction, changes in biomass). We interviewed 30 students from UW and EdCC, ranging from first-quarter freshman to graduating seniors and graduate students. We used grounded theory to analyze interview transcripts and uncover emerging patterns. From this analysis we propose a learning progression framework for understanding Flux and Mass Balance: Lower level L1: teleological and anthropomorphic reasoning; three Intermediate levels L2: algorithmic reasoning without mechanistic understanding and no use of principles (e.g., student knows the steps in a process but not why they occur); L3: Incorporating principles as just another variable in algorithmic thinking; L4: Principle-based reasoning with gaps in contextual knowledge, Upper level L5: Principle-based reasoning with full contextual knowledge. We have used our proposed learning progression to design a constructed-response assessment instrument. Using constructed-response (CR) assessments allows students to fully express, in their own words, their current understanding of physiological mechanisms, rather than merely recognizing the correct answer among distractors. We are exploring computerized text analysis tools to facilitate the analysis of students’ responses. CR assessments afford faculty a more nuanced understanding of student thinking to inform changes to instruction. When developed, this automated assessment system will allow for wide-spread use of the learning progression framework and assessments in undergraduate physiology teaching. We will present the progress we’ve made on developing these tools.

Abstract # 90 (Round Table )

Unpacking the criteria for video engagement in a biology MOOC
Sera Thornton*, Massachusetts Institute of Technology; Ceri Riley, Massachusetts Institute of Technology; Mary Ellen Wiltrout, Massachusetts Institute of Technology

Molecular Biology is a massive open online course (MOOC) that we designed in collaboration with two professors who have long taught the subject on campus. The MOOC offers learners a number of modes of learning, including two types of short video segments: lecture videos (delivered unscripted by a professor, with animated graphics edited in) and deep dive videos (fully animated and logically scripted, addressing specific learning objectives; narrated by an un introduced undergrad). Graphics are especially important in teaching biology because our field is so intrinsically visual. Biological descriptions – of the structure of DNA, for example – are made so much more accessible, especially to the novice, by visual representations. Research suggests that moving graphics, such as those used in both of our video types, are beneficial to learning when the visuals depict concepts central to the learning objective(s), and are not simply motivational (Höffler and Leutner 2007). However, for an animation to affect learning, the video or course design must persuade the learner to actually watch the video. Learners on the course discussion forum are vocally appreciative of our deep dives. We were thus surprised to notice that while the engaged learners overwhelmingly watched the lecture video segments through to completion (93% +/- 3% of watchers watched to the end), many watched only a portion of each deep dive video (only 65% +/- 5% of watchers watched to the end). Our research questions are thus: Is the difference in learner engagement between lecture videos and deep dives statistically significant and pervasive? What characteristics of the lecture videos and deep dives might cause this difference in learner engagement? We hypothesize that video length (within the 3-11 minute range) and placement within the online course structure do not correlate with changes in engagement (as supported by our preliminary data analysis), but that the difference in the video host (trusted professor vs. unknown) does have an impact on engagement. We also ask what elements (for example, key term labeling or animated graphics) are present where
learners either re-watch or stop watching the video, to better determine what encourages or discourages engagement. We will address these questions through statistical analysis of the existing clickstream data, and through A/B testing planned for the summer 2016 run of this MOOC. The results will be invaluable in the design of educational video for biology courses.

Abstract # 91 (Short Talk Fri)
Domain-Specific Biochemistry Problem Solving in Undergraduate Students
Ersta Ferryanto, University of Georgia; Kush Bhatia, University of Georgia; Bryant Choe, University of Georgia; Stephanie Halmo, University of Georgia; Alexandra Howell, Augusta University; Kaitlin Kehoe, University of Georgia; Cheryl Sensibaugh, University of Georgia; Morgan Watson, University of Georgia; Paula Lemons*, University of Georgia

Although there is widespread agreement about the importance of problem solving in biology education, biology education research on problem solving has been limited primarily to genetics and evolution (Smith & Good 1984, Smith 1988, Nehm and Ridgway 2011). This project investigates the question: how do undergraduate students solve problems about threshold concepts in biochemistry (Loertscher et al. 2014)? Our research is grounded in the theoretical framework of domain-specific problem solving, which proposes that successful problem solving depends upon a well-developed knowledge base of content knowledge, knowledge of strategies, and the awareness of how to apply knowledge to the problem at hand (Newell and Simon, 1972; Chi et al., 1981; Smith, 1988; Alexander et al., 1998; Bodner, 2015). To investigate our research question we conducted a study with undergraduates, including five introductory biology and eight introductory biochemistry students, as well as eight biology/chemistry PhDs. We developed a problem set that required the solvers to predict the folding and function of a protein. The problem set was administered using a think-aloud interview protocol. Interviews were video recorded, transcribed, and analyzed using standard qualitative methods. A detailed code system was developed to characterize participants' content and strategies knowledge. Two researchers coded the data set and their work underwent several rounds of review by other research team members. Our analyses revealed that biology and chemistry PhDs solved the problem set efficiently, almost exclusively using accurate content knowledge and supportive strategies that were highly structured. Some students also exhibited this type of problem-solving behavior, although much less efficiently than PhDs. In contrast, other students' solutions were inefficient and contained a mixture of accurate and inaccurate declarative knowledge and supportive and unsupportive strategies. Overall, five of eight biochemistry students and two out of five introductory biology students generated successful solutions to the problem. Our analyses also uncovered several difficulties specific to the domain. For example, several students could not describe the attractive interactions that occur among nonpolar groups within a protein. Others struggled to interpret the important features of an amino acid structure. This study adds to the biology education literature base by providing a theoretically-grounded approach to the study of biology problem solving. This approach can be scaled to study the problem-solving processes and difficulties of larger numbers of students. Additionally, our findings can be used to build learning tools for biology students and instructors.

Abstract # 92 (Poster Sat # 41)
Flipped Classroom Using Virtual Learning Environments: Performance Implications in a Biochemistry Lab Course
Thanuci Silva*, University of Campinas; Eduardo Galembeck, University of Campinas

Planning and conducting experiments are some of the most important components of a biochemistry lab course. Successful experiments require the student to understand their goal and have deep understanding of the different techniques. In order to have students better prepared to perform experiments and enhance their understanding of the theoretical content, we
used a flipped classroom approach embedded in a virtual learning environment, to deliver quizzes as preparatory activities for the upcoming lectures and laboratory experiments planning sessions. All students (n=45) received weekly quizzes before each lecture and planning session, and were given unlimited submissions. As a formal assessment, students are tested on concepts covered in the online quizzes and in class (laboratory and lectures) using open-ended questions. In order to understand the implications of this preparatory approach, we compared exam performance between two groups of students: those who took the enzymes quiz and those who did not. Specifically, we compared the scores on the enzyme preparatory quiz, an exam question covering the quiz concepts and the overall exam scores. Our results show that despite given the unlimited number of submissions for the quiz, only two students took the enzymes quiz more than once and 19 students chose not to take the quiz. Despite this, 25 students took the enzymes quiz at least once. Results from the enzymes exam question revealed that the average score of students who took the preparatory quiz was 0.72 out of 1 point (SD=0.30). While the average score of students who did not take the quiz was 0.47 out of 1 point (SD=0.36). The Kruskal-Wallis statistical analysis between the scores of the two groups showed a significant difference (p<0.05). Results from the overall exam scores show that the group of students who took the quiz, only 20% did not achieve the minimum score of 5.0 considered acceptable, while 55% of the students who decided to not take the quiz did not achieve the minimum score. Our results suggest that students engaged in take the preparatory quiz performed better on the exam question regarding the concepts presented on it as well as in the referred exam as a whole, which may indicate that this approach is helping students to achieve the enzymes course objectives. Beyond that, these students may have improved their overall course learning outcomes compared to those who are used to not take the quiz, facet that further will be discussed.

Abstract # 93 (Poster Sat # 37)

With massive courses come massive challenges: a new approach for cell modeling and large-scale assessment in the MOOC era

Mayara de Oliveira*, Unicamp; Eduardo Galembeck, University of Campinas

Models have shown to aid student learning, but current literature does not report their development in online courses. In these environments students are supposed to independently understand models, without an instructor to explain in person. In this sense, there is a need for appropriate models to assist students in the effort to capture the abstraction involved in microscopic structures such as cells. In digital media, models of cells are mainly static and do not take into account organelles proportionality. Thus, to provide valuable support to the large numbers of students embedded in massive courses, it is relevant to build external representations that are closer to the reality. Using cells as our context, we developed a MOOC (massive open online course) with an immersive scenario consisting of a three-dimensional model of a cell where organelles are designed in scale. Students can access the MOOC through a mobile application called The Cell. To develop the course we used a multi-faceted process incorporating instructional design and the four basic steps described in the Ed Tech Developer’s Guide of the U.S. Department of Education. Through the MOOC, users can interact with the cell model and develop “Missions” that requires processes that happens across multiple organelles. This model is an opportunity for students to integrate the cell parts into a whole system, exercising the synthesis level of Blooms’ taxonomy. In order to better understand how students interact with the model and to provide feedback to both, students and instructors, we embedded our model with an assessment tool specially designed to track and store user’s behavior flow. In the data science era web analytics tools have a central role allowing instructors to assess a large amount of students even remotely. In our case, we developed a statistical analysis module that enable track and store user’s performance in the MOOC database.
Preliminary results obtained through the database allowed identifying students’ scores; time spent answering questions and engagement in each activity. These data allow instructors to understand where students struggle and accordingly plan interventions to help them to achieve the learning objectives. This approach also reduces the subjectivity of the formative assessment process and the time spent for preparation, tabulation and analysis of assessment data at a large scale and in real time. The association between reasoned models and learning analytics tools are promising and can be effective to help instructors and students in the MOOC development and evaluation.

Abstract # 94  (Poster Fri # 21)
**A 3D Intervention Addressing Enzyme-Substrate Interaction Misconceptions**
Cassandra Bongers*, University of Minnesota, Rochester; Cassidy Terrell, University of Minnesota, Rochester

Many students enter biochemistry courses with enzyme-substrate interaction misconceptions stemming from prior biology and chemistry courses where this core concept is inadequately illustrated, explained, and/or assessed. Moreover, research has shown two-dimensional representations not only fail to effectively convey biochemical concepts, but also propagate misconceptions. Reported enzyme-substrate interaction misconceptions highlight the necessity for better, targeted instructional tools and assessments. We hypothesize that three-dimensional (3D) physical models used in conjunction with targeted active learning assessments will increase student understanding of shape, stereochemistry, and electrostatic interactions involved in enzyme-substrate interactions. We further propose that the use of these physical models will decrease the amount of time needed to complete the active learning assessments while also facilitating a deeper understanding of enzyme-substrate interactions, therefore offering the instructor more time to cover other course topics. This intervention study also addresses several biochemistry threshold concepts, including the physical basis of interactions and free energy; and supports the “Vision and Change in Undergraduate Biology Education: A Call to Action” report by offering concept-oriented active learning opportunities. A series of active learning assessments, with corresponding learning objectives and physical models designed by a team of undergraduate students, were developed to address the identified misconceptions of space, electronic interactions, and stereochemistry in enzyme-substrate interactions. Here we aim to present (1) the design and development of these assessments and corresponding 3D physical models along with (2) the preliminary results of this study. In a control classroom, the active learning assessments were administered and video-recorded in the absence of 3D physical models. After a second control semester, the physical models will be implemented simultaneously with the assessments into the classroom. In addition, the validated Enzyme-Substrate Interaction Concept Inventory (ESICI) survey is administered at the beginning and end of each semester to establish a baseline for each class, measure gains in each of the three misconception areas, and offer a comparison against the published national average. Likert-scale coded scoring of individual questions in the active learning assessments, ESICI results and observational evaluation of the recorded activities will be analyzed for the control and experimental classrooms using a mixed-methods approach that includes quantitative inferential and descriptive statistical analysis. Preliminary data has been collected and analyzed on the first control semester in Spring 2016. Further development and results of this study set the stage for curriculum wide development of enzyme-substrate interaction targeted assessments.
Connecting Lab Course Design to Student Outcomes: Project Ownership & Intent to Persist in Science
Lisa Corwin*, University of North Carolina Chapel Hill; Christopher Runyon, University of Texas at Austin; Eman Ghanem, Sigma Xi; Moriah Sandy, University of Texas at Austin; Greg Clark, University of Texas at Austin; Erin Dolan, University of Texas at Austin

Course-based Undergraduate Research Experiences (CUREs) are often championed as a way to increase students’ access to research experiences and thus involve a greater number and diversity of students in research. Recent work has highlighted many student outcomes resulting from CUREs, including outcomes that influence persistence in science, such as increased project ownership (Hanauer et al., 2012). Yet, no studies have investigated how the design and implementation of CUREs, as compared to other laboratory learning experiences, affects these outcomes. The Laboratory Course Assessment Survey measures three elements of CURE design (Corwin et al., 2014). These include (1) Discovery and Relevance, or the opportunity for students to make or find something new that is of interest to the scientific community, (2) Iteration, or the opportunity to revise or repeat aspects of scientific work to move research forward, and (3) Collaboration, or the opportunity to work with and assist other students and reflect on one’s learning. This instrument was used in conjunction with the Project Ownership Survey (Hanauer et al., 2012) and a question asking students to rate their likelihood to pursue a scientific career in order to examine relationships between course design, ownership, and persistence. We collected and analyzed data from a total of 836 students in 71 laboratory courses, including CUREs, traditional labs, and inquiry labs, across the United States. Using a structural equation modeling approach, we examined hypothesized relationships among course design, ownership, and intentions to persist. We tested and compared nine different SEM models to elucidate relationships with the highest degree of support. Based on analysis of consistent relationships across models and description of the model with the best fit, we found that a) prior intentions to persist in science have a strong relationship with students intentions to persist after completing a laboratory course, b) each course design element has a direct effect on project ownership with iteration having the strongest relative effect, and c) the effects of course design on intentions to persist are mediated by ownership. Our hope is that these results can inform research-based course design for instructors seeking to increase students’ sense of project ownership and thus their intentions to persist in science.

What are Biology Instructors Saying in Class? Comparing Instructor Talk Across 55 Biology Courses
Colin Harrison*, San Francisco State University; Shannon Seidel, Pacific Lutheran University; Alycia Escobedo, San Francisco State University; Katie Lam, San Francisco State University; Kristen Liang, San Francisco State University; Jeff Schinske, De Anza College; Kimberly Tanner, San Francisco State University

Authors: Colin D. Harrison, Shannon B. Seidel, Alycia M. Escobedo, Katie Lam, Kristen S. Liang, Jeffrey N. Schinske, and Kimberly D. Tanner  Instructors not only facilitate students’ conceptual learning, but also as serve as role models and mentors. As a result, what instructors say in classrooms can have profound effects on student motivation, self-efficacy, and identity, as well as learning. As such, we hypothesize that instructor language itself may be a mediator of phenomena such as Instructor Immediacy, Student Resistance, and Stereotype Threat. Previously, we characterized and established Instructor Talk (IT) – non-content language used by instructors to establish the learning environment – as an understudied aspect of classrooms (Seidel, 2015). In the present study, we pursued three research aims: 1) to investigate whether IT is a feature of biology courses beyond the initially described course, 2) to quantify the
prevalence of different IT categories in other courses, and 3) to measure IT variability between the beginning and middle of courses. To address these aims, we transcribed two 15-minute samples from class audio recordings contributed by 55 biology instructor collaborators from 14 community colleges and a 4-year public university involved in a faculty development effort. Samples were systematically taken from the first class session recorded (early course) and a class session 6-8 weeks later (mid-course). Samples were analyzed for instances of IT, each of which was assigned to one of five previously established IT categories. Analyses revealed that 96% of instructors evidenced IT, ranging from 0 to 33 instances per instructor. Overall, the most to least prevalent categories of IT present in the 501 identified instances were, in order – Building the Instructor Student Relationship, Establishing Classroom Culture, Sharing Personal Experience, Explaining Pedagogical Choice, and Unmasking Science – generally reflecting the initially published description of IT. Across the two samples, significantly more IT instances were found early course compared to mid-course (p<.001), and 81% of instructors used more IT in the first versus second sample. This second research study investigating IT in biology courses demonstrates that: 1) IT is a widespread phenomenon among many instructors at many institutions, 2) the IT framework is widely applicable, with all previously described IT categories being detected, and 3) instructors appear to use more IT early versus mid-course. The IT framework is a robust tool for measuring biology instructors’ non-content, classroom language, an important yet understudied classroom variable. With the ability to measure IT, future studies may investigate the extent to which different categories of IT may mediate phenomena such as Instructor Immediacy, Student Resistance, and Stereotype Threat.

Abstract # 97 (Short Talk Sun )
Lab reports: more than writing to learn conventions in biology
Cynthia Hill*, Tufts University; Juli...
how students and instructors understand the purpose of laboratory instruction and their roles. Building on these results, we propose and discuss practices of instruction that re-frame the purpose of labs and reports in order to encourage TA engagement with biological reasoning.

Abstract # 98 (Poster Fri # 52)
Course-based Undergraduate Research Experience (CURE) in molecular genetics improves students' confidence in using the scientific method and promotes interest in biological research
Erica Gerace*, Georgetown University

Course-based Undergraduate Research Experiences (CUREs) expose students to authentic research within their coursework. In our Genetics class, comprised of a majority of second-year undergraduate students who have completed our introductory biology sequence, we incorporated a CURE that replaces traditional cookbook laboratory exercises. In this CURE, students participated in discovery in molecular genetics by making a novel genetic knockout in the opportunistic fungal pathogen Candida glabrata and subsequently assaying for cell wall phenotypes. Students learned biological concepts during this semester-long project while actively engaging in the entire research process beginning with reading of the primary literature to formulating and testing a hypothesis to interpreting phenotypic results and drawing conclusions within the context of the broader field. We hypothesized that because the students have ownership and direction of their research this would lead to heightened interest in the project and further, this experience would spark their interest in conducting research in the future. We also hypothesized that exposure to research in this course would improve students' confidence in their ability to read primary literature, formulate hypotheses, and interpret experimental data as well as other aspects related to conducting basic research. Analysis of the preliminary data gathered from pre- and post-survey assessments has supported our hypotheses. After the completion of this CURE, students indicated improved confidence in their ability to read primary literature (Student's t-test, p<0.01), formulate a hypothesis (p<0.002), follow a laboratory protocol (p<0.05), as well as connect their research to the broader field (p<0.02). In addition, a majority of students reported that they had a solid understanding of the overall goal of the research and felt their project had significant scientific importance. Furthermore, most of the students at the end of the project indicated that they preferred the CURE over traditional laboratory course exercises, and importantly, would consider conducting biological research in the future as a result of participation in our Genetics lab. Overall, these results support the evidence that CURE-based laboratories are an effective mechanism to enhance students' understanding of the scientific method and to promote student interest in research.

Abstract # 99 (Poster Fri # 45)
Shifting the frame to responsiveness: a case study
Cynthia Hill*, Tufts University; Julia Gouvea, Tufts University; David Hammer, Tufts University

The science and mathematics education research literature discusses the benefits of responsive teaching—instruction that attends and responds to student reasoning (Robertson, Scherr & Hammer, 2016). In science, responsive teaching has been studied in verbal discourse, but not as yet in written work. We are interested in developing practices of instruction that support student reasoning in writing because 1) lab reports are ubiquitous in biology curricula, 2) articulating ideas in writing may help students deepen their conceptual understanding of biological phenomena, and 3) instructors may learn to use this space to attend and respond to student reasoning. This study focuses on instructor attention in marking lab reports. Over two consecutive years, we collected marked lab reports and conducted interviews with three graduate lab instructors (TAs) for an introductory undergraduate biology course. In the first year,
TAs used a rubric that emphasized conventions of style and form in scientific writing. In the second year, the second author became the lab coordinator and asked TAs to focus their feedback on student reasoning about the experiment. For this poster, we present a case study of Dana (pseudonym), who was a TA both years. In the first year, like other TAs, she mainly addressed style and form in her written comments to students (see short talk by author 1). Analysis of her written feedback suggests she focused on helping students produce an end product that resembled professional scientific written communication. To a much smaller degree, she also attended and responded to how students articulated their reasoning about what happened in their experiment. In the second year, the pattern reversed: Dana’s comments became more about students’ reasoning than about style and form. She remarked on students’ ideas, posed substantive questions, and pointed out gaps in logical flow. She also suggested areas the student might be interested to pursue further, perhaps sending a tacit message to the student that the completed lab report is not an endpoint, but something to continue to think about and refine. The evidence shows Dana was capable of responding in multiple ways to student work, depending on her understanding of the task and her role in it. We found similar patterns across other TAs. The results suggest the benefits of providing professional support for TAs to help them frame student reasoning as the central matter of attention, not only in verbal interactions but also in written work.

Abstract # 100  (Poster Fri # 4)
**The impact of a short evolution module on students’ perceived conflict between religion and evolution**
Elizabeth Barnes*, Arizona State University; James Elser, Arizona State University; Sara Brownell, Arizona State University

Evolution is simultaneously one of the most important theories in biology and one of the most controversial in society. Even among students in college biology classes, rates of rejection can reach up to sixty percent. Research shows that the source of rejection of evolution most often stems from an interplay of students’ misconceptions about evolution and their perceptions that evolution and religion are in conflict. While there is a wealth of research illustrating how to provide instruction on student misconceptions about evolution, there is very little research that explores how to reduce students’ perceptions that evolution is in conflict with religious beliefs. In this study, we designed a two-week module on evolution aimed at both increasing student knowledge of evolution and reducing students’ perceived conflict between evolution and religion. Using an open ended survey, we analyzed students’ perceptions of conflict between evolution and religion before and after our two-week module. We categorized students perceptions before and after the module as “in conflict” or “compatible” and then documented changes from pre to post module. We found that students’ perceptions that evolution and religion are in conflict were reduced by half. Surprisingly, we saw this reduction among both religious and non-religious students. This study suggests that by incorporating explicit discussion of the conflict between religion and biology we may be able to ameliorate students’ perceived conflict and thus improve student attitudes towards evolution.

Abstract # 101  (Poster Fri # 62)
**How identity, biology content, and instructional practices impact religious students’ sense of belonging in the biology classroom**
Jasmine Truong*, Arizona State University; Elizabeth Barnes, Arizona State University; Sara Brownell, Arizona State University

In response to the growing need for science and technology-related solutions, there has been a call to increase both the number of STEM graduates entering the workforce and the diversity of individuals within the sciences who can bring unique perspectives in creating these solutions. In
an attempt to increase the number and diversity of STEM graduates, an abundance of research has been conducted that looks at underrepresented groups such as women, ethnic minorities, and first-generation college students. However, little research has examined the experiences of other cultural groups that may struggle with persisting in a science-related major, such as religious students in biology. In this study, we explored the experiences of students from Judeo-Christian religious backgrounds in biology classes that may affect their sense of belonging in the biology community and subsequently their decisions to persist in biology. We interviewed 28 religious students enrolled in biology classes at a large research-intensive university in the Southwest United States. We analyzed the interview transcripts using grounded theory and content analysis. Our results indicate that religious students may face unique struggles in navigating their religious identity in biology classes. From this study, we found that students have different methods of reconciling their religious identity in the context of a biology class, including sometimes restricting their religious identity or disassociating themselves for other religious individuals who believe there is conflict between religion and biology. The religious student interviewees also perceive disadvantages and advantages of being religious in biology classrooms. Though students believe that there are advantages to being religious in biology such as offering unique perspectives and helping others learn and appreciate science, they also believe that there are several disadvantages in that they feel as though they are in the minority and are sometimes mocked by peers for their beliefs. Furthermore, these students perceive that their religious identities are more relevant for certain topics of biology instruction, including evolution and ethics. Many students limited their acceptance of evolution. Most students stated that their positive experiences occurred when instructors acknowledged religion when teaching evolution, while their negative experiences occurred when instructors did not acknowledge religion or highlighted conflicts between religion and biology. These findings indicate that religious students face unique challenges in the biology classroom, which may influence their sense of belonging and retention in the discipline.

Abstract # 102 (Poster Sat # 63)
Factors supporting undergraduate Biology degree completion at a regional public university.
Marcus Walker*, University of Minnesota Duluth; Richard Ragan, University of Minnesota Duluth; Ronald Regal, University of Minnesota Duluth; Carla Boyd, University of Minnesota Duluth; Benjamin Clarke, University of Minnesota Duluth; Amy Prunuske, University of Minnesota Duluth

Insofar as the aim of undergraduate Biology education is to successfully educate students through the completion of a degree to support the development of the scientific workforce, an investigation into factors predictive of degree completion would be valuable for both students and educators in the field. In addition there are significant disparities in graduation rates for minority students and institutions that best support minority graduation are those with an awareness of their graduation rates for students with lower probabilities for completion as indicated by Alexander Astin. We are applying decision tree machine learning to student records at the University of Minnesota-Duluth from 2005 through 2010 acquired from the Minnesota Data Warehouse in order to generate predictive ensembles that will enable us to identify those factors predictive of degree completion and quantify their predictive potency. Preliminary analysis suggests that while traditionally considered factors such as grade point average contribute the greatest predictive effect, factors such as first term grade point average, the number of transfer credits a student accrues, and the proportion of male to female instructors of a student’s classes may have significant predictive power.
**Abstract # 103 (Poster Sat # 1)**

**Our Progress in Creating the Chemistry in Cellular Respiration Concept Inventory**

Jay Forshee II*, Oklahoma State University; Donald French, Oklahoma State University

According to the AAAS’ Vision and Change Report, there are five major concepts students in general biology must understand. Of these core concepts, our students report concepts related to "Pathways and transformation of energy and matter" to be the most difficult. Our research focuses on the chemistry concepts that underlie cellular respiration and student knowledge related to these concepts. As reported by faculty members, these concepts are energy transfer, gradients, electron transfer, thermodynamics (laws), and chemical reactions. Our presentation will provide information surrounding our progress in the creation of the Chemistry in Cellular Respiration Concept Inventory (CCRCI), an 11 question instrument, the focus of which is to elicit naïve conceptions concerning the core chemistry concepts underlying cellular respiration in introductory biology students. These questions were synthesized from current, chemistry based concept inventories, textbooks, and/or experts in the concepts identified as important to the understanding of cellular respiration. Data collection took place during the spring 2016 semester, with students enrolled at a large Midwestern university, in a mixed majors, large enrollment introductory general biology course. Preliminary results indicate the instrument’s reliability to be low (Cronbach’s alpha $\alpha = .473$), but improvements to reliability are made when removing questions (up to $\alpha = .635$). An increase in reliability comes at the cost of removing 7 of the 11 questions, indicating further testing is needed. The instrument did, however, uncover interesting student responses to questions concerning gradients, thermodynamics, and chemical reactions. Furthermore, the instrument exhibited significant, positive, correlations between students score on exam questions related to evolution and chemistry and their score on the CCRCI. Future research will continue to focus on improving the validity, reliability, generalizability, and predictive power of the CCRCI.

**Abstract # 104 (Round Table Fri )**

**Examining the Reliability of the Diagnostic Question Cluster – Matter and Energy**

Jay Forshee II*, Oklahoma State University; Donald French, Oklahoma State University

Previous studies have positively associated general biology end of semester performance to high school science backgrounds including type and quantity of courses and final grades. Literature on chemistry and biology histories, and student preparedness for college biology, focuses on student overall success rather than targeting specific course content. The researcher’s focus is on incoming biology students preparedness for learning cellular respiration. The researchers intended to measured student preparedness via responses on the matter and energy diagnostic question cluster (DQC). While collecting data, however, the researchers identified no published data concerning the reliability of the DQC matter and energy inventories. To ascertain the inventories reliability, we collected student responses to form A and form B of the matter and energy DQC from students enrolled in a large, mixed majors, section of introductory biology at a large Midwestern university. The focus of the reliability study was then shifted to form B only as this form garnered the greatest response rate. The researchers also collected beginning of semester demographic survey data, which focused on student high school biology and chemistry backgrounds, college biology and chemistry backgrounds, and class standing. Results indicate the reliability of the instrument is high (Cronbach’s alpha $\alpha = .754$), but can be improved by removing three specific questions from the inventory (up to $\alpha = .8$). In addition, student responses to these questions indicate interesting response patterns and trends. Published reliable concept inventories provide practitioners with valuable formative and summative assessment tools. Using these tools, however, is only useful if we can trust the instrument, and its internal reliability.
Abstract # 105 (Poster Sat # 11)
Developing an explanatory framework to characterize student reasoning about interdisciplinary phenomena  
Emily Scott*, Michigan State University

The Framework for K-12 Science Education and the Next Generation Science Standards call for educators to consider how cross-disciplinary concepts facilitate students’ understanding of phenomena. However, it is unclear to what extent students’ actually use these concepts in their reasoning. Therefore, to investigate how students use cross-disciplinary ideas when reasoning about scientific phenomena, we interviewed 12 undergraduate biology majors who were enrolled in a second semester physics course and who had previously taken introductory chemistry and biology courses. Each student was asked to reason about several phenomena that contained elements from biology, chemistry, and physics, such as, “Why does an egg white turn solid when boiled?” or “How does a person who sneezes make another person sick?” In this poster, we present an emerging coding scheme developed from these interviews that characterizes students’ strategies for explaining scientific phenomena. We identified four dimensions of analysis: 1) Structural scale of reasoning: the scale of matter that students used to describe phenomena, ranging from macroscopic to submicroscopic elements; 2) Causal reasoning: students’ explanations about how the phenomena occurred, including force-dynamic relationships or structure-function models; 3) Characterization of phenomena: how students used analogies to categorize the phenomena, either by relying on surface features of the phenomena or attributes that directly aligned with the phenomena; 4) Precision in language and principles: what constraints students used to explain why the phenomenon occurred, relying on either personal experience/teleological motivations or scientific principles, relationships, or concepts. Each dimension is divided into three categories that describe students’ reasoning in increasingly sophisticated ways. These dimensions will be linked to a separate framework characterizing disciplinary concepts to identify when and how students’ reason with cross-discipline ideas.

Abstract # 106 (Poster Fri # 22)
Group composition for team-based learning: Random versus designed groups as it affects individual and team performance and course perceptions  
Anna Mosser*, University of Minnesota; Brian Gibbens, University of Minnesota; David Matthes, University of Minnesota, Twin Cities; JD Walker, University of Minnesota

Team-based and cooperative learning is increasingly common in the undergraduate classroom. Along with this mode of learning comes the question of how the teams should be formed. Disparate research suggests that group composition should be heterogeneous with respect to characteristics such as student academic ability and gender, yet this idea has not been widely tested in the undergraduate classroom. In a large introductory course for biology majors, we examined the effects of random versus designed group composition on individual and team performance as well as individual perceptions of team work and the course environment. Designed teams were balanced in terms of gender, self-reported confidence in science ability, honors student status and international student status. Information we did not have was gathered via a pre-course survey. Course instructors and teaching assistants were blind to the type of group composition. Across two sections of the course, with equal distribution within each section, 36 teams of 7-9 students were either randomly assigned or designed. Throughout the course, individuals took quizzes and exams and teams engaged graded quizzes, ungraded short-term activities, and graded long-term projects. In addition to individual and team performance on summative assessments, data on perceptions of team work and course environment were collected via team peer evaluations and an individual survey. Data (not yet available at the time of abstract submission) will be evaluated to test the hypothesis that more
balanced and heterogeneous group composition increases individual and team performance and positive perceptions of team work and course environment.

Abstract # 107 (Short Talk Fri)

A Faculty Learning Community Transforms a Department’s Curriculum around Course-Based Undergraduate Research Experiences
Kelly McDonald*, California State University, Sacramento; Allison Martin, California State University, Sacramento; Thomas Landerholm, California State University, Sacramento

Here we describe the outcomes of a Faculty Learning Community (FLC) used to promote curricular and cultural changes across the Department of Biological Sciences at a predominantly undergraduate Hispanic Serving Institution. FLC activities, including summer workshops and semester-based meetings, are being employed to recruit, train and support faculty as they develop and implement Course-based Undergraduate Research Experiences (CUREs). Many studies illustrate the positive influences of undergraduate research experiences on student learning, attitudes and retention in the sciences, and these effects are particularly pronounced for women and underrepresented minorities. In our department, a 2013 survey indicated that over 90% of biology majors wanted to participate in undergraduate research, but only 3% per year had the opportunity to work in a faculty-mentored setting. To address this discrepancy, we are re-designing and coordinating 13 existing laboratory courses to include research activities that address a real scientific problem – the human impacts on the American River Ecosystem. The labs are being created with the five critical components of CUREs: Scientific Practices, Discovery, Relevance beyond the classroom, Collaboration and Iteration. This effort will provide 2,000 majors with multiple opportunities to gain research experiences and contribute novel data to existing knowledge concerning the impaired waterway that runs through our campus. We are evaluating the impacts of our FLC using the five levels suggested by Connolly and Millar: participation, satisfaction, learning, application, and impacts on student learning. Surveys, interviews, focus groups and student work serve as the basis for analyses. Two-thirds (n=16) of the biology faculty attended a week-long Summer Institute (SI) in June 2015. Responses to surveys and interviews were exceedingly positive, with faculty at different stages of their careers revealing different motivations for participating and 100% of participants agreeing that the SI created a productive and collaborative environment for designing CUREs. One year following the SI, four new labs have been implemented and two have been assessed for student outcomes. Most notably, 92% of students in one CURE indicated that they were performing “real science” compared to only 50% in the same course before CURE implementation. Results from the Laboratory Course Assessment Survey showed that the majority of these students also recognized the elements of collaboration, discovery and iteration in the curriculum. These surveys further revealed differences in the responses of students taught by CURE-trained versus untrained faculty, highlighting a critical need for expanded training to reach faculty not participating in the FLC.

Abstract # 108 (Short Talk Sun)

Using Socio-scientific Issues in the Laboratory to Increase Student Motivation
Lori Kayes*, Oregon State University; Krissi Hewitt, State of Oregon; Jana Bouwma, Oregon State University; Robert Mason, Oregon State University

Rapid increases in technology and biological knowledge have contributed to an increase in societal issues that require attention from both scientists and citizens. Consequently, there is a need for the development of biologically literate citizens who have the ability to use their biological knowledge and skills to make informed decisions in their daily lives. Socio-Scientific Issues-Based Education (SSI) is a pedagogical approach that contextualizes science content within global and local social issues that intersect with science (e.g., GMOs, human genome
sequencing, and local water quality issues). In this study, we utilized the lens of the Self-Determination Theory of motivation to investigate how the contextualization of biology laboratory course activities with scientific and socially relevant issues impacted undergraduate student motivation and student perceptions regarding their ability to apply biological knowledge and skills in their daily lives. We utilized a mixed methods approach based on survey results collected from the Situational Motivation Survey (SIMS) and open ended questions distributed pre, mid and post-term in two different types of curriculum, termed traditional and SSI-based. Additionally, we employed a follow-up survey with additional open ended questions one year after the initial curriculum implementation. Results from the study showed that the SSI approach positively impacted both immediate and long-term student outcomes related to student motivation and the development of biological literacy in comparison to a control group. We investigated the effects of implementing an SSI-based laboratory curriculum on biology student motivation in a large introductory biology course for science majors. Through a hierarchical linear model, we examined the effects of the SSI curriculum relative to the existing curriculum in place as well as its’ effects over the course of the term on biology student motivation. An analysis of the data revealed a significant increase in motivation in the SSI group relative to the control group. Additionally, we determine how an SSI course that focused on fostering relevancy by contextualizing introductory biology content with locally and globally relevant socio-scientific issues affected student perceptions of relatedness. Through thematic analysis and quantification of code frequencies to facilitate comparisons between the SSI and the control groups, we found similarities in the ways that students perceived their peer and instructor relationships and significant differences between the two groups in the perceptions of the course curriculum as relevant and useful both at the time of the course and one year post.

Abstract # 109 (Poster Sat # 19)

**Evaluation of the State of the Introductory Biology in Oregon**

Lori Kayes*, Oregon State University; Amy Beadles-Bohling, University of Portland

The Northwest Biosciences Consortium (NWBC) was established to facilitate a “bottom-up” approach to integrating Vision and Change in introductory biology courses across institutions in the Pacific Northwest. As we worked towards our goals, it become apparent to us that even within our own institutions that there was considerable variation in what Introductory Biology for majors covers and requires and what the implementation of the Vision and Change should look like in this course. Thus, we sought to determine the state the current state of implementation of Vision and Change-based ideas in introductory biology for majors across institutions in Oregon. To accomplish this lay of the land, we developed and distributed a survey to all institutions in Oregon and the NW Pulse list serv. The survey asked faculty to self-report on the content and competencies covered in their Introductory Biology for majors sequences, as well as asking upper division faculty to report on content and competencies that were most valuable for the transition to upper division courses. Additionally, the survey asked for specific examples of activities and assessments used to address the competencies. We received responses from 40 faculty from 15 different institutions that included community colleges, private liberal arts, regional comprehensive, and R1-institutions across the broader Pacific Northwest. Preliminary results indicate that majority of faculty were familiar with Vision and Change and using it to guide their teaching. Faculty reported general agreement on the importance of specific content and competencies both in the faculty that teach in the introductory biology for majors sequences and in the upper division courses. There was considerable variation in the content delivered in the introductory biology sequences in the Oregon that does not align with the factors determined to be of the most importance by the faculty. On the other hand, there was considerable agreement in the competencies emphasized in the introductory sequences and the competencies deemed to be the most important for faculty teaching both at the lower and upper
division levels. Factors uncovered by this survey were reported back to faculty at a workshop in February where we worked with faculty to build consensus on essential topics covered in introductory biology.

Abstract # 110 (Poster Fri # 23)

**Student Sense Making Strategies while Using an Interactive Simulation**
Argenta Price*, University of Colorado, Boulder; Carl Wieman, Stanford University

PhET interactive science simulations are used 100 million times a year by students in elementary school through college. Because of this wide range of use, we are investigating how different ages of student build understanding through interactions with PhET simulations. This research will inform future simulation design and instructional strategies. Our questions include: What features of the simulations do students attend to, and how do different prompts affect their inquiry? What sense making strategies do they engage in? And how do those sense making strategies lead to shifts in conceptual understanding? In this study we focus on the pH scale simulation – a topic necessary for understanding biology at the molecular level. A unique feature of simulations is that students can choose what to explore, what data to collect, and how to interpret their data. The pH scale simulation allows students to explore pH at macroscopic and microscopic levels. In the macroscopic view, they can compare the acidity of various solutions and explore the effect of dilution. In a microscopic view, they can relate the concentration of hydronium and hydroxide ions to pH and further explore the effect of dilution. Students can also view multiple representations of hydronium and hydroxide concentrations: the concentration or quantity of each molecule on a logarithmic or linear scale, a qualitative representation of the ratio of molecules in the solution, and representations of the molecular structures of H2O, H3O+ and OH-. To investigate how students interact with and make sense of the simulation, we conducted think-aloud interviews with grade 7-15 students. Students were either prompted to “just explore and talk out loud” or “figure out what affects the pH of a solution.” As students interacted with particular aspects of the simulation, they were asked more guiding questions such as “what do you think the water is doing?” and “how would you predict the pH of a mystery solution if the pH number were hidden?” We have identified several categories of sense making activities that students engaged in while exploring the simulation: self-generated questioning and hypothesis testing, creating analogies to something they know from the real world, recalling directly relevant knowledge from class, mechanistic reasoning about the molecules involved, and comparing information across multiple representations. We are now in the process of analyzing how these sense making strategies result in conceptual shifts and understanding, and how student attention to different simulation features impacts sense making strategies or levels of understanding.

Abstract # 111 (Poster Sat # 12)

**Developing a classroom-based, tactile activity to explore differential gene expression: the “genome pod”**
Adriana LaGier*, Grand View University

Students often enter introductory biology courses with preconceptions that keep them from understanding the material. This study addresses the challenge of teaching cell differentiation when students assume that because all cells contain the same genetic information, they all have the same genes expressed. Many teaching strategies to address different patterns of gene expression are restricted to the laboratory or are skill or resource intensive. The objective of this project was to develop a teaching tool to facilitate understanding of differential gene expression that could be implemented in the classroom with minimal student training. The activity focused on accommodating tactile (kinesthetic) and visual learners so touching and manipulating objects was a priority. Therefore, small containers each containing the same fifteen toy figures were
used to represent the nucleus of the cell with each toy representing a gene (DNA) that codes for a different protein. To perform the activity, each student was asked to draw from the ‘pod’ a specific number of the toys at random. Because most students drew different toys (proteins) from the other students, the entire class ended up differentiating many specialized cells from the same genome. Preliminary summative assessments from exams indicate that both sets of students (one having performed the activity and the other having not performed the activity) performed similarly. Formative assessments were encouraging as the activity only took fifteen minutes of lecture time and most students indicated that it helped them appreciate in a palpable way how different cells can be made even if all the cells have the same genomic information. This newly developed tool, the ‘genome pod’, holds promise in providing biology instructors a classroom based, tactile way to teach differential gene expression.

Abstract # 112 (long talk Sat )
Opportunities and tension points associated with course-based undergraduate research experiences from student and faculty perspectives
Sara Brownell*, Arizona State University

National calls for more broadly integrating research into the undergraduate curriculum have sparked the development of course-based undergraduate research experiences (CUREs). In a CURE, students engage in the process of research in a formal lab course by exploring a question with an unknown answer that is of relevance to the broader scientific community. The dual functions of a CURE - as a learning opportunity for students and a research generating opportunity for faculty - create unique opportunities and tension points that have yet to be fully explored. Although most research on CUREs has focused exclusively on the experiences of students, this ignores that the research generation occurring in CUREs has the potential to impact faculty. To fill this gap in the literature, we conducted the first national interview study of 61 faculty who both develop and teach their own CURE and faculty who have implemented CUREs developed by someone else. Through semi-structured interviews, we explored faculty motivation to teach CUREs, benefits that resulted from CUREs, and reasons why faculty recommend teaching CUREs. We used grounded theory to code participant responses and identified that participant responses could be categorized as tangible or intangible, related to both student and faculty-centered themes. Our results highlight similarities and differences among faculty members who teach these two different CURE types. Our findings indicate that faculty motivation and benefits are important to consider when promoting the adoption of CUREs. Based on these new findings on CURE faculty motivations and benefits, we have created a conceptual framework surrounding the opportunities and tension points associated with CUREs from a student and faculty perspective. This framework considers how student and faculty benefits may be in conflict, how the intersection of research goals and learning goals may create tension in a course that students take for credit, and how the authenticity of research may be dampened by the structural elements of the course. This conceptual framework posits that the tension points surrounding CUREs may limit either some of the research productivity of a CURE or some of the student benefits associated with CUREs. Thus, as we move into the next phase of CURE implementation, we may need to carefully consider the ethical implications of conducting research in the context of a credit-bearing course before rushing to CURE lab courses.
Abstract # 113  (Round Table Sat )

**Long-term Outcomes Associated with High Impact Practices in an Honors Biology Course**

Amy Kulesza*, Center for Life Sciences Education; Judith Ridgway, The Ohio State University; Kelsie Bernot, North Carolina A&T State University

To support national efforts to educate a scientifically literate citizenry and a well-prepared workforce, we added service learning, a high impact educational practice (Kuh, 2008), to an honors introductory biology class. Our inquiry-based service-learning model, based on Kolb’s (1981, 1984) experiential learning cycle theoretical framework, supports student application of the process of science as they connect community service with course learning goals. Just as Kolb intended learners to continue to cycle through his four stages (concrete experiences, reflective observations, abstract conceptualization, and active experimentation) as they gained understanding and expertise, we intend our service-learning students to continue through the cycle as they extend their service involvement and apply it to their STEM learning throughout their lives. In many service-learning models, students participate in extensive service-learning throughout the semester. The benefits of participation in extended service-learning have been well-documented. Less attention has been paid to models of brief service-learning experiences such as ours, which involve under 10 hours of service-learning per semester. Our previous research examined short-term (within semester) differences in gains in motivation and scientific literacy between students with brief service learning (SL students) to students with brief research experiences (RP students), but detected few statistical significant differences. Because, like Kolb, we expected the brief experiences to trigger repeated cycles of service or research linked to learning, we then looked at the long-term differences between the SL and RP students. We compared SL students to RP students regarding their long-term involvement in service and STEM (measures included participation in additional service or research activities, persistence in STEM major) as well as their perceptions of service and science (measures included memories of the project, relevance of biology to lives, motivation to learn biology, and influence of project on career choice). In Spring 2016, SL and RP students previously enrolled in a 2013 honors introductory biology course completed a survey with open- and closed-response items associated with each of the previously mentioned measures. In addition, students completed Science Motivation Questionnaire-II (Glynn et al., 2011) and provided demographic data. To control confounding variables, we compared the structural aspects of the SL and RP classes. We will look for emergent themes in the open-ended questions, and provide descriptive statistics for the two groups. We will present our model, the new survey questions, and pilot summary. We seek feedback on our instrument items as well as other ways to measure student changes over the long-term.

Abstract # 114  (Short Talk Sat )

**Metacognition in upper-division biology students: awareness does not always lead to control**

Julie Dangremond Stanton*, University of Georgia; Kathryn Dye, University of Georgia

Students with awareness and control of their own thinking are positioned to learn more, perform better, and persist longer than students who are not metacognitive. In Brown's framework for metacognition there are two key components: metacognitive knowledge and metacognitive regulation. Metacognitive knowledge involves what you know about your own thinking, and what you know about approaches to learning. Metacognitive regulation includes the actions you take in order to learn, including the self-regulated learning skills of monitoring, evaluating, and planning. Using exam preparation as a context for studying metacognition, we previously proposed a continuum of metacognitive regulation development in introductory biology students.
To further characterize the key transitions that occur as undergraduates acquire these skills, we studied students taking an upper-division biology course. We asked: 1) which metacognitive regulation skills do senior-level biology students use, 2) what prompts them to use these skills, and 3) in what ways do they use them? To address these questions we collected data from cell biology students using open-ended self-evaluation assignments after the first and second exams in the course (n=126). From these assignments we selected students who provided clear evidence of metacognition, and studied them further through semi-structured interviews (n=24). Using content analysis we coded both types of data for statements of metacognition. We found that upper-division biology students are able to monitor, evaluate, and plan to a greater extent than introductory biology students. In particular, senior-level students excel at assessing what an academic task or situation requires of them, and selecting approaches to learning accordingly. The data also suggest that students do not use metacognitive regulation skills unless they are challenged. Participants that were homeschooled reported using these skills prior to college, but others described monitoring, evaluating, and planning for the first time in undergraduate science courses. This result fits with our previous finding that a critical event, such as earning a poor grade on an exam, can force introductory biology students to metacognitively regulate their learning. Interestingly, some upper-division biology students displayed strong metacognitive knowledge of effective approaches to learning, but they chose not to implement these approaches despite understanding their benefits. Their primary reason for not using strategies that they knew to be effective was a desire to avoid feeling uncomfortable. We explore relevant behavioral change theories, including social-cognitive theory, to help interpret these findings.

Abstract # 115 (Round Table Fri )

EQIP: A rapid, criterion-based categorization tool for assessing constructed-response questions
Anne-Marie Hoskinson*, Michigan State University; Andrea Bierema, Michigan State University; Rosa Moscarella, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University; Mark Urban-Lurain, Michigan State University

The Automated Analysis of Constructed Response (AACR, pronounced “acer”) Project is a collaboration among multiple institutions that uses automated text analysis to evaluate students’ constructed responses (CR) to questions based upon fundamental scientific concepts. These questions allow both researchers and instructional faculty greater insight into what students actually think about scientific concepts. Once researchers and faculty formulate new questions, the next step in the question-vetting process is their administration to student populations for collection of pilot data. Collected responses allow us to probe two key factors for developing robust CR items: 1) whether the question targets the concept in the ways instructors expect, and 2) whether student responses are complete enough to evaluate their understanding of the targeted concept. Because this evaluation requires reading and evaluating potentially several hundred student responses, this can be a time- and resource-intensive step in the question development cycle. In response, we developed a rapid, criterion-based interpretation rubric for questions in the exploratory phase of development. The Early Question Interpretation Protocol (EQIP) allows coders to rapidly categorize student responses, then use the pooled responses to make data-driven decisions (accept, revise, or discard) about the new question. Based on prior experiences in evaluating CR questions, we designated four categories for sorting student responses: 1- targeting concept (including scientific and alternative concepts), 2- mixed concepts, 3- off-concept (did not answer question posed) and 4- nonsense responses. Three coders evaluated 150-400 student responses to six new faculty-created questions. We used this round of evaluations for two purposes: 1) to advise faculty about their questions, and 2) to explore future refinements to the EQIP categories. EQIP allowed us to make targeted
recommendations to faculty about their new questions. For instance, EQIP showed that a question about chromosome non-disjunction was well-targeted, but student responses were almost always incomplete; we recommended revisions to the question stem. Another question about the Calvin cycle prompted a plurality of mixed-concept responses. Faculty recognized that the question itself could prompt at least three different concepts; this question was discarded. From this initial trial, we demonstrated that EQIP allows rapid calibration, and can help target question revisions. We envision expanding its reach to evaluating other assessment questions, such as those from both selected- and constructed-response questions. We seek feedback from the roundtable discussion about enhancing the utility and applicability of this tool.

Abstract #116 (Poster Sat #64)

**Using Visual Networks to Map the Systems Thinking Literature**
Caleb Trujillo*, Michigan State University; Patrycja Zdziarska, Michigan State University; Tammy Long, Michigan State University

As a field, discipline-based education research (DBER) infrequently crosses traditional boundaries and would benefit from research frameworks informed by other fields. Here, we demonstrate how a previously developed method from Information Sciences could be used to identify cross-disciplinary ideas and frameworks to support DBER and STEM education broadly. Using large bibliographic databases and computation tools, we created co-citation networks that map and cluster documents related to a common construct. To illustrate the method in a useful context, we show how we have used the approach to map the trans-disciplinary scholarship related to systems thinking. Many curriculum reports have advocated for inclusion of systems education in biology, but accurately identifying systems ideas across different knowledge domains has been difficult. Our results revealed the top 3 co-cited documents across each of 7 scholarly communities that have received peer-recognition in the systems-thinking literature. Ultimately, the resulting documents will inform the creation of a systems thinking framework for teaching and learning in undergraduate biology. For DBER scholars, an adaptation of this method may be useful for exploring a range of interdisciplinary ideas, thus breaking from domain boundaries and enhancing what is achievable in biology education research.

Abstract #118 (Round Table Fri)

**Investigating Syllabi for Three-Dimensional Learning**
Claire Morrison*, Michigan State University; Becky Matz, Michigan State University; Sarah Jardeleza, Michigan State University

In 2012, the National Research Council released A Framework for K-12 Science Education. The three dimensions of learning outlined in this framework are Science Practices, Crosscutting Concepts, and Core Ideas. Science Practices describe how scientists conceptualize, carry out, and present their research; Crosscutting Concepts are ideas that exist across disciplines in science and engineering; Core Ideas are central to specific disciplines and can help explain new disciplinary phenomena. The concept of three-dimensional (3D) learning has outlined a new direction for science curriculum development. We have developed a rubric to identify evidence of the three dimensions in biology postsecondary course syllabi, which aligns with a larger effort at Michigan State University to identify 3D learning in postsecondary science courses. Although different instructors might include different types and amounts of information, and syllabi may not fully represent the concepts highlighted in class, they can be a valuable data set. Syllabi are especially useful because they tend to be more easily accessible than observation and exam data and because they are often archived. The syllabus rubric we have developed will allow us to identify changes in syllabi over time and to compare evidence of 3D learning found in syllabi with classroom observation and exam data.
Abstract # 119 (Short Talk Fri)

**Contextual differences influence student reasoning about natural selection**
Joelyn de Lima*, Michigan State University; Mitch Distin, Michigan State University; Tammy Long, Michigan State University

Applying knowledge communicated in one context to a different one is a central feature of learning. Knowledge transfer can be weakened by human biases, such as anthropocentrism in the case of biology. Similarly, minor changes in question context have also been shown to influence undergraduate student reasoning. We tested whether contextual features such as taxon (human and cheetah) and trait type (structural and functional) influenced student reasoning about natural selection, and whether a semester of biology instruction could reduce contextual influences. We expected that students would construct responses that exhibited scientific reasoning to a greater extent (i.e., have more key concepts, and less naive ideas in their responses) when asked questions about a non-human animal (cheetah), and a structural trait. We asked students in a large (n=160) introductory biology course how a biologist would explain the evolution of traits in humans and in cheetahs. Structural traits (heel/leg bones) were contrasted with functional traits (abilities to walk upright/run fast); and these were contrasted within each taxon. Evograder (an online assessment tool) scored students’ responses for the presence of 6 key concepts (variation, heritability, competition, limited resources, differential survival, and non-adaptive) and three naïve concepts (adapt, need, and use/disuse). Using a multinomial regression approach, we found that: (1) The odds of students’ answers using only naïve concepts was 3.5 times higher when asked about human evolution than when asked about cheetah evolution. (2) Students were twice as likely to use naïve concepts when explaining functional traits as when explaining structural traits. (3) After instruction, the proportion of explanations that contain only key concepts increased by a third. Our results are consistent with prior research that shows a clear effect of contextual influences on student reasoning about evolution. However, we also observed that students’ use of scientific concepts increased and naïve concepts decreased following a semester of active, learner-centered instruction. Our findings suggest that certain features of instructional design have potential to promote transfer and reduce contextual biases associated with learning about natural selection.

Abstract # 120 (Poster Sat # 13)

**Using the Genetic Drift Inventory to Identify and Target Conceptual Weaknesses**
Rebecca Reichenbach*, North Dakota State University

Students at all levels fail to demonstrate adequate conceptual understanding and application of non-adaptive mechanisms of evolution such as genetic drift and mutation, and yet little research has been done to identify effective methodologies to address this issue. Commonly used analysis tools and interventions instead concentrate on natural selection even though genetic drift is an equally powerful force of evolution. The few studies that do propose an intervention fail to report data as to the effectiveness of the intervention. Our The few studies that do propose an intervention fail to report data as to the effectiveness of the intervention (Andrews et al., 2012). This study begins to address this gap through identification and eventual design of targeted instructional interventions for addressing genetic drift. The objective of this first part of the study is to identify the specific conceptual weaknesses among our undergraduate population with the administration of the Genetic Drift Inventory. We also seek to determine the effectiveness of current instruction regarding genetic drift within our department. This information will be used within a constructivist framework to develop more effective instructional strategies as part of future years’ work. Preliminary findings that will be reported here were generated from undergraduate that will be reported here were generated from undergraduate of students in upper-division biology courses. Using the Genetic Drift Inventory (GeDI) and a simple tabulation of incorrect answers, using the Genetic Drift Inventory (GeDI), we have
identified a subset of two critical conceptual areas where our student population’s scores show deep deficits. Both involve different aspects of a continued confusion of genetic drift with natural selection. The first is the idea that both mechanisms both mechanisms of which require a “need” to work. The second is to work. The second is as well as the idea that natural selection is always the most powerful mechanism as of evolution.

Additional data in a broader spectrum of upper-division and introductory level biology of courses is also being collected to deepen our understanding of our students’ learning progression so that we can inform design of specific instructional interventions in the next phase of our project. Data will be collected on the learning gains made by our students using our interventions so that the effectiveness can be evaluated. This will contribute to the Biology Education community as there is currently no information about the relative effectiveness of any learning interventions. Such information is needed so we may better enable our students to achieve a deeper understanding of evolution, the foundational glue for all of the biological sciences.

Abstract # 121  (Poster Fri # 58)
Adapting Data Nuggets for College Introductory Biology Courses
Joelyn de Lima*, Michigan State University; Melissa Kjelvik, Michigan State University; Elizabeth Schultheis, Michigan State University; Louise Mead, Michigan State University; tammy long, Michigan State University

Data Nuggets (DNs; http://datanuggets.org) are instructional resources designed to for promoting the quantitative reasoning and data analysis skills that are foundational for science. DNs connect students in classrooms with researchers in the field and their raw data. Students read about a researcher and their research questions and are then presented with a dataset that they graph and reason from. DNs have been widely adopted and proven successful in diverse K-12 classrooms by helping students learn the scientific practices of data analysis, representation, and interpretation. Our current work extends the reach of DNs as an assessment for college biology and expands their scope by incorporating core scientific competencies identified in Vision and Change. Specifically, our adaptation of DNs progresses students through a series of practices that mirror authentic scientific practice: graphing data in order to visualize trends, constructing meaning from the data in the form of a scientific argument, and using models to represent and reason about system interactions. We developed 2 versions of the college DN: one requires students to construct models, and the other requires students to use provided models to represent the logical structure of a system. In a pilot test of the version requiring students (n=184) to construct models, we observed significant variability in the components student chose to incorporate in their models and in the organization of those components. Most students used a box-and-arrow construct similar to a modeling approach learned in class, but 10% of students chose to incorporate figures/drawings into their models. Models are foundational to biological science and therefore should be represented in biology curricula. As instructional tools, models can help students visualize complex systems, develop and test hypotheses about system functions, and predict consequences of system perturbations. However, diversity among students’ representations can pose challenges for instructors in terms of practical issues, such as scoring and feedback. Future analyses will focus on the relative advantages and disadvantages of having students construct, rather than use provided models to reason about systems.
Abstract # 122 (Poster Sat # 23)

**Charting Change in a Faculty Cohort**
Rebecca Reichenbach*, North Dakota State University; Lisa Montplaisir, North Dakota State University

It is generally agreed that reform needs to occur in the American Education system at all levels. However, studies continue to show that university faculty are extremely resistant to change even when presented with evidence as to the efficacy of reformed instructional practices, especially active learning techniques. We will monitor what occurs as we introduce active learning techniques through workshops and Faculty Learning Communities (FLCs) to our cohort. The cohort is largely comprised of STEM faculty wanting to institute instructional change. Participants were selected through an application process that targeted those who were not only willing to change but also taught areas of high DFW (“D”, “F”, and “Withdraw”) rates. They agreed to attend periodic workshops and participate in Faculty Learning Community (FLC) meetings over the course of two years. Workshop and FLC topics are chosen from a constructivist viewpoint to scaffold the instructors through better pedagogy. This cohort entered the program with an extreme willingness to change and a favorable opinion towards active learning. Attitudes and beliefs were documented through survey of attitude, beliefs, and norms administered prior to entry into the program as well as at key points after workshops. To track any changes in practice, we are documenting what occurs in the classrooms using the Classroom Observation Protocol for Undergraduate STEM (COPUS). The COPUS was developed as an instrument to provide feedback to faculty about the active learning occurring in their classroom and has been shown to be able to track shifts in practice. Baseline observations occurred during Fall 2015 with first semester of implementation being Spring 2016. The initial instructional technique workshop occurred in January 2016 with additional training occurring in May 2016, August 2016, and January 2017. As the first semester of instruction passes, we are finding some shift in instruction towards greater implementation of active learning but not as much as anticipated. We are faced with a new question: This group of instructors entered with the attitude that they wanted to change, so why aren’t we seeing a greater shift? If we are able to answer this question we may better inform pedagogical instruction in faculty development at other institutions.

Abstract # 123 (Poster Sat # 14)

**Using drawing-based assessments to document change in students' conceptual understanding of genetics**
tammy long*, Michigan State University; Hannah Rose, Michigan State University; Noah Julyk, Michigan State University

Mastering core genetics concepts is a key learning goal for students in introductory biology. Understanding the structure and function of biological information is foundational for explaining organizing biological principles at larger scales, including the origin, expression, and evolution of organismal variation. However, teaching and learning genetics concepts can be challenging since it requires visualizing structures that cannot be readily observed. Although multiple-choice assessments are used in large-enrollment courses, drawings can provide insight into the range and variability of student thinking. In this project, we ask: how do students’ drawn representations of foundational genetics concepts vary before and after instruction? Bio 2 (Organisms and Populations) is second in a 2 course sequence required for life science majors (preceded by Bio 1 – Cells and Molecules). On the first and last days of class, students (n=183) completed an assessment that asked them to define and draw 7 genetics-related concepts that were a focal part of Bio 2 instruction: DNA, chromosome, gene, allele, nucleotides, protein, and phenotype. We used a grounded approach for developing codes that describe elements of
students’ drawings. Two raters analyzed a subset of drawings (> 80% agreement); the remainder were coded by a single rater. Frequencies of codes for each concept were compared before and after instruction. For some concepts, pre-post changes in representations reflect improved conceptual understanding. For example, many students represented proteins as amorphous “blobs” in pre-tests, but post-tests were more likely to show proteins in terms of their structural components, functions within cells, or as products resulting from a process of assembly. Other concepts (chromosome, phenotype) were relatively unchanged, but were more likely to include labeling and descriptive text following instruction. Gene, allele, and mutation – concepts identified through prior research as particularly problematic for learning – showed the greatest variability before instruction, but converged toward more consensus-type representations that were superficially similar to versions used in class. Drawings have potential to offer insight into student thinking beyond standard assessment formats (forced choice, verbal response). In some cases, drawn representations better reflect students’ reported mental models and therefore have potential to inform both students and instructors about student learning. Iterative drawing tasks serve to document changes in conceptual understanding over time and afford students opportunities to practice the core scientific skills of representing and communicating their understanding to others.

Abstract # 124 (Poster Sat # 24)
Analysis of Postdoctoral Training Outcomes that Broaden Participation in Science Careers
Brian Rybarczyk*, UNC Chapel Hill; Leslie Lerea, UNC Chapel Hill; Dawayne Whittington, Strategic Evaluations, Inc.; Linda Dykstra, UNC Chapel Hill

Numerous studies have examined supportive interventions to broaden participation in STEM disciplines. Postdoctoral training is an optimal time to expand research skills, develop independence, and shape career trajectories, making this training period important to study in the context of career development. Research indicates that trainees’ waning interest in pursuing academic research careers occurs during graduate studies and has led to concern about the state of the scientific workforce in the U.S., particularly with disproportionately low numbers of underrepresented racial minorities (URM) in STEM fields. Seeding Postdoctoral Innovators in Research and Education (SPIRE) is a training program that balances research, evidence-based pedagogical training, and professional development through a partnership between a research-intensive institution and minority-serving institutions (MSIs). This study examines factors that promote the transition of postdocs into academic careers. Data were collected using a repository tracking database, interviews, and surveys over a 15-year period. Comparison data indicate that SPIRE scholars published scientific articles at similar rates as compared to postdocs not in the program. SPIRE scholars taught over 180 courses involving 3,000 students and mentored over 260 students in research. Data indicate that SPIRE scholars (n=77, 25% URM, 69% female, 6% disability) transitioned into tenure-track faculty positions at three times the national average (66% vs 19.4%, c2 =30.2, p<0.001). Data also indicate that the scholars’ transition into academic faculty positions were not affected by the 2008 economic downturn as indicated by similar numbers of academic job applications submitted pre- and post-2008 independent of demographics and their attainment of academic faculty positions pre- and post-2008 (c2 =2/31, p= 0.13). Logistic regression models indicate that significant predictors of career attainment were scholars’ intended career track (OR: 3.29; 95% CI: 1.15-9.43; p<0.05), the number of first-authored scientific publications (OR: 3.57; 95% CI: 1.12-11.35; p<0.05) and total number of scientific publications (OR: 2.75; 95% CI: 1.12-11.35; p<0.05). Factors reported for successful transition into faculty positions were teaching experience as instructors-of-record, training in evidence-based pedagogy, and the experience balancing teaching with research. Longitudinal tracking revealed that scholars continued their commitment to increasing diversity
in their faculty roles as demonstrated by attainment of tenure-track positions at MSIs, mentorship of URM s in research, and engagement with diversity committees and service opportunities. These results are important as they reveal critical factors for progression into academic careers and suggest that a postdoctoral program structured to include research, teaching, and diversity, facilitates attainment of desired academic positions with long-term contributions to broadening participation.

Abstract # 125 (Short Talk Sat)
**Effect of Cumulative vs. Non-cumulative Assessments on Student Learning in an Introductory Biology Course**
Nicole Rice, Brigham Young University; Da Baek, Brigham Young University; Nicholas Nelson, Brigham Young University; Shannon Rose, Brigham Young University; Kurt Williams, Brigham Young University; Elizabeth Bailey*, Brigham Young University

Assessment has long played an important role as a measurement tool of student mastery over course content. However, testing has also been shown to be an effective learning tool in its own right. Assessments need not be only tests of learning, but can also be tests for learning. Previous research has shown that one way to transform exams from being metrical to learning tools is increasing frequency of assessment. Typical undergraduate courses rely on a few, large midterm exams; unpublished data suggest that smaller, more frequent assessments significantly increase student learning. In addition, growing evidence supports the idea that cumulative assessments promote student learning more than traditional, non-cumulative exams. The purpose of this study was to investigate the effects of cumulative vs. non-cumulative assessments on student learning within the model of smaller, more frequent exams.

Cumulative assessments provide repeated exposure to course content, allowing student performance to increase because of the testing effect. Alternatively, non-cumulative assessments provide opportunities to test course material with greater focus. In this study, one section of an introductory biology course for non-majors was given cumulative assessments, with about half of the questions drawn from previous units and the rest covering the current unit. The other section was given non-cumulative assessments, with the entire assessment drawn from current material. All other instructional techniques were identical between both sections: same lectures, same assignments, same class activities, etc. At the end of the semester, student learning was analyzed by comparing scores on a common final exam for the two sections, controlling for student reasoning ability upon entrance to the class. Surprisingly, cumulative assessments did not increase student performance compared to non-cumulative assessments. Attitudinal data was gathered to investigate student attitudes toward cumulative vs. non-cumulative assessments. From this survey, there is evidence that the type of midterm assessments did influence how students studied for the final exam, with students in the non-cumulative section cramming more right before the final. Both sections viewed the assessments as helpful and worth their time. However, a greater proportion of the non-cumulative section would have preferred cumulative tests compared to students in the cumulative section preferring non-cumulative tests. To investigate whether cumulative exams increased retention compare to non-cumulative exams, another will be given after a semester has passed. An attitudinal survey will also be given to investigate more explicitly how study behavior was affected.

Abstract # 126 (Short Talk Sat)
**In-Class Participation and Performance Gender Gaps in Introductory Biology Courses: Majors versus Non-Majors**
Nicholas Nelson, Brigham Young University; Da Baek, Brigham Young University; Shannon Rose, Brigham Young University; Tyler Quirante, Brigham Young University; Nicole Rice,
It is well known that women are underrepresented in STEM disciplines, but the explanation for this phenomenon is not completely understood. Interestingly, the life sciences are often considered an exception to STEM gender bias since it is common to observe a greater proportion of females in bioscience majors. However, a clear gap is seen in postgraduates of biology disciplines as females fall short in relation to males when post doctorate appointments and career opportunities are compared. Presumably, this inequity is influenced by earlier experiences that affect female confidence and performance in the discipline. In the past, we have demonstrated that females consistently participate less than their male peers in upper-level life sciences classes at a private university. This particular aspect of the education experience was chosen because in-class participation has been shown to be related to retention in a specific discipline, ability in a course topic, and increased critical thinking skills.

Interestingly, there was no gap in student achievement in those same classes. Because other universities have reported achievement gaps in their introductory major courses, we wanted to extend our previous study to 100-level classes. Non-major courses were also observed to investigate whether student interest affects participation and performance. We observed five 100-level life sciences courses for majors and four non-major biology courses. Pairs of student researchers (a male and a female) sat in on each course at least two or three times and recorded all participation events during the class period, including verbal interactions between the instructor and a student and raised hands. Just as we observed in upper-level courses, the percentage of verbal participation events performed by female students in 100-level classes for majors was significantly lower than the percentage of students present who were female (paired samples T test, mean difference: -19%; p = 0.016). This gap was still significant when students were only counted the first time they participated, eliminating the effect of “talkers” (paired samples T test, mean difference from % females in attendance: -15%; p = 0.019). Interestingly, in 100-level classes for non-majors, there was also a significant gap in participation (paired samples T test, mean difference from % females in attendance: -4%; p = 0.043), but it was much smaller than the gap observed in majors classes (independent samples T test; p = 0.024). Performance data for these classes is not yet available, but these will be reported as well.

Improving and Assessing Quantitative Reasoning in Lower Division Biology Students

Tracy Ruscetti*, Santa Clara University; Christelle Sabatier, Santa Clara University

Quantitative Reasoning is one of the core competencies outlined by Vision and Change and a core competency for undergraduate education writ large. Grawe (2011) defines quantitative reasoning as the ability to consider the power and limitations of quantitative evidence in the evaluation, construction, and communication of arguments. In Biology, we generally focus on data analysis (evaluation). We rarely “teach” quantitative writing explicitly even when we expect students to use quantitative writing to demonstrate conceptual understanding or write quantitative analyses. Moreover, we infrequently assess quantitative writing skills unless their inability to write interferes with our ability to assess. In our lower division laboratory intensive Cell and Molecular Biology course, we observed students struggling with quantitative writing. In 2016, we scaffolded quantitative writing throughout the term. We used assignment dependent rubrics to assess the same assignment from 2016 (scaffolded) compared to 2015 (no scaffolding). We observed 35-40% increase in writing quality in our scaffolded cohort compared to a cohort without intentional scaffolding. To track quantitative writing across the biology curriculum, we want to build an easy to use tool that allowed assignment-independent evaluation of quantitative writing. We developed a coding strategy to assess individual quantitative comparative statements. When we applied our coding strategy to the same
assignment from 2016 compared to 2015, we did not observe a significant difference in quantitative writing quality between the two cohorts. We have two hypotheses that may explain our results. One, our coding strategy is a good measure of rubric independent quantitative writing quality and our observed increased in writing quality is due to biased assignment-dependent rubrics. Alternatively, our coding strategy is not sensitive enough to measure writing quality. Given our inexperience with qualitative analysis, we suspect the latter. We will discuss specific scaffolding strategies for both numeracy and quantitative writing. We will also discuss (and welcome feedback on) our coding strategies for quantitative writing.

Abstract # 128 (Poster Fri # 46)

Teaching Hardy-Weinberg Equilibrium Using Population-level Punnett Squares: Emphasizing Biology While Facilitating Calculation

Kurt Williams, Brigham Young University; Da Baek, Brigham Young University; Nicholas Nelson, Brigham Young University; Tyler Quirante, Brigham Young University; Nicole Rice, Brigham Young University; Shannon Rose, Brigham Young University; Elizabeth Bailey*, Brigham Young University

Hardy-Weinberg equilibrium and its accompanying equations are widely taught in non-major introductory biology courses. However, students often struggle to understand Hardy-Weinberg equilibrium because of the calculations involved. Whether this is a result of math anxiety or low calculation proficiency, focusing on the Hardy-Weinberg equation may obscure the underlying biological principles that instructors are trying to help students learn, and time invested helping students master these calculations displaces time that could be spent helping students understand their biological underpinnings. Population-level Punnett squares have been presented as potential teaching tools for Hardy-Weinberg equilibrium, but actual data from classrooms has not yet validated their use. In our study, we tested the instructional value of population Punnett squares over two days of instruction in two sections of an introductory biology course for non-majors. Before Hardy-Weinberg instruction, students completed a pre-assessment measuring math anxiety (Abbreviated Math Anxiety Scale), probability and calculation proficiency, and math confidence (sections indistinguishable; p = 0.45, p = 0.90, p = 0.07 respectively). On the first day of instruction, one section learned Hardy-Weinberg equilibrium using population Punnett squares, while the other section derived the Hardy-Weinberg equations using probability. After this first day of instruction, students completed an assessment measuring performance on Hardy-Weinberg calculation problems (Punnett square section outperformed equation section; pre-test results used as covariates, p = 0.02) and student confidence regarding these items (sections indistinguishable; p = 0.16). During the second day of instruction, each section received the opposite treatment. Students then completed a post-assessment measuring performance on Hardy-Weinberg calculation problems (sections indistinguishable, p = 0.19), conceptual understanding of the biological meaning of the Hardy-Weinberg equation terms (sections indistinguishable; p = 0.22), ability to derive more complex Hardy-Weinberg equations to account for three possible alleles instead of two (section that learned Punnett squares first outperformed the section that learned the equations first; p < 0.001), and confidence in solving Hardy-Weinberg problems (sections indistinguishable; p = 0.84). In summary, after only one day of instruction, students were better able to perform Hardy-Weinberg calculations if they were taught population Punnett squares as opposed to the equations. After learning both methods, student performance improved and the order of instruction had no effect on Hardy-Weinberg calculations. However, those that learned the Punnett square method before the equations demonstrated more advanced understanding of the principles by deriving more complex equations. More attitudinal data and student interview results will also be reported.
Abstract # 129 (Poster Sat # 2)

**Phys-Maps: An Assessment Tool to Measure Student Learning in Undergraduate Physiology Programs**

Katharine Semsar*, University of Colorado, Boulder; Jenny Knight, University of Colorado, Boulder

Setting educational goals and assessing student learning of those goals are fundamental steps to improving both teaching and learning. The recent Vision and Change report provides faculty and institutions with a set of core concepts and competencies in biology to use as a guide to assess students’ understanding as they progress through an undergraduate biology curriculum. To meet this assessment goal, we have established an NSF-funded, multi-institution collaboration to develop a suite of assessment tools (Biology Measuring Achievement and Progression in Science: Bio-MAPS) that will measure student learning across a curriculum. By using these tools to measure students’ conceptual understanding at multiple points throughout a program, data will be available to faculty, department chairs, and deans to help understand and gauge student learning, and could also be provided to accreditation agencies as evidence of programmatic success. Here we present the development of one of the Bio-MAPS assessments, the Physiology-MAPS (Phys-MAPS). The Phys-MAPS is designed to address two frameworks of key concepts in physiology: 1) the BioCore Guide, which elaborates on the Vision and Change core concepts, and 2) the top seven Core Principles of Physiology outlined by Michael and McFarland. We iteratively developed questions using faculty feedback (n>32 faculty) and student interviews (n>79 students) to collect evidence of face and content validity. We conducted a national pilot in Fall 2015, collecting data from 14 undergraduate institutions, 21 courses, and over 2600 students ranging from sophomores to seniors. Using a 3PL item response model, we eliminated poorly discriminating items, and refined others using additional student interviews. The final assessment includes 12 question stems, each with 5-6 associated statements (70 total items); students select each statement as likely/unlikely to be true. Student performance on the pilot demonstrated that the Phys-MAPS discriminates well, with the top quarter of students scoring an average of 75% correct and the lower quarter of students scoring 49% correct. The assessment includes items with a range of difficulties in each of the concept categories, allowing the Phys-MAPS to reflect both easier and more difficult sub-concepts within the larger concept categories. Overall, Phys-MAPS discriminates different levels of students in a physiology program with students scoring 61% following introductory courses and 68% following upper division physiology courses. Together these data suggest the assessment will be useful for tracking student progress through a physiology program. We are piloting the revised Phys-MAPS nationally in April 2016 and will present these results.

Abstract # 130 (Poster Fri # 25)

Reconciling Breadth with Depth in an Upper Division Biology Course: A student FOCUSed approach

Tracy Ruscetti*, Santa Clara University

Upper division courses are generally designed to accomplish two goals simultaneously: broadly cover a sub-discipline in Biology (such as Ecology, Immunology, Neurobiology, etc), and push students to delve deeply. Instructors must make decisions about what content/concepts get the “deep dive” and which are cursorily discussed. To manage that balance, I developed a pedagogical approach called FOCUS (Frame, Organize, Contextualize, Understand, Synthesize) in my upper division Immunology course. Each student chooses an independent immunological problem for their FOCUS topic. Student FOCUS topics include immune responses to a specific pathogen, hypersensitivities, immunodeficiencies, etc. During lecture periods, I frame and organize the general immunological response for the students. We use concept mapping, group discussions, and active learning activities during lecture to help them
contextualize their FOCUS topic into the broader framework of the immune response. Instead of exams, students write a detailed description of how their FOCUS topic relates to a broader immunological topic (e.g., inflammation). I assess their ability to use primary literature, the level of depth (mechanism), and their ability to communicate their ideas. The culminating experience is the final exam in which students are asked to synthesize their knowledge to answer questions about the more general immune response as it relates to their FOCUS topic. Through the FOCUS process, students develop both the broad overview of the immune response and underlying molecular processes. I will discuss the practical applications of the FOCUS approach, the limitations and challenges of using this approach, and qualitative data that supports effectiveness and utility of this approach as a broader teaching tool.

Abstract # 131 (Poster Sat # 3)
Instructor use of biology concept assessments: a survey about the practices and impacts of concept assessments
Katharine Semsar*, University of Colorado, Boulder; Jenny Knight, University of Colorado, Boulder

The value of concept assessments as a powerful education research tool has encouraged the development and publication of over 20 specialized concept assessments in biology. While these assessments have proven useful for individual research purposes, we know very little about how they are used by instructors. To better understand the use and impact of concept assessments, we have developed an online survey with questions that ask faculty about their practices in administering and collecting data from concept assessments, as well as how they may use this data to influence their teaching practices. The iteratively-designed survey used feedback on question wording and content from 16 instructors, including 7 think-aloud interviews to establish evidence of face validity. We then piloted the survey with 14 instructors at 11 institutions to further ensure the survey questions were being answered as intended. After minor modifications following the pilot survey, the final survey was distributed to the following groups: instructors who requested use of the Genetics Concept Assessment as well the SABER, FIRST IV, and HHMI Summer Institute listservs. To date, 121 respondents have completed the survey, 105 of whom currently use concept assessments in their course. The survey results include data about what types of statistical analyses instructors find most useful, what hurdles and successes instructors encounter, and how instructors use concept assessment results to inform their teaching practices. Notably, only 46% percent of respondents use all the questions on a concept assessment and almost 33% modify the wording of assessment questions. In relation to how instructors use concept assessment results, 63% of respondents reported changing their teaching practices in response. The three most common changes reported included reducing/increasing time spent on particular topics, changing or adding instructional activities, and specifically addressing misconceptions and/or persistent student difficulties. Interestingly, instructors report similar course-level, department-level, and university-level support for teaching reform, and participate equally in a science education community regardless of whether they report changing teaching practices. However, those who change teaching practices are more likely to find the data from concept assessments ‘very useful’ and are more likely to share the results of concept assessments with others.

Abstract # 132 (Short Talk Sat )
Persistence to graduation in biology: Gender and generation status matter
Sarah Eddy*, University of Texas at Austin; Erin Dolan, University of Texas at Austin

Diversification of the STEM workforce is a national priority. Of all the possible undergraduate STEM majors, Life Science majors (e.g., Biology) tend to enroll the most students from historically underrepresented groups including Latina/o, Black, female, and first generation
students. Although Life Science majors can attract more of these students, the question remains: do these students persist in these majors or does attrition from the Life Sciences contribute to the STEM workforce representation gap? In this study, conducted at a diverse R1 university in the southwest, we followed five cohorts of first year biology majors for five years (n = 3,407 students). We specifically explored the relationship between race, gender, and generation status on (a) persistence to graduation, (b) timing of leaving for those who leave the major, and (c) where students go if they leave. We employed event history analysis and multinomial regression techniques to assess these outcomes. All analyses included measures of high school preparation and the three demographic variables. The high school variables were: number of science classes completed, number of math classes completed, number of college level credits completed, and number of AP credits earned. We found that generation status and gender, but not race, impacted overall persistence to graduation, but the timing of attrition differed for students in these groups. Across all years, first generation students were 1.3 times more likely to leave than their continuing generation peers. On the other hand, females were 1.3 to 1.5 times more likely to leave than equally prepared male peers in their first year in the major, but equally likely across the rest of the years. Gender, race, and generation status all impacted student paths if they left biology. In particular, male, Latino/a and first generation students are more likely to drop out of college after this transition than their female, White, or continuing generation peers. All together, these findings suggest that biology may be contributing to the workforce gap by retaining fewer women and first generation majors, although majors of all races are persisting at equal rates. In addition, our data suggest that efforts to reduce the loss of women from the life sciences may need to focus on the first year, whereas efforts to support first generation students should span all four years.

Abstract # 133 (Poster Sat # 42)  
**Testing the Mechanisms of Pre-Class Content Delivery in a Flipped Classroom**  
Jamie Jensen*, Brigham Young University; Emily Holt, Utah Valley University; Heath Ogden, Utah Valley University

It has been solidly established that active learning is superior to traditional teacher-centered instruction. One popular new student-centered approach is the flipped classroom. Recent research has suggested that the flipped classroom is only beneficial because it encourages the switch to activity learning. But, are there alternative ways of implementing a flipped pedagogy that lead to differential success? It is this question we chose to address. To determine if and under what circumstances a flipped classroom is an effective pedagogical strategy, we tested the causal mechanisms behind the format of the content delivery during the ‘at home’ portion of the learning process. To test this, we set up three well-controlled treatment conditions across two university settings and three instructors: 1) Interactive pre-class tutorials, 2) Pre-class video lectures, or 3) Pre-class non-interactive, textbook-style readings. We controlled for the content and examples by using virtually identical scripts in each condition. All three conditions performed identical application exercises in class. Preliminary data from these treatments show that, in a flipped classroom, interactive versus non-interactive content attainment prior to class shows little effect on ultimate learning outcomes (presumably, as long as the time spent in class is student-centered and active in nature). Additional data show, however, that 1) students are learning less from non-interactive attainment than interactive attainment prior to coming to class, evidenced by lower pre-class quiz scores (68% versus 71%, p = .02), and 2) students are attempting to accommodate for these learning gaps through more attempts on the pre-class quizzes (an average of 3.9 attempts versus 3.6 attempts, p = .02). These results suggest that in-class time may be more critical for those who attained the content through a non-interactive approach. Additional data on the remaining treatments will be available and included in May for a full report at SABER.
Abstract # 134 (Short Talk Sun)
**Effective Translation of Highly-Structured Course Design from an R1 Institution to a Comprehensive University**
Anne Casper*, Eastern Michigan University; Sarah Eddy, University of Texas at Austin

Despite repeated demonstration in the literature that active learning and highly structured course design is a more effective strategy for student learning than traditional lecture, the spread of this teaching approach remains slow. There are many anecdotal reports from instructors for whom active learning “didn’t work,” and adoption of active learning requires a significant investment of time and energy on the part of the instructor as well as support from the department and institution. Research is needed to determine how the highly structured course design approach should be modified to translate its effectiveness between different student populations. Here, we tested the hypothesis that a highly-structured course design developed for a large-enrollment introductory biology course for majors at an R1 institution can be successfully implemented in a similar large-enrollment course at a comprehensive university with permissive admission requirements and a substantial minority student population. In its original format at the R1 institution, the course design included pre-readings in the textbook before each class, extensive active learning during class with little to no lecture, and weekly online quizzes for formative assessment. We collected data on student success over five semesters of introductory biology at the comprehensive university taught by the same instructor. The first two semesters were taught with traditional lecture. The third semester added weekly, formative online quizzes on topics covered in class that week. The last two semesters were taught with full implementation of highly structured course design. The first full implementation was matched as closely as possible to the implementation at the R1. In the second semester of implementation, the design was modified to use pre-class videos rather than pre-class readings. Using regression analysis and controlling for student ability, gender, and ethnicity, we find that only the modified implementation of highly structured course design, using pre-class videos, was effective at increasing overall student performance on exams. The exams used each semester included several identical questions and many questions that were nearly identical. Students also reported fewer hours spent studying biology in the semester using pre-class videos, which suggests that student study approaches were more focused, directed, and productive during this semester compared to earlier semesters. At the R1, highly structured course design was particularly effective for students from disadvantaged backgrounds; however, at the comprehensive university all students appeared to benefit equally. Our results demonstrate the mechanism through which students prepare for class is a critical aspect of highly-structured course design that will need to be carefully considered and appropriately modified for this teaching approach to be successfully translated to a variety of student populations.

Abstract # 135 (Poster Fri # 59)
**Exploring instructor rationale for designing classroom assessments**
Christian Wright*, Arizona State University; Austin Huang, Arizona State University; Sara Brownell, Arizona State University

Instructor-generated exams in undergraduate biology classrooms are often the primary means by which student course grades are determined. For many of these classrooms, instructors are principally responsible for designing their own exams. Numerous studies have shown that the way in which exams are designed can differentially impact student performance. Thus, the decisions that instructors make when constructing their course exams have the potential to have a significant effect on whether a student passes a course, a student’s GPA, and/or retention in the major. To our knowledge, there is a scarcity of research examining the decision-making
process that underlies the construction of course exams. Such information is crucial in helping to elucidate why instructors construct their exams the way they do and can be used by departments and/or by training programs to help increase the use of research-driven assessment design in classrooms and ultimately improve the learning experiences for students and the utility of the assessments for instructors. As such, the goal of this study was to explore the rationale behind instructor’s decision making when constructing classroom exams. We conducted a series of semi-structured interviews with undergraduate biology instructors at a large R1 university. Using grounded theory, we coded out emergent themes from the interviews. Our preliminary analyses suggest that there is variation in the rationale of instructors when constructing exams, ranging from relying on personal opinions and experiences to reasoning using pedagogical literature. Interestingly, we found that instructor decisions are also driven by external factors including time and resource constraints, the structure of their courses, and/or the behaviors of their students. We discuss the common themes emergent from our interviews and provide suggestions for potential interventions that may facilitate the increased use of research-based assessment designs in undergraduate biology classrooms.

Abstract # 136 (Poster Sat # 56)
Using a lens of Expectancy Value Theory to explore student resistance to active learning
Katelyn Cooper, Arizona State University; Michael Ashley*, Arizona State University; Sara Brownell, Arizona State University

Active learning has been shown to be a more effective way for students on average to learn science. However, as undergraduate science courses are being transitioned away from traditional lecturing into active learning, a frequent complaint is that students resist active learning approaches and do not seem to value the benefits of active learning. This likely extends to them not maximizing their experiences in active learning classrooms. One way to explore how students are maximizing their experiences in active learning classrooms is through a lens of expectancy value theory. The relative value and the probability of success are critical determinants of the theory and are conceptualized as three components: expectancy, value, and cost. Expectancy value theory predicts that students will put more effort into activities that they simultaneously perceive to have value and at which they expect to succeed. We used a lens of expectancy value theory to evaluate student perceptions of their experiences in active learning after participating in a biology-focused two-week summer bridge program that was taught in an active learning way. We conducted a set of semi-structured interviews with 28 students who participated in the program that were focused on their attitudes towards active learning after the program. Interviews were transcribed and analyzed using content analysis. Two independent raters identified themes related to expectancy value theory and when they disagreed, they came to consensus. We found that students exhibited a self-reported increased sense of self-efficacy in active learning, an increased value for active learning, and decreased resistance to it. These findings indicate that expectancy value theory could be a way to explore student resistance towards active learning. Students highlighted that repeated exposure to active learning, explicit instructor talk that active learning was useful, and their own perceived learning gains were major reasons why their resistance decreased. As biology classrooms across college campuses are increasingly transitioning away from the traditional lecture-centered courses towards active learning student-centered models of instruction, instructors may want to focus on ways in which they can encourage students to value active learning in hopes of decreasing student resistance.
Abstract # 137 (Poster Sat # 15)

**A Conceptual Framework for the Core Concept of Cell-Cell Communications for Undergraduate and Professional School Physiology**

Jenny McFarland*, Edmonds Community College; Joel Michael, Rush Medical College; William Cliff, Niagara University; Ann Wright, Canisius College; Harold Modell, Physiology Educational Research Consortium; Patricia Martinova, Czech Academy of Sciences; Mary Pat Wenderoth, University of Washington

A conceptual framework is a hierarchical structure that “unpacks” a concept into its constituent ideas. We have published conceptual frameworks for the physiology core concepts of homeostasis and ‘flow down gradients’ or flux. Physiology faculty also identified cell-cell communications as one of the core concepts their students should understand and be able to apply. Most recently we unpacked the core concept of cell-cell communications and validated a conceptual framework for this core concept. This framework consists of 51 items, descriptions of physiological phenomena, which are arranged in as many as four hierarchical levels: core concept (or main idea, i.e. cell-cell communications), critical components (e.g., a cell synthesizes and releases a chemical messenger), constituent ideas (e.g. cells that release messengers can be anywhere in the body), and elaborations. Thirty-seven faculty were surveyed about the importance of each of the 51 items, using a 5-point Likert scale (5=Essential to 1=not Important). Written feedback about the items was also obtained from the respondents. The survey respondents teach at 2-year colleges, 4-year colleges granting only bachelors degrees, 4-year colleges offering some masters degrees, research universities and professional schools. Mean responses over all 51 items ranged from 4.92 (slightly less than Essential) to 3.27 (between Important and Moderately Important). No more than 2 respondents rated any item as Not Important, and all items were rated as Essential by at least 2 respondents. We conclude that our respondents found the framework as a whole to be important for students to understand. Written feedback revealed one item that needs to be re-written to conform with current understanding of the phenomena it addresses. There is a strong and linear relationship between importance and the level of hierarchy, with critical components being deemed the most important and with lower importance for items at lower levels (constituent ideas and elaborations). Although our respondents teach at different educational levels analyses support the conclusion that there are no differences between ratings based on the different categories of institutions. The cell-cell communications conceptual framework is large, complex, and encompasses many physiological mechanisms. It is more comprehensive and contains more ideas than students in a typical undergraduate introductory physiology course are expected to learn. On the other hand, students in a professional level physiology course (in medical, pharmacy or dental schools) might well be expected to understand and be able to apply all of the constituent ideas.

Abstract # 139 (Short Talk Fri )

**How a Vision and Change reform of introductory biology improves faculty perceptions and use of active learning**

Anna Jo Auerbach*, University of Tennessee

Active learning practices have been shown to cognitively engage students, which increases their course success. However, increasing faculty use of active learning pedagogies in college classrooms has been a persistent challenge in biology education. The University of Tennessee, Division of Biology, implemented curriculum changes to their majors’ two-course introductory sequence (Biodiversity and Cell Biology; N = 216 students per class) as outlined by the Vision and Change in Undergraduate Biology Education final report (AAAS, 2011). Goals of the curriculum reform included integrating core biological concepts and competencies into the courses using active learning pedagogical approaches. Throughout the process of reform
faculty had regular meetings in which they engaged in discussions of best practices, professional development, and reflected on the observational feedback to create goals as individuals, by course, and as a program. The purpose of this study was to determine how the active learning practices used by faculty (N = 10) changed throughout the three-year reform process and why those practices might have changed. Instructor observations occurred monthly, were unannounced, and recorded the frequency, duration, and types of active learning (i.e. clickers, activities, small group work) used. Instructors participated in interviews at the end of each semester they taught to track their perceptions of instruction as the reform progressed.

A repeated measures analysis of variance revealed instructors significantly increased their average use of active learning by 12% throughout the study (p = .02), despite a loss of instructional time in the third year (one lecture per week was converted to discussion as part of the reform). Much of these increases occurred between the second and third year of the reform. While active learning use increased across the years of reform, qualitative analysis showed that the way instructors defined active learning, planned for active learning, and implemented active learning also shifted. In addition, faculty estimates of active learning improved as a predictor of observed active learning practices over time (year 1 r² = .338, year 2 r² = .364, year 3 r² = .87).

This three-year study provides evidence that changes in instruction towards best practices can be achieved by faculty, but it likely requires collaboration with other instructors, use of feedback for reflection, and time.

Abstract # 140 (Short Talk Sat)

**How external representations of a biological concept change learners’ internal representations**

Anveshna Srivastava*, Homi Bhabha Centre for Science Education, TIFR; Sanjay Chandrasekharan, Homi Bhabha Centre for Science Education, TIFR

As most of the entities current science deals with are not available for perception, students’ understanding of the related scientific phenomena is closely tied to the external representations used to describe them. In this study, we investigated how interventions based on three different external representations of a biological concept, the structure of the Deoxyribonucleic Acid (DNA) molecule, influence the internal representations of pre-college biology students. The study followed a case study design, where individual sessions were video recorded. Three groups of five students each were asked to either 1) construct a concept map using preset concepts related to DNA structure, 2) dissect a symbolic model or 3) dissect a 3D molecular model of DNA structure into simpler components. To understand how students' internal representations changed, we asked them to draw a diagram of the DNA structure both pre- and immediately post-task, and after a one week interval. Further, clinical interviews were done both pre- and post-task, to track changes in each student's reasoning process, her understanding of the task, and the changes in her diagrams. The analysis of this data revealed that the interventions led to enhanced verbal-spatial performance in 73% of students in the post-test diagrams. The verbal-spatial scores were calculated by dividing the number of concepts represented both spatially (through arrows) and verbally (through labeling) divided by the total number of concepts represented in the diagram. Students’ diagrams also systematically changed in visual format and emphasis, sensitive to task demands. Whereas 87% students drew diagrams emphasizing the double helical structure of the DNA molecule before the intervention, 69% of them switched to drawing ladder-like two-dimensional cross-sections of DNA after intervention, and persisted with this format in the 1 week post-test, suggesting long-term learning as a consequence of the intervention. Most striking, though, was the finding that there were substantial differences in performance improvement between the three interventions. Students who interacted with the diagram-like symbolic model showed consistent, small improvements in performance. Students who interacted with the other two representations...
showed either extremely high or low improvements in performance. Given the large size of variability relative to average performance improvement itself, this finding supports models that suggest difficulties in translating information across multiple representations is a critical bottleneck in pedagogical interventions.

Abstract # 141 (Poster Fri # 5)  
**Student expectations regarding learning activities in introductory biology**  
Tanya Brown*, University of Colorado; Kati Brazeal, "University of Nebraska, Lincoln"; Brian Couch, University of Nebraska-Lincoln  
National calls for STEM education reform have advocated that college instructors shift from traditional lecture toward the use of active learning. Studies across STEM fields demonstrate that implementing active learning rather than traditional lecture increases student learning. However, the use of active learning may conflict with what students expect regarding how college courses will be taught and how to succeed in the college classroom. To better understand the potential openness of students to interactive teaching practices, it is necessary to determine how students expect to prepare for class and spend class time. Understanding student expectations has the potential to provide insights into how students view learning in STEM fields and better prepare instructors to implement targeted interventions that help students understand how to succeed in college. In this study, we administered a survey containing open-ended and closed-ended questions to students in an introductory biology course, and we used a mixed methods approach to determine student expectations. Our results indicate that student expectations partially align with active learning and that first-year students expect to spend more class time participating in small group activities, more time preparing outside of class time, and more time interacting with others outside of class time than non-first-year students. Our findings demonstrate that at the start of introductory biology courses, students hold expectations that are consistent with some degree of active learning in the classroom and that first-year students have different expectations than non-first-year students.

Abstract # 143 (Short Talk Sat )  
**What's in a name? The importance of student perceptions of an instructor knowing their names in a high enrollment biology classroom**  
Katelyn Cooper*, Arizona State University; Brian Haney, Arizona State University; Anna Krieg, Arizona State University; Sara Brownell, Arizona State University  
While knowing student names has been promoted as an inclusive classroom practice, we do not know whether students value having their name known by an instructor, particularly in a large enrollment classes. Calling students by name has been identified as an aspect of instructor immediacy which has been linked to student learning and motivation. However, it is unclear how this aspect of instructor immediacy influences biology undergraduates. We set out to explore this question in the context of a high-enrollment active learning undergraduate biology course. Using surveys and semi-structured interviews, we investigated whether students perceived that instructors know their name, the importance of instructors knowing their name, and how they think an instructor learned their name. We found that 20% of students typically have their name known in a high-enrollment biology class, but 77% of students in this course perceived that an instructor of the course knew their name. Using grounded theory we analyzed student survey responses and identified nine distinct reasons why students feel that knowing their name is important that were reported by more than 5% of the students in the class: student feels valued (30.6%), student feels the instructor cares (26.9%), builds an instructor-student relationship (23.1%), student feels more invested in the course (19.4%), student feels more comfortable getting help (19.4%), builds classroom community (14.2%), student feels more comfortable talking to instructor (11.9%), improves student performance (11.9), and helps the
student obtain a letter of recommendation (6.7%). When we asked students how they thought that instructors learned their names, the most common response was in-class discussion with the instructor as part of active learning. Specifically, students highlighted the use of name cards that they placed on their desks as a way that they perceived instructors learned their names in a high enrollment class. Instructors could say the student’s name when interacting with him or her in class. Interestingly, many students perceived that their name was known, even though instructors did not know their names. This implies that instructors teaching high-enrollment courses may not need to actually know students’ names in order for them to perceive value from the perception that an instructor knows their name. These findings suggest that students perceiving that their name is known seems to be important to students for a variety of reasons and that name cards could be a relatively easy way for students to think that instructors know their name.

Abstract # 144 (Short Talk Sun )

The role of mRNA in genetic information flow presents a conceptual barrier to student understanding
Alexandria Mazur*, Michigan State University; Rosa Moscarella, Michigan State University; Mark Urban-Lurain, Michigan State University; John Merrill, Michigan State University

Genetics is a fundamental concept for biology literacy, yet previous research has identified that many students struggle to understand genetic concepts. The processes underlying the flow of genetic information at the molecular level (i.e. the “central dogma” of molecular biology), are particularly difficult for students. Effective teaching relies on understanding what students think and the alternate conceptions they hold. Student writing can reveal student reasoning and the heterogeneous nature of their thinking. The Automated Analysis of Constructed Response (AACR) research group investigates techniques for analyzing students’ writing using computerized scoring models that combine lexical and statistical analyses to predict human scoring. One of the AACR items assesses student understanding of how a mutation that creates an early stop codon will affect the flow of genetic information in replication, transcription and translation. Written responses to this question from introductory biology students collected before and after an in-class activity indicated learning gains for replication and translation. However there was little change for transcription. To investigate this apparent difficulty with transcription, we conducted semi-structured exploratory interviews with 19 students who had previously completed the written assessment. We analyzed the interview transcripts and results revealed that students have difficulty describing the role of mRNA. Based on these results we hypothesized a framework for describing student thinking about RNA. The framework describes the possible alternative conceptions students hold about mRNA, such as mRNA driving transcription, transforming DNA into mRNA through a series of chemical reactions and mRNA being the product of transcription. We conducted a second round of 35 student interviews across three undergraduate courses to test our proposed framework. These preliminary results suggest that students do not understand the role of mRNA in transcription and this difficulty persists among upper level students. We will discuss detail about what the analysis reveals about student thinking based on the framework.

Abstract # 145 (Poster Fri # 8)

Using Systematic Application of Retrieval Practice to Enhance Student Achievement in Introductory Biology
Clark Coffman*, Iowa State University; Carly Manz, Iowa State University; Shana Carpenter, Iowa State University; Patrick Armstrong, Iowa State University; Robert Reason, Iowa State University; Shuhebar Rahman, Iowa State University; Monica Lamm, Iowa State University; Szumei Leow, Iowa State University; Laura Pederson, Iowa State University
Retrieval practice promotes the acquisition of knowledge that can be flexibly retrieved and transferred to different contexts. However, many students do not make use of retrieval practice when studying course materials. Instead, they often chose less effective and less efficient study modes such as rereading. The goal of this project was to test the hypothesis that the systematic application of retrieval practice will enhance student achievement and metacognition in introductory biology. Students completed a series of in-class exercises involving retrieval of course information and reflection on their confidence, familiarity with the concepts, and out-of-class preparation. Weekly online study quizzes also provided additional opportunities for using retrieval practice as a study strategy. Students’ responses and participation in these exercises throughout the semester were used to determine whether regular doses of retrieval practice were associated with increased accuracy, confidence, and out-of-class preparation. Performance on course assessments in two sections, one with the intervention and one without the intervention, were compared to see if particular response patterns on the exercises correlated with achievement. We will present our findings on the use of retrieval practice and reflection in introductory biology courses with the goals of improving student achievement and metacognition.

Abstract # 146 (Poster Sat # 57)
The Role of Achievement Motivation in Students’ Choice of Study Habits in a Large Biology Course
Carly Manz*, Iowa State University; Clark Coffman, Iowa State University; Shana Carpenter, Iowa State University; Patrick Armstrong, Iowa State University; Robert Reason, Iowa State University; Shuhebar Rahman, Iowa State University; Monica Lamm, Iowa State University

Previous research has shown that low-performing students often report using less effective study strategies compared to high-performing students. In particular, low-performing students are more likely to cram before exams—an approach that is known to be ineffective in promoting durable retention of the material (Toppino & Gerbier, 2015)—and less likely to use effective studying techniques such as practicing to recall what they are learning (Hartwig & Dunlosky, 2012). In our study, we explored whether these choices of study habits were related to the reasons why students are motivated to achieve. In a large undergraduate biology course, we administered the same survey over study habits that has been given in many previous studies (Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007; Yan, Thai, & Bjork, 2014), in addition to a well-known survey on achievement motivation (Elliot & McGregor, 2001). In line with previous studies, we found that compared to high-performing students, low-performing students more often engaged in cramming (77% of low performing students crammed, while only 52% of high-performing students crammed), and less often engaged in retrieval practice (69% low performing versus 79% high performing). We also found that students' tendency to engage in these behaviors was related to their motivation for achievement. Students characterized as “avoidant-driven” (i.e., those who are driven by the fear of performing poorly in the class) more often engaged in cramming compared to students characterized as “approach-driven” (i.e., those who are driven by their desire to do well in the course or to master the material). Interestingly, this was true for both high- and low-performers, indicating that even high-performing students, if they are driven by avoidant goals, do not always use the best study strategies. Conversely, we did not find a strong difference in retrieval practice behavior between avoidant-driven and approach-driven students. There were similar proportions of students who engaged in retrieval practice within the high-performers and within the low-performers regardless of approach-driven or avoidant-driven behavior. Our next steps are to address the challenge of improving student learning across diverse student populations by 1) developing exercises to encourage recall practice both in and outside of class and 2) providing data to the students that will motivate them to engage in more effective study strategies.
Collectively Improving Our Teaching: Biology Department-Wide Professional Development in Scientific Teaching
Melinda Owens*, San Francisco State University; Gloriana Trujillo, Stanford University; Carmen Domingo, San Francisco State University; Shannon Seidel, Pacific Lutheran University; Kimberly Tanner, San Francisco State University

Many efforts to improve science teaching in higher education focus on a few faculty members at an institution at a time, with limited published evidence on attempts to engage faculty across entire departments or institutions. Research instead supports the theory of change that professional learning communities where groups of instructors grapple with similar teaching challenges are key for promoting on-going pedagogical growth (Lave, 1991; Loucks-Horsley, 1998). With funding from an HHMI Undergraduate Science Education grant, we created a long-term, collaborative professional development program in scientific teaching, Biology Faculty Explorations in Scientific Teaching (Bio FEST). Many biology education colleagues predicted low faculty participation and minimal implementation of active learning strategies from this effort. However, in three years of Bio FEST, 89% (55 of 62) of the department’s instructors (full-time faculty and long-term lecturers) completed a weeklong Scientific Teaching Institute, and 83% of eligible instructors participated in additional semester-long follow-up programs focused on implementing and assessing scientific teaching strategies in their classes. To see whether Bio FEST alumni had changed their teaching practices, instructors were surveyed about their teaching a semester after Institute completion. Most reported adding active learning (80%), while fewer reported adjusting assessment strategies (50%) or implementing strategies addressing equity and diversity (53%). These instructor self-reports were corroborated by a 186% increase (from 14 to 40) in the number of instructors using materials from our Teaching Resource Center. Also, a survey of biology course students (n=1128 respondents, out of 3265 contacted) showed that significantly more students reported frequent small group discussion (p<0.001) and in-class exercises (p<0.001) in classes taught by Bio FEST alumni than in classes taught by non-Bio FEST faculty. Three years after Bio FEST launched, instructor participants overwhelmingly reported that their teaching had been positively affected (96% of 50 respondents) and that they were more likely to reflect on and change their teaching (84%). Unexpectedly, we also found that most respondents believed that their relationships with departmental colleagues were positively affected (86%) and that they felt a greater sense of belonging to the department (72%). Instructors who participated in a follow-up program were significantly more likely to report positive impacts relating to departmental community than those who only completed an Institute (p=0.01). Overall, our results suggest that biology department-wide efforts to collaboratively develop scientific teaching skills can indeed attract large numbers of faculty, spark widespread change in teaching practices corroborated by students, and even improve departmental relations.

A bridge to active learning: A summer bridge program helps students to maximize their active learning experiences and think about equity in groupwork
Katelyn Cooper*, Arizona State University; Michael Ashley, Arizona State University; Sara Brownell, Arizona State University

National calls to improve student academic success in STEM have sparked the development of summer bridge programs designed to help students transition from high school to college. Academic success during the first year in college is often a focus of biology centered bridge programs because of the high rate of student attrition from the major during the first year. However, it is unclear whether these bridge programs are taking into account that many
introductory biology courses are being transitioned from traditional lecture to active learning. We designed a two-week summer bridge program to teach first-year students introductory biology content and taught the program in an active learning way. Through exploratory interviews of a subset of students who participated in the bridge program, we unexpectedly identified that students seemed to have a more sophisticated conception of active learning. We further explored whether the bridge program positively influenced student approaches to active learning and conducted an additional set of semi-structured interviews focused on active learning and compared interviews of 26 Bridge students to 8 comparison Non-bridge students who had been eligible but did not participate in the program. We used grounded theory and content analysis to identify themes from the interview transcripts. We found that Bridge students perceive that they benefitted more from active learning in introductory biology than Non-Bridge students. Bridge students also described using more strategies than Non-bridge students to maximize their experiences in active learning. Strategies that only Bridge students identified included: deeply engaging in active learning (reported by 81% of Bridge students), encouraging others to participate in active learning to benefit the other student (65%), being open minded/optimistic when approaching active learning (50%), and intentionally sharing their thoughts with others (54%). Lastly, in stark contrast to Non-bridge students, Bridge students indicated that they take an equitable approach to groupwork, viewing part of their role in the group to help other students participate. These findings suggest that we may be able to prime students to maximize their own experiences, as well as others’ experiences in active learning classrooms. This has implications for helping us create inclusive classroom communities where students support the learning of each other.

Abstract # 149  (Poster Fri # 26)
Exploring students’ attentiveness to ecological themes when decision-making about a wildlife conservation-related socioscientific issue
Ashley Alred*, University of Nebraska-Lincoln

Background/Questions/Methods  How do we provide students the tools they need to become scientifically literate citizens? One research-supported method is to incorporate socioscientific issues and decision-making instruction into curriculum, encouraging students to address real-world problems encountered in their lifetime. To effectively teach decision-making in the classroom, we need to develop a deeper understanding of the degree to which knowledge and values influence reasoning and decision-making about complex issues. This study specifically explores undergraduate decision-making in the context of mountain lion conservation in Nebraska. It is unclear 1) how well students understand the concepts of ecology, biodiversity, and conservation underlying the mountain lion hunting issue, 2) how students apply this knowledge to their opinions and decision-making, and 3) how other factors such as values or social norms play a role in decision-making. Our study was conducted in a large-enrollment general science class that asked students to practice a six-step decision-making framework that included selecting “options” for solving the problem and “criteria” to evaluate those “options.” We investigated student inclusion of “criteria” with ecological themes of 1) top predator influence on food webs, or 2) concern about small population size, in their six steps for deciding about what should be done about mountain lion hunting in Nebraska. In this sequential explanatory mixed-methods study we conducted a quantitative analysis to reveal the significance of knowledge sophistication, demographics or value orientation for students’ inclusion of ecological themes in their decision-making criteria (n=130). These results will inform the qualitative analysis (n=40), which will explore more deeply how students’ criteria ultimately influence decision-making and how these explanatory variables are manifested throughout students’ opinions and decision-making. Results/Conclusions Preliminary quantitative findings suggest that students who have a more sophisticated understanding of food webs were more likely to express concern in their
decision-making about how mountain lions impact food webs. Value orientation may also play a key role in predicting students’ use of ecology themed criteria for decision-making. For instance, students who have a biospheric worldview were more likely to include ecosystem impacts in their decision-making than students who have an egoistic worldview. Preliminary qualitative findings suggest that students’ value orientations may be an informative lens into the inclusion of ecological criteria in their decision-making, as well as to how holistic and scientifically-informed their final decisions are in regard to solving the issue of mountain lion conservation.

Improving Student Learning Takes More Than Just “Flipping” Your Classroom
Leah Brown*, Murray State University; Terry Derting, Murray State University

With major calls for reform in STEM education from professional organizations (e.g. AAAS, NIH, NSF), studies have found that faculty in higher education can improve student learning by changing their teaching from teacher-centered to learner-centered. Change in teaching practice can be difficult, however, especially without significant training. One method of introducing learner-centered teaching practices into the classroom is through the use of a flipped classroom model where students engage in learner-centered activities within the classroom and receive passively-transmitted information outside the classroom. The focus of our study was to determine whether ‘flipping’ a course results in implementation of learner-centered classes by faculty. We also assessed impacts of flipped courses on student learning gains and attitudes towards science and science literacy. We characterized the teaching practices of faculty in four flipped and three non-flipped sections of Introduction to Biology for non-majors using surveys of teaching beliefs, teaching practices, and classroom observations of faculty participants by experts in STEM pedagogy. None of the faculty received training in the use of learner-centered teaching. Faculty who flipped their course used more learner-centered teaching practices. Students who attended a flipped course, however, had significantly lower overall learning gains than those in traditional courses. Students’ attitudes towards science and scientific literacy did not differ between class types. Although use of a flipped approach was associated with greater use of learner-centered teaching methods, it was not associated with improved student education. We propose that training faculty in pedagogy and its implementation is necessary for effectively implementing a flipped classroom.

Analyzing participation and impact of an optional discussion section in a large upper-division genetics course
Marina Crowder*, University of California, Davis

Increasing undergraduate enrollment has resulted in both lower and upper-division courses continuing to grow in size. Large introductory biology courses can have as many as 700-1000 students. These courses commonly include a required discussion section or lab component that give students the opportunity to interact with course content in a smaller setting and allow for direct interaction with a content expert, usually in the form of a graduate student teaching assistant. Upper-division biology lecture courses can have as many as 200-500 students, but in many cases do not have a required discussion section component. Similar to introductory courses, these upper-division core courses service a broad range of majors and act as gateway courses for many students, specifically for transfer students who experience these courses when they first arrive at the university level. The goal of this ongoing study is to characterize student participation and impact of a 1-unit optional discussion section in a high-enrollment, upper-division genetics course that serves as a requirement for a large percentage of other upper-division biology courses at a large 4-year public university. This course is enrolled by 300 students, 35% of which are transfer students that are new to the university. An average of 60%
of students enrolled in the large lecture course chose to enroll in the optional discussion section, of which each section has 30-40 students. Students who enroll in the discussion section received 1-unit of course credit if they completed weekly problem-sets and attended weekly one-hour discussions, led by graduate student teaching assistant. All students in the large-enrollment lecture course were surveyed at the beginning and end of the quarter to characterize which students chose to enroll in the discussion and which students chose not to enroll in the discussion. The surveys also characterized reasons for why students opted to not enroll in the discussion and of the students that did participate in the discussion whether they identified the discussion to be a valuable resource to their learning and success in the course. Further, a separate analysis was done to determine the impact of participation in the optional discussion section on student success in the course.

Abstract # 152 (Poster Sat # 26)
Faculty perceptions of student learning while engaged in professional development programs
Robert Idsardi*, University of Georgia; Julie Luft, University of Georgia; Jenna Wingfield, University of Georgia; Paula Lemons, University of Georgia; Peggy Brickman, University of Georgia

This study seeks to expand the literature base on effective professional development programs on active learning in higher education. This presentation will share a new research project which compares changes in faculty perception of student learning. Participating faculty will be part of one of four naturally occurring Science, Technology, Engineering, and Mathematics professional development (STEM -PD) programs promoting active learning. The four programs include a SCALE-UP learning community (traditional PD), experience-novice faculty pairings (mentorship program), learning assistants program (indirect support through undergraduate assistants), and department-based community initiatives. This study asks, in what ways do faculty perception of student learning change while they are engaged in different professional development programs? Researchers recruited participants from four STEM-PD programs. As the participants engaged in the different PD programs there were interviewed about the learning and knowing of their students. Interviews were conducted in the spring and the fall of ‘16. The interviews gathered data on faculty perceptions of student learning during the PD process. The interviews are semi-structured and utilize a standardized open-ended protocol to guide the researcher’s questions (Patton, 2015). In addition to the interviews, faculty participating in the study will be observed teaching courses during the fall 2016 semester. Researchers will conduct participant observations (Merriam & Tisdell, 2015) of faculty instruction and they will also conduct interviews in the fall semester. The second interviews will be structured to elicit changes in faculty perceptions of student learning. Additionally, artifacts from the different PD programs will be collected. Data will be analyzed using a constant comparative method (Auerbach & Silverstein, 2003). This study is currently underway, and initial interviews are currently being collected. While it is too early in this study to present any preliminary results (these will be available for the conference presentation), initial interviews have revealed insights on how faculty initially perceive knowing and learning. This study seeks to highlight important distinctions in faculty perceptions of student learning to better inform future professional development programs for undergraduate STEM instructors.

Abstract # 153 (Poster Sat # 43)
How does student learning differ in an online and face-to-face lab?
Malin Hansen*, First Nations University of Regina

As more biology courses are developed for online delivery, instructors and curriculum developers need to think of ways to design online labs which offer students an experience that
is comparable to face-to-face labs. An important step in the development and evaluation of online courses (lectures and labs) is the comparison of student learning and attitudes in online and face-to-face courses. In this pilot study we compared student learning and attitudes in an introductory biology course which was offered both face-to-face (22 students) and online (18 students). The two courses were taught by the same instructors and the content of all course components: lectures, labs, practice questions and exams were almost identical. In one of the face-to-face labs students performed a gram stain and used microscopes to study prokaryotes such as bacteria and cyanobacteria. In the online lab students performed a gram stain using a virtual lab and studied images and watched video clips of bacteria and cyanobacteria. To evaluate student learning and attitudes, all students completed an online post-lab quiz with identical questions after the lab. While students in the face-to-face lab said they felt more confident performing the gram stain after the lab (74% vs. 60%), the students in the online lab tended to better explain both the purpose (87% vs. 68%) and procedure (87% vs. 63%) of gram staining. There was no difference in the responses between the two student groups for other questions on prokaryotes. The results suggest that while students in online labs may better understand the concepts behind experiments, they may not feel confident conducting those experiments in real life. The results from this study raise two questions: 1) How can students’ conceptual understanding be improved in face-to-face labs, and 2) How can online labs be designed to give a more real-life experience?

Abstract # 154 (Round Table Fri)
Gamified Learning for Blended Student-Centered Classroom Environments
Miriam Ferzli*, NC State University; Kimberly Pigford, NC State University; Betty Black, NC State University; Michelle Nugent, NC State University

Current STEM undergraduates are considered “millennial” or “digital learners,” meaning that they are visually literate and respond well to multi-media forms of learning. In response, digital games are increasing in popularity for their potential to facilitate learning. Studies have suggested that educational digital games enhance student self-efficacy, motivation, and performance by providing immediate encouragement, praise, and reinforcement. At the same time, well designed digital games work to actively engage students by immersing them in a virtual world, where they are center stage and their game choices have a noticeable impact. The implementation of gamified learning fits in well with the blended learning model, which has proved to be efficient for facilitating the expansion of student-centered approaches to traditional biology classroom settings. In this approach, students learn basic background material and concepts through a variety of online modules and apply their knowledge during class time. In accordance with this model, we currently teach our introductory biology for majors in a format known as SCALE-UP (Student Centered Active Learning Environment with Upside-down Pedagogies). This approach allows for students to manipulate concepts in a very active manner, while the instructor is present for clarifying and answering questions. Due to the flipped format of SCALE-UP, it is essential that students complete out of class learning tasks so that they come prepared for class. In alignment with the current literature on millennial learners and gamification, we designed a digital educational experience. In this gamified approach, players take on a persona and enter a scientific themed room where they are given a series of quests that require them to gather content knowledge by answering specific questions as they move from room to room in order to solve a “mystery.” The content and questions in the game are built to be customizable so that they can change depending on the course or instructor. This transforms the game from a single-use application into a tool that instructors can utilize throughout an entire course or over several different courses. A Likert-style survey based on the intrinsic motivation inventory will be used to assess student motivation and interest in the game. In addition, an open ended survey will be given to capture student perceptions of
usability and usefulness as well as their willingness to play the game as a means of learning or studying course content.

Abstract # 155  (Round Table Fri )
Analyzing the Effect of Context in Student’s Genotype-to-Phenotype Models in Molecular Genetics
Kristy Wilson*, Marian university

Students often see biology and the life sciences as disconnected facts. Research has shown that the building of models like concepts maps and their variations like box and arrow plots (BAPs) can connect topics to allow students to see the big picture. The specific question addressed is: would models better instill system understanding and skill transfer if they were generalized or if they incorporated a specific biological example to create context. This research is influenced two competing theories to define student performance and understanding. First, does the specific example increase the cognitive load in a way that increases difficulty for learning? Second, does the example provide interest and motivation to increase learning? These questions were addressed in two sections of a Molecular Genetics course for biology majors at a small liberal arts college in the Midwest. Students were asked to draw BAPs in response to questions that provided a list of structures that would be in boxes to describe an overall function. For example, most questions asked the students to show the affect of genotype on phenotype while incorporating ideas like gene expression, DNA replication, and/or mutation. One section received instructions that included an interesting example gene or situation that were related to issues like human disease, treatment, or the environment. Whereas, the other section had the same overall function but lacked the example and instead made their BAP about a numbered or lettered gene and phenotype. BAPs were given as practice throughout the course and collected during high stakes assessments. The demographics for both sections of the course were similar in terms of average incoming SAT score, gender, and ethnicity. BAPs were examined for correctness and formatting. Preliminary analysis reveals that over the course of the semester the students receiving generalized questions had a decrease score on the BAP questions. This is in contrast to the students receiving a specific example, their BAP score increased over the semester. These trends may indicate that providing a specific example allows students to better integrate topics across the course. For both sections, the scores on the multiple choice and short answer portion of the exam increased over the course of the semester. Additional data and analysis will examine if students are able to complete an unfamiliar problem. I would like feedback on how to differentiate between the effect on cognitive load and the effect of motivation on student performance. I would also like to discuss the larger context of this project: the transfer of skills from specific context to an unfamiliar problem.

Abstract # 156  (Short Talk Sun )
Comparing a flipped hybrid course format to traditional and online formats of General Biology I
Sat Gavassa*, Florida International University; Rocio Benabentos, Florida International University; Marcy Kravec, Florida International University; Timothy Collins, Florida International University

Hybrid courses are gaining attention as an alternative to traditional face-to-face classes or fully online courses. In addition to the pedagogical flexibility afforded by a hybrid format, these courses are also appealing to campuses with limited classroom space. The literature, however, reports conflicting results regarding the effect of hybrid courses on student learning. We designed, taught and assessed a hybrid-and-flipped course (50% online 50% face-to-face) that maximizes both the advantages provided by technology in an online environment and the
benefits of interpersonal interaction (among students and between students and the instructor). Here we report the results from the hybrid course in comparison to traditional 100% face-to-face and 100% online courses. This course was taught by the same instructor in a large Hispanic-Serving Research University. We found that students in the hybrid course performed better on exams compared to students in the lecture or fully-online versions of the course. The improvement in student performance, however, is likely due to an increase in active learning rather than the hybrid format per se. We present our course design and how it related to student success. This work adds to the emerging literature on hybrid courses and will inform curricular practices modeled after such blended pedagogical strategies.

Abstract # 157 (Poster Sat # 59)
The Flipped Lab: reimagining science education with next-generation virtual laboratories
Maarof Fakhri*, Labster

Imagine if your students could have unlimited access to multi-million dollar world-class laboratory facilities anywhere in the world, anytime. Simulations have long been known to improve learning, motivation and engagement while reducing costs in fields such as aviation. These benefits now extend to online laboratory simulations, with next-generation Labster virtual laboratories showing the same kinds of improvements (Nature Biotechnology, July 2014) when used along-side or in replace of traditional teaching methods. While many distance education technologies focus on taking the physical university experience of lectures and textbooks and digitizing them, we show what technology can provide to complement or supplement the physical experience - incorporating 3D-molecular animations, self-paced enquiry-based lab courses, immediate access to fully simulated versions of the latest lab equipment, real-world scenarios, story-telling, and immersive virtual environments. Labster virtual labs are now being used by universities world-wide, including at MIT, Harvard, University of New England, ETH Zurich, Imperial College London, and many more, continually creating an improved student learning experience. We collaborate with institutions to co-develop and implement labs supporting new curriculum in order to cover more subjects and support more students every year. The institutions use Labster in different ways: as a pre-requisite before entering a wet lab, as a complementary tool to lectures or even in replacement of some lab facilities, for instance in the case of online education. We've created a rich virtual laboratory learning experience with the aim of empowering the next generation of scientists around the world.

Abstract # 158 (Poster Fri # 47)
A constructivist activity to teach life-history evolution from elementary to college
Clint Laidlaw*, Brigham Young University

Abstract Life history theory explains the ecological circumstances under which natural selection favors differing patterns of energetic investment into three competing life history components (growth, maintenance of the soma, and reproduction) between organisms and over the lifetime of individuals. These patterns of investment explain the evolution of some of the most conspicuous and evolutionarily significant attributes of organisms. The entire theory is nonetheless generally absent from instruction across grade-levels. While the theory itself is relatively simple to understand, it may be neglected both because instructors are unaware of it and because there is a complete absence of suitable activities to guide student learning. We designed and tested a novel activity to introduce students to the concepts of diversity, natural selection, and life history using a constructivist format. The activity consists of two parts: 1) a discussion on diversity in various organisms and the effects of selection on population phenotypes, and 2) a game that introduces life history strategies. The entire activity can easily be conducted in a single 50-minute period. The activity was tested on two unique populations: Fifth-grade students and college non-majors biology students. Gains in understanding, using a
pre-test/post-test design, were shown to be significant in both populations. This activity is therefore an effective means of fostering a deep and transferrable conceptual understanding of the principles of natural selection specifically through the lens of life history strategies. Interesting interactions with particular science skills between grade levels are discussed.

Abstract # 159 (Poster Fri # 53)
The Small World Initiative: A crowd source authentic research project in the classroom, dedicated to discovery of novel antibiotic-producing bacteria
Scott Kreher*, Dominican University

While many biology courses include laboratory components, the lab exercises often have forgone conclusions and don’t portray the actual process of science. By contrast, authentic research experience labs comprise open-ended questions, where students learn tools and skills to address research questions. There is strong evidence that authentic research experience activities better engage students and lead to improved learning. However, several important questions remain: first, do authentic research experiences in the first and second year of a science curriculum lead to better retention and completion of STEM degrees? Second, can authentic research modules be successfully implemented at a wide variety of institutions, such as two-year colleges, small four-year universities, as well as larger research universities? Third, can an authentic research module be adapted and aligned to multiple courses to allow flexibility in its deployment? The Small World Initiative (SWI) is an authentic research module, developed by Jo Handelsman and her team at Yale University, dedicated to the discovery of novel antibiotic-producing bacteria from soil. In the course module, students collect a soil sample, use basic microbiological methods to grow bacteria from the soil, and test for the production of antibiotics. Students finally identify the novel bacterial strains using DNA sequencing, and then upload their data to a worldwide database on soil bacteria sampled by students from multiple schools. Data on knowledge and attitudes were collected from paired intervention and control courses at multiple institutions deploying the SWI module during the 2014-2015 academic year; these institutions included two-year colleges, small four-year universities, and larger research universities. Pre and post data were collected from intervention and control students; the pre-survey included the CLASS-Bio (Colorado Learning Attitudes about Science Survey) and the SPARST (Science Process and Reasoning Skills Test - Experimental Design and Science Communication modules). The post-survey included the Project Ownership Survey (POS), CLASS-Bio, and SPARST. While the larger multiple-institution data set is still being analyzed, comparison of data between control and intervention groups at my institution indicates improvements in attitude, statements of confidence in ability, and increased knowledge. I am adapting the activities of the SWI and creating new modules to be better aligned with the objectives of genetics and molecular biology courses. We have sequenced the genome of a novel soil bacterial strain, and my molecular biology course is analyzing and annotating the genome. I am also creating forward and reverse genetics experiments that can be conducted on our novel soil strain. I am utilizing the Genetics Concept Assessment (GCA) and validated critical thinking assessments to examine learning gains.

Abstract # 160 (Short Talk Sun )
Using student constructed responses to guide the development and adoption of instructional activities by a cross-institutional instructional development team.
Karen Pelletreau*, University of Maine; Jenny Knight, University of Colorado, Boulder; Paula Lemons, University of Georgia; Jill McCourt, University of Georgia; Rosa Moscarella, Michigan State University; Ross Nehm, Stony Brook University; Mark Urban-Lurain, Michigan State University; Michelle Smith, University of Maine
Student written answers to questions provide insight into the strength of their understanding about fundamental scientific concepts and can illustrate mixed models of student thinking. However, logistical constraints in large enrollment STEM classes often prevent the use of writing to illustrate understanding. The Automated Analysis of Constructed Response (AACR) Research Group (www.msu.edu/~aacr) is addressing this issue by developing computer-based analysis tools that analyze student answers to constructed response questions and provide formative assessment about student thinking. To facilitate the dissemination of these questions and analysis tools, local faculty learning communities have been developed at six institutions to support faculty who ask AACR questions. After reviewing data from the AACR questions, thirteen of these faculty from five different institutions self identified as interested in exploring how to improve both instruction and student understanding of the central dogma of biology. These faculty members formed a cross-institutional instructional development team (ci-IDT) that collaboratively worked and learned together to: (i) develop a student-centered activity that addressed conceptual difficulties identified in student’s responses to the AACR stop codon question; (ii) use data to monitor their student learning; and (iii) publish the activity. In tandem, the ci-IDT faculty were observed repeatedly using the Classroom Observation Protocol for Undergraduate Stem and were monitored for their involvement and contributions towards the ci-IDT outcomes. The work by the ci-IDT resulted in an activity that was used with over 2000 students in 8 different courses ranging from introductory biology for non-majors to upper level majors. The final version of the activity increased student understanding of DNA replication, transcription, and translation with the normalized learning gains <g> increasing 50%, 63%, and 31% respectively. The ci-IDT faculty represented a diverse group of instructional styles ranging from classrooms that predominantly presented to others that used collaborative learning. When using the self-generated activity, all observed faculty trended towards more collaborative learning in their classroom. This work with the ci-IDT identified factors known to be important to student learning are likewise important to successful instructional development; primarily the importance of maintaining ownership, minimizing time requirements, and collaborative learning. We propose this as a potential model for building virtual communities of practice across varied learning environments.

Abstract # 161 (Poster Sat # 16)
Using the Biology Card Sorting Task to measure changes in conceptual expertise during post-secondary biology education
Sarah Bissonnette*, San Francisco State University; Julia Smith, Holy Names University; Kimberly Tanner, San Francisco State University

While there have been concerted efforts to reform undergraduate biology towards teaching students to organize their conceptual knowledge like experts, there are few tools that attempt to measure this. We previously developed the Biology Card Sorting Task (BCST), designed to probe how individuals organize their biological knowledge. During the first phase, participants are asked to sort 16 biology problems according to fundamental biological principles and to name their resulting groups (unframed task condition). The card set was designed to represent two hypothesized conceptual frameworks, one based on organism type (surface features) and another based on fundamental biological concepts (deep features). Pairings of particular cards could be characterized as surface feature, deep feature, or unexpected pairings. During a second phase (framed condition), the hypothesized fundamental biological concepts are given to the participants, who are asked to sort the cards into those categories. Previous results showed the BCST could differentiate between extremely different populations, namely non-biology majors (NBM) and biology faculty (BF). In this study, we have administered the BCST to three additional populations, using a cross-sectional design: entering biology majors (EBM), advanced biology majors (ABM), and biology graduate students (BGS). So, to what extent can
the BCST differentiate between groups of students with different amounts of formal biology education? Here we present five key findings. When measuring the proportion of deep feature card pairs in the unframed condition, there was no statistically significant difference between NBMs (29.2±2.2%, n=101) and EBMs (35.7±1.9%, n=185). Nor was there a difference between these populations when measuring deep feature card pairs in the framed condition (39.6±2.0% and 45.2±1.5% respectively). Intriguingly, compared to EBMs (35.7±2.1%), ABMs (38.0±2.6%, n=109) were also not statistically distinct in the presence of deep feature card pairings in the unframed condition. However, EBMs (45.2±1.5%) and ABMs (54.7±2.2%) did show statistically significant differences in the production of deep feature card pairings in the framed condition (p<0.05). ABMs (n=101) and BGSs (n=29) also showed statistically significant differences in deep feature card pairs, but only in the unframed condition (38.0±2.6% and 57.0±4.5% respectively p<0.05). These results are consistent with the conclusion that biology education allows advanced biology students to use an expert-like conceptual framework. However, this framework does not appear sufficiently established for ABM students to apply it unprompted in the unframed task. Furthermore, these results demonstrate the utility of the BCST in measuring differences between groups of students over the course of their undergraduate education.

Abstract # 162 (Poster Fri # 28)
What is the impact of student reading and video watching on exam performance?
Katie Shannon*, Missouri S&T

I have flipped one day a week of my Cell Biology course. For the flipped day, students watch online videos before class. For the other two days of the week, students are assigned a textbook reading before the lecture. Although there are incentives for both types of pre-class preparation, studies have shown that students rarely read the textbook before class. I hypothesized that more students would watch the videos than read the textbook, and that reading the textbook and watching online videos would correlate with exam performance. To examine the effect of student engagement outside of the classroom, I used student surveys and data automatically collected by the video streaming software. Extra credit questions at the end of each exam on student reading and study habits were used to give a reading or studying rating. For student video viewing analysis, the percentage of total minutes of video watched was determined. I have collected data for four semesters with four exams each semester. Analysis of single variables showed correlation with some exam grades but not others, likely due to small sample size. When all four exams from one semester were pooled, both textbook reading and video watching showed a correlation with exam grades in a single variable analysis using Spearman rank coefficient. Multivariate analysis for each semester to control for student GPA was also performed. Analysis of the data so far shows that exam performance correlates significantly to GPA and reading the textbook in a multivariate analysis. A significant correlation between watching the online videos or time spent studying occurred in some semesters but not others after controlling for GPA. Although attitude surveys showed that students reported liking videos more than reading the textbook, actual engagement was mixed, with approximately equal numbers of students watching videos more or reading the textbook more often. Additional analysis will be performed to determine if particular methods used to study or while reading, and if combinations of reading, watching videos, and studying correlate with exam performance.

Abstract # 163 (Short Talk Sat )
Further Effects of Phylogenetic Tree Style on Student Comprehension
Jonathan Dees*, North Dakota State University; Caitlin Bussard, North Dakota State University; Jennifer Momsen, North Dakota State University

Phylogenetic trees have become increasingly common across biology disciplines. As a result, learning to interpret and reason with phylogenetic trees is now a critical component of biology
Previous studies have concluded that diagonal (ladder) phylogenetic trees are more difficult for students to interpret compared to the bracket (tree) style. However, the specific instructional experiences of participants in these studies are unknown. Biology textbooks now use bracket phylogenetic trees almost exclusively, and it is possible that instruction was also largely biased toward the bracket style. The purpose of this study was to examine effects of style for interpretation tasks before, after, and long after controlled instruction that used an equal number of diagonal and bracket phylogenetic trees. We collected data from an introductory biology course (n=86) where phylogenetic tree instruction included an introductory screencast and numerous activities. During instruction, students interacted equally with both styles, often simultaneously. Students completed isomorphic interpretation tasks for each style at four different times throughout the course: pre-instructional homework, post-instructional homework, evolution unit exam, and an in-class review activity for the comprehensive final exam. We controlled for order effects on all assessments by assigning students to receive assessment items for either diagonal or bracket phylogenetic trees first. Style order had no significant impact on student performance across all assessments items on all assessments. On the pre-instructional homework, most recent common ancestor identification (p=0.021), monophyletic group recognition (p=0.041), contemporary descent interpretations (suggesting extant taxa are descended from other extant taxa; p=0.008), and relative time recognition (p=0.027) significantly favored the bracket style. However, these differences disappeared on all assessments following instruction. For taxa relatedness interpretations, there was no significant style effect on the pre-instructional homework, although students performed very poorly with both styles (less than 15% correct). A significant style effect emerged following instruction, as students interpreted relatedness significantly better on bracket phylogenetic trees (p<0.039 on all assessments). These results reveal that effects of phylogenetic tree style on interpretation tasks largely disappeared following instruction that was controlled for style. However, for taxa relatedness interpretations, a style effect favoring bracket phylogenetic trees emerged and persisted after controlled instruction. These results represent the first direct, classroom evidence that bracket phylogenetic trees may better support student learning at the introductory level.

Abstract # 164 (Poster Sat # 38)

Do models matter? Comparing concept mapping and simulations for student learning of ecology concepts
Margaurete Romero*, 1988; Luanna Prevost, University of South Florida

Science education research continues to demonstrate improved learning with active-learning techniques compared to lectures. However, the question of which active-learning methods are the most effective for learning complex scientific principles in various context still remains. Models are commonly used in activities that allow students to simplify complex systems and understand how components interact. We investigated the outcomes for student learning and engagement of two model-based activities - concept maps and simulations. The activities were conducted in an introductory biology course in sixteen teaching-assistant led discussion sections of approximately twenty students each. Eight sections were semi-randomly assigned to the concept-mapping activity and eight to the simulation activity. To assess engagement, students filled out a Likert-scale questionnaire on enjoyment and usefulness of activity. To assess student learning, we used a pre-post homework assignment based on conservation and transformation of matter. Questions consisted of multiple choice (MC), true and false (TF), and short answers. Over 80% of students enjoyed both the concept-mapping and simulation activities. More students in the concept-mapping group (84%) reported better understanding of food webs and carbon cycling than did the simulation group (73%). Students reported that the hands-on nature of the concept activity was helpful for understanding the connections in food webs. For the homework assessment, all students significantly increased in their scores from
pre to post on the MC (paired t-test, meanpre = 4.86±1.6; meanpost = 5.23±1.6; p<.05) and TF assessments (paired t-test; meanpre = 2.06±1.0 meanpost = 2.32±1.0; p<0.05). For the TF assessments, we observed the trend that students in the simulation group showed a greater improvement in their scores than students in the concept-mapping group (t-test; meanΔconcept = 0.11±1.4; meanΔsimulation =0 .43±1.0 p=.059). There was no difference between student improvement for the two groups on the MC assessment (t-test meanΔconcept = 0.27±2.1; meanΔsimulation = 0.51±1.8 p=.474). Students’ responses to short answer questions showed that students’ ideas about the concept of matter conservation varied from naive to scientific. For example, students failed to conserve matter during nutrient cycling. More scientific responses demonstrated principled reasoning such as references to conservation of matter. Overall, students in both activity type demonstrated learning gains, though there was no significant difference between the activity types. With the trend toward higher learning gains, the simulation activity may be useful for introducing students to these complex ideas.

Abstract # 165 (Poster Fri # 29)
**Analyzing student learning using bioinformatics course modules as a platform for student engagement in research**
Vinayak Mathur*, Georgetown University; Gaurav Arora, Gallaudet University; Anne Rosenwald, Georgetown University

As a result of burgeoning sequence databases there are opportunities for students to be engaged in novel bioinformatics research either as independent research or embedded in traditional coursework. Although these datasets and the tools to analyze them are freely available online, many faculty members do not have the necessary skillset to teach bioinformatics. To overcome this challenge we developed the Genome Solver (GS) website (http://www.genomesolver.org), a community of practice for faculty support and student learning. One of the major aims of this project is to positively influence student learning through faculty development. Here we present student learning data collected from institutions whose faculty were trained by us in the use of bioinformatics and genomics tools and provided with curriculum modules that were used as building blocks for individualized curricula. We designed a set of 20 questions that tested basic concepts of biology and recorded the pre-course and post-course results. This data included student answers recorded along with the name of their school and their class year. The three main questions we are investigating are: 1) Do students do better on the post-test versus the pre-test after taking the bioinformatics course module? 2) How does the performance of students vary depending on their school? 3) Is there an increase in student performance with instructor experience in schools where the course module has been taught for more than two semesters? Our preliminary results suggest that: 1) there is a significant increase (p < 0.05) in performance of all students for 13 out of the 20 questions 2) six out of seven schools did significantly better (p < 0.05) on the post-test versus the pre-test. 3) For schools where this module has been administered for multiple years (>2 semesters), we observed the same amount of increase in student performance over the three course modules even though there were differences in the pre and post-course scores. With this student learning data, we hope to show that involving students in bioinformatics research provides a positive correlation with understanding core biology concepts and that this hands-on course design promotes STEM education.
Abstract # 166 (Short Talk Fri)

Which way is better? Assessing the effectiveness of two different modeling approaches for teaching mitosis and meiosis.
Kelsey Metzger*, University of Minnesota Rochester; Joanna Yang, Mayo Graduate School, Mayo Clinic

Instruction in mitosis and meiosis is ubiquitous in undergraduate biology education. However, it is well documented that students harbor many misconceptions concerning these cellular processes. Additionally, students struggle to differentiate key mechanistic differences between the processes of mitosis and meiosis, and consequent biological differences in the cells that result, leading to difficulty in connecting these basic concepts to genetic variation, Mendelian inheritance, and evolutionary processes. While many examples of “how to do it,” innovative instructional approaches are published in the literature, publications including measurement of learning gains using such innovative practices are fewer to be found. Moreover, when measurement of learning gains associated are reported, the outcomes of innovative approaches are most often compared to outcomes from a traditional lecture format style of instruction. Our project sought to compare two different innovative approaches to teaching mitosis and meiosis, both involving manipulable materials and modeling in two lecture sections of an introductory undergraduate biology course for health sciences majors. The modeling approaches were designed to address student misconceptions regarding ploidy, and also to reinforce the particulate nature of genetic loci. Items from the published, validated Meiosis Concept Inventory were used for pre- and post-instruction learning assessment. In addition, we collected data regarding student perceptions of the learning experience in each modeling scenario through two Likert-scale items (Modeling mitosis and meiosis in class helped me understand the processes of cell division; Modeling mitosis and meiosis in class helped me understand that genes are physical entities located on chromosomes) and two free-response items (If you agreed that modeling mitosis and meiosis in class was beneficial to your learning, please explain in what ways the modeling activity was helpful; In what ways do you think the modeling mitosis and meiosis activity is limited, or could be improved?). Appropriate statistical approaches were used to test for differences between student responses to Likert-scale items between the two sections receiving different instruction, and to test for significant differences in performance on pre- and post-assessment items. Demographic and incoming performance data was used to normalize learning gains between sections. Additionally, qualitative analysis approaches aligned with grounded theory were used to analyze student responses to free-response items, relying on descriptive themes that emerged from students’ responses to further contextualize the quantitative results. The results of student performance and perceptions in the two treatment groups will be presented and explored to offer suggestions for effective instruction of these critical biology concepts.

Abstract # 167 (Poster Sat # 20)

Faculty Intent and Faculty Practice—Do They Align?
Laura Paulson*, North Dakota State University; Lisa Montplaisir, North Dakota State University

With a push for education reform, it is important to educate faculty on new teaching practices that they could implement within their classrooms. However, being presented with recommended teaching practices does not mean the faculty will implement them within their own classrooms. According to the Theory of Planned Behavior, there are many factors that contribute to an instructor’s intent to implement active learning. The factors influencing intent include attitude toward active learning, perceived control during implementation, and anticipated effectiveness. We look at a small subset of participants (n= 8) from a self-selected cohort of faculty to determine alignment with practice. The subset was selected based upon a maximum
intent score on two administrations of an attitudes, norms, and behaviors survey. Observational data using the Classroom Observation Protocol for Undergraduate Students (COPUS) was used to identify practices for those participants. The COPUS was developed as a possible way to provide feedback to faculty about active teaching/learning in their class. Baseline COPUS observations were completed in Fall 2015 and follow-up observations in Spring 2016. A 2.5 day professional development workshop on a variety of active learning practices occurred prior to the start of spring semester. Preliminary analyses suggest that intent for active learning may be a proxy for instructor activity level. Of the 10 possible instructor categories on the COPUS, all participants had at least 7 present. However, when looking at the student involvement categories, 4 of the 8 classrooms had 50% or more of the activity as simply listening and less than 50% of the possible student categories coded for. If faculty members state they have maximum intent for active classroom practices but observations reveal a different picture, a need to understand what barriers exist may inform future faculty development programs.

Abstract # 168 (Poster Sat # 27)
Supporting undergraduate STEM educators instruction: Evaluating the impact of different professional development programs on educators use of active learning
Jenna Wingfield*, University of Georgia

Supporting undergraduate STEM educators instruction: Evaluating the impact of different professional development programs on educators use of active learning Jenna Wingfield*, University of Georgia; Paula Lemons, University of Georgia; Peggy Brickman, University of Georgia; Robert Idsardi, University of Georgia; Julie Luft, University of Georgia The research question this study addresses is: How do different STEM professional development programs impact the instructional practice and orientations of STEM faculty/instructors towards active learning? Undergraduate STEM educators frequently have instructional goals focused on problem solving, conceptual understanding, or higher order thinking for their students. Unfortunately, their instructional methods often constrain students in terms of meeting these goals. Active learning helps amend this inadequacy. To facilitate undergraduate STEM educators in their teaching endeavors, the University of Georgia has initiated different professional development programs that promote active learning. The programs differ in terms of structure, while participating faculty differ in their motivation to engage in the different programs. This study pertains to the faculty who are participating in the different programs, and was conducted to understand how their instruction changed as a result of their involvement in the different programs. The different interventions consist of a SCALE-UP learning community, pairing faculty experienced in active learning with novice faculty, a learning assistants program, and department-based community initiatives. In addition to data from the faculty members, data are collected from instructors who are not participating in any of these interventions. This ‘null’ group serves as a control. Qualitative data will be collected in spring 2016 and will consist of interviews about the implementation (or not) of active learning approaches and artifacts related to instruction. Quantitative and qualitative data will be collected in the fall 2016, which will examine the teaching of faculty who participated in the different programs and the null group. These will include interviews and classroom observations utilizing the COPUS method. Initial data will be presented in this poster.

Abstract # 169 (Short Talk Sun )
Characterizing statistics understanding and attitudes in life sciences graduate students
Abha Ahuja*, Minerva Schools at KGI

A basic understanding of statistics is essential for conducting biological research, but many research papers are published with clear misuse or misinterpretation of statistical analyses. It is imperative to train life scientists in the proper use and interpretation of statistical methodology,
and to help them frame statistical problems in the context of examples from the life sciences. Statistical misconceptions have been described in detail in the education research literature and the nature of these misconceptions is well documented among varied populations. However, a systematic study of life science graduate students has not been performed. We administered a survey to graduate students in the various Harvard Integrated Life Sciences graduate programs. The survey instrument contains questions about (1) student demographics and attitudes about, and confidence in, conducting statistical analyses (2) statistics concepts, application and interpretation that fall under three categories: Confidence Intervals, Sampling Distributions and P-values. Preliminary analyses suggests that lack of training in statistics is a factor contributing to statistics anxiety in our population. We also identified categories of misconceptions that were under- and over-represented in our population of life scientists in training. For instance, students often misunderstand the application of theoretical sampling distributions to real data. This work has greatly informed the design of courses and curricula for the training of graduate students and postdocs. Moreover, characterization of statistics misconceptions in different student populations at different levels of training will provide important insight into the process of how conceptual change occurs in the understandings of statistics.

Abstract # 170 (Poster Fri # 30)
A snapshot of student quantitative abilities in introductory and upper-level biology courses
La Toya Kissoon*, North Dakota State University; Trevor Deere, North Dakota State University; Jennifer Momsen, North Dakota State University

Mathematics plays an increasingly important role in various disciplines, including 21st century biology. Quantitative skills are vital for future biologists and physicians, who must be able to apply quantitative approaches to develop research questions, generate testable hypotheses, analyze and interpret evidence, and develop models. These skills are also critical for citizens who need to be able to interpret quantitative data and ideas to make reasoned decisions. Integration of quantitative concepts in biology courses gives students the opportunity to practice applying quantitative skills while learning biology. In a previous study, we gathered assessments from a range of biology courses offered by a biological sciences department over the course of an academic year to investigate the integration of quantitative skills across a biology curriculum. Results of this study indicated that instructors integrate a variety of quantitative skills into their assessments, including graphing, statistics, and modeling. The current study examined student quantitative abilities using the quantitative portion of the Test of Scientific Literacy Skills (TOSLS) at the beginning and end of the semester in courses at the 100-level (n=490) and 300-level (n=91). The TOSLS is a validated assessment that includes a quantitative portion that measures students’ abilities in graphing and statistics. The overall average normalized change score for the TOSLS in the 100-level courses was 0.15 (SD=0.38) compared to 0.30 (SD=0.38) in the 300-level courses. For graphing questions, the average normalized change score in the 100-level courses was 0.02 (SD=0.40), while the average normalized change score in the 300-level courses was 0.38 (SD=0.49). For statistics questions, the average normalized change score in the 100-level courses was 0.07 (SD=0.45), while the average normalized change score in the 300-level courses was 0.27 (SD=0.54). These results indicate that student learning gains for the overall TOSLS and for the graphing and statistics portions were greater at the 300-level than at the 100-level. Our previous work indicated that courses at the 300-level had significantly more quantitative questions in assessments compared to courses at the 100-level. Our findings suggest that instructors of 300-level courses may be providing students with more opportunities to practice their quantitative skills, resulting in substantial improvement.
Abstract # 171  (Poster Fri # 9)
**What is a germ? Students think about viruses and bacteria differently**
Lisa Wiltbank*, North Dakota State; Chelsey Grassie, North Dakota State University; Jennifer Momsen, North Dakota State University

Student perceptions of microbiology are likely influenced by exposure to information about microorganisms experientially or through the media, which focus on the role of microbes as disease-causing “germs”. In fact, the impacts of microorganisms on humans and the environment—beneficial, detrimental, or neutral—are significant to many areas: ecology, physiology, environmental science, molecular biology, biotechnology, agriculture, immunology, as well as a host of topics in microbiology. Additionally, everyday encounters with microbiology topics are unlikely to lead to an understanding of the underlying biology of microbes, and may even promote misconceptions. Student preconceptions in microbiology are largely unexplored in DBER research, despite the large numbers of students taking microbiology courses. We designed a survey to probe the knowledge and views of microorganisms that non-majors biology students bring to the classroom, including those related to the impacts of bacteria and viruses on humans and the environment. A ten-question online survey about microorganisms was deployed in two large non-majors biology courses. We hypothesized that students would think differently about cellular microbes (bacteria) and non-cellular microbes (viruses). Therefore, two forms of the survey were used: one with questions about bacteria and one with isomorphic questions about viruses. Each class was divided randomly into two groups, with half of the students responding to the bacteria survey (n=220) and half responding to the virus survey (n=211). Interestingly, our results to date revealed two areas that students think differently about viruses and bacteria. First, students view the impacts of viruses on living things more negatively than those of bacteria. For example, when prompted by the question, “What are viruses?” students described viruses mainly as disease-causing agents. In contrast, “What are bacteria?” prompted responses about structural characteristics and both negative and positive impacts of bacteria on humans. Coding and statistical analyses for this question are on-going. Second, students are able to identify viruses by name or disease state more readily than bacteria. For example, 68% of students were able to name an example of a disease-causing virus, while only 19% of students were able to do the same for bacteria. We are currently expanding this survey to students in other non-majors classes, as well as nursing and pre-professionals. The results of this study suggest differences in student perceptions and knowledge about bacteria and viruses, which may impact how students learn in the classroom. These results may also have implications for microbiology outreach programs to the public.

Abstract # 172  (Poster Fri # 31)
**Learning Gains Assessment in a Biochemistry MOOC**
Marshall Thomas*, Harvard Medical School; Joseph Williams, Harvard University

Massive Open Online Courses (MOOCs) provide tremendous opportunities for people to learn on their own, at no cost. But these educational settings differ greatly from registered courses that award credit and frequently require paid registration and commitment. Like many traditional courses, most MOOCs do not include comprehensive and validated assessments of knowledge prior to and following participation in courses. This work investigated the extent and nature of learning for participants in a MOOC that covered undergraduate biochemistry, with a focus on metabolism. Participants were administered asynchronous, optional pre- and post-tests. There were two tests: a validated concept assessment (Shi et al., 2010) that measured learning across the entire course, and a custom test that targeted a metabolism-focused unit of the course. We found statistically significant learning gains on both tests. Notably, learning gains were specific to biochemistry items taught in the course; the student population did not have significant learning gains on non-biochemistry items. The metabolism test was much more sensitive to
learning gains than a general concept inventory. This highlights the importance of using content-aligned tests for learning gains assessment and the need for a metabolism-focused biochemistry concept inventory. Pre-test scores were correlated with course completion: students with high prior knowledge were much more likely to complete the course than those with low prior knowledge. However, students with low prior knowledge, as measured by pre-test, posted the greatest learning gains of any group. These results suggest that students with little to no subject-specific background benefit greatly from open online resources, but may struggle to complete courses. We hypothesize that concept inventories can be used as diagnostic pre-tests in online and residential courses to identify at-risk students. Implications for the design of future online courses and assessments of learning gains are discussed.

Abstract # 173 (Round Table Fri)
**Rapid response rubric (3R): A novel tool for instructors**
Rachel Salter*, North Dakota State University; Jennifer Momsen, North Dakota State University

In a large-enrollment classroom, instructor time is at a premium. When the student-instructor ratio is low, instructors can create a one-on-one or tutor-like relationship with each student and provide individualized, directed feedback to each learner. However, in a large-enrollment classroom of 300-500 students, typical of undergraduate introductory courses, an instructor does not have time to communicate individualized feedback directly to each student. As a result, constructed-response (CR) items are often avoided in these courses due to the time investment for grading. However, commonly used multiple-choice items are difficult to write, often only assess basic recall, and are easily gamed by test-savvy students. Some instructors have grading assistants who can mitigate the grading burden, but this does not create a direct communication line from instructor to student. To overcome these limitations, the goal of this research is to develop and investigate how a rapid response rubric (3R) impacts student reasoning with core biological concepts in large-enrollment courses. The 3R will (1) focus on core biological concepts, (2) provide encoded feedback to the student that they will decode using the full 3R, and (3) support the use of CR items such as the Bishop & Anderson Open Response Instrument (ORI) or ACORNS prompts. A modified ORI coding rubric serves as the template for the 3R: Evolution, which provides a robust explanation of each principle to the coder (instructor) and the student. The instructor will be trained to use the 3R to provide encoded feedback to the student. Students will download the full rubric and use the rubric to decode the feedback they find on their constructed-response item. This encoding/decoding process results in active student participation in the feedback. To assess the usefulness of the 3R I will use three data streams: student assessment data, interview data (both instructors and students), and students’ digital exhaust from 3R access on Blackboard. Currently, the rubric is under construction and I am seeking feedback at this early stage before full deployment in Spring 2017. Pilot data analysis is ongoing from Spring 2016 and will be presented. Students appeared overwhelmed using the rubric for the first time. I would like specific feedback on (1) initial impressions of the rubric components, (2) potential streams for data analysis, and (3) improving ease of use for students and instructors. A round table will support active discussion and constructive criticism of this instructor tool.

Abstract # 174 (Round Table Fri)
**Student difficulties in human physiology**
Tara Slominski*, North Dakota State University; Jennifer Momsen, North Dakota State University

The physics education research community has documented that contextual surface features can shape and direct a student’s approach to framing and solving problems. Evidence from physics education literature suggests that while students can correctly reason about a given
scenario, context features can alter their reasoning strategies and result in an incorrect response. Biology education research is beginning to explore the role of context in evolution education, but to our knowledge, no such endeavor has occurred in the context of physiology, specifically that of human anatomy and physiology (HA&P). Because students and instructors report that physiology is inherently difficult to learn, we are exploring the potential role of context effects on student understanding of physiological concepts. Specifically, our study is a preliminary investigation of how physiology context impacts student reasoning about fluid dynamics. In collaboration with physics education researchers, we created and deployed isomorphic prompts that probed student understanding of fluid dynamics in the context of HA&P and physics. The prompts ask students to compare fluid movement through either blood vessels (HA&P context) or pipes (physics context). Specifically, students must first predict how vessel/pipe diameter impacts fluid flow characteristics. Students are then directed to explain their reasoning. We administered the prompts in two high enrollment science courses, HA&P II and College Physics I, after relevant instruction on fluid dynamics occurred in each course. Students in both courses randomly received either the HA&P prompt or the physics prompt. Our analysis of student responses is ongoing and will focus on comparing student performance across the isomorphic prompts to reveal differences in student reasoning. This comparative approach will enable us to identify and characterize the impact of HA&P context on student reasoning. In addition, we can begin to identify common reasoning patterns that may reflect teleological or intuitive reasoning. This study will provide novel insight into how students reason about human physiology, and has the potential to result in a new lens with which to approach student difficulties in HA&P.

Abstract # 175 (Poster )
Science Happens Here: Using Place Conscious Education to Investigate Rural Science Education
Heather Rudolph*, University of Northern Colorado

Little attention is given to rural science education despite 11.4 million American children living in rural areas, compared to 14.6 million in urban areas (Avery, 2013). The goal of this pilot study is to determine how place conscious education is being used in rural Colorado middle and high school science classes. One of four research questions from the larger study will be addressed, specifically “How is place conscious education (PCE) being used in rural science classes?” Conducted as a grounded theory study, this research uses place conscious education as the theoretical framework. Place conscious education attempts to reduce the struggle of detachment from science learned in school, compared to their lives, through an educative process that employs the of “thinking broadly about schools’ integral relationship to the community and local environment” (Smith & Sobel, 2010, p. ix) Grounded theory offers a set of general principles and tools which then provide support for the data forming the foundation of the theory which is then built or “grounded” in the data as it is analyzed (Charmaz, 2014). This paper focuses on one rural school, located 100 miles southeast of Denver, and consisting of approximately 50 students in grades prek-12. Participant observations, reflective journaling, and interviews were conducted over five weeks. Participants included one science teacher, one agricultural science teacher, two volunteers, and nine high school students. Preliminary results indicate positive responses by the students to the agricultural teacher’s concepts of PCE. The agricultural science teacher, a sixth generation rancher, sees PCE as a way of relating students’ local knowledge to classroom discussions and then expanding on their understanding to related businesses and community members in nearby towns, and continuing on to post-secondary education. He applies science concepts like genetics, nutrition, and ecology to the world right outside the agricultural shop door. His connections to the town, the University, and national beef organizations provide support for students learning to apply science at all of these levels.
Students demonstrated detailed scientific knowledge relevant to life in rural Colorado but struggled to verbalize concepts when asked about "science" instead of "ag." Initial analysis suggests support for integrating science education with agricultural science in rural schools to demonstrate relevancy of science to students’ present and future. Research in rural Colorado relates to biology specifically because there is a need for medical practitioners, soil specialists, forestry researchers, and more many people trained in the sciences.

Abstract # 176 (Poster Sat # 4)
Creating and testing a reliable instrument for assessing students’ perceptions of social media in higher education.
Zach Nolen*, Texas State University; Kristy Daniel, Texas State University

Recently, social media has become a critical part of people’s lives, particularly millennials. As such, social media has garnered much attention as an educational tool. Several studies have found that social media can be useful for education in other fields such as business and medical classes, but few studies have tried integrating social media into science education. These studies have worked on the assumption that students want to use social media in their classes. Currently there exists no instrument to measure students’ perceptions of social media in the classroom. The goal of this study was to establish and test a reliable instrument for assessing students’ perceptions of social media in the classroom. The Perceptions of Social Media Survey (POSMS) instrument is composed of 26 likert-like questions split into three factors: Usage, Potential, and Integration and 7 demographic questions. We tested the POSMS during the Summer and Fall 2015 semesters at three universities in the southeast. We determined instrument reliability using Chronbach’s alpha. We found that each factor and the overall instrument was reliable, with alpha >0.7 for factors and alpha >0.9 overall. Thus, we conclude that the POSMS is a reliable instrument for assessing students’ perceptions of social media in higher education. Now, future investigations can determine if students want to use social media in their course before trying to integrate it into their curriculum.

Abstract # 177 (Round Table Fri )
Student perceptions of instructor-generated feedback
Jennifer Momsen*, North Dakota State University; Rachel Salter, North Dakota State University; Lisa Wiltbank, North Dakota State; Jeff Boyer, North Dakota State University; Melody McConnell, North Dakota State University; Erika Offerdahl, North Dakota State University

Formative assessment is widely assumed to create a critical link between instructors and students that supports meaningful learning. Empirical evidence to support this interaction is, however, lacking. Effective formative assessment triggers students to reflect on and evaluate their understanding, prompting instructors and students alike to adjust learning activities to meet learners’ needs. However, in many instances, instruction simply transmits feedback to students, ignoring how students translate feedback into action. Students may have difficulty unpacking the intended feedback or in identifying actionable learning tasks. Alternatively, students may act but revise learning based on misinterpreted feedback. Our goal is to understand how students use instructor-generated feedback, including identifying the types of feedback students use and how frequently they access that feedback. Here, we describe the development of our methodology to capture student use of instructor-generated feedback and provide preliminary results. We began by creating a survey asking students to reflect on a class meeting and describe how they knew they had learned what the instructor had intended. In other words, did students recognize formative assessment and instructor-generated feedback? We ran two iterations of a pilot survey in an introductory biology course, refining the survey between iterations. In the final iteration, students (n=107) most commonly identified receiving feedback through clicker questions (11%), general verbal feedback (44%), and visualization using a whiteboard (26%).
Students specifically mentioned verbal feedback from learning assistants. Several students (6%) indicated they received no feedback. To more deeply investigate students’ (a) ability to recognize and (b) ways of using instructor-generated feedback, we are developing and piloting cued retrospective interviews. This method asks participants to verbalize their thought process after completing a task—in this case, responding to a formative assessment prompt. Students are shown a video of their class (cued) and asked to describe what they were thinking and doing (retrospection) and how instructor-generated feedback impacted their learning. We are pairing this cued retrospective interview with a second interview that occurs following a summative assessment event. In this second interview, students are asked to reflect on how instructor-generated feedback impacted their preparation and performance on test questions related to the content. Using surveys and interviews, we are collecting data from undergraduates across a range of introductory STEM courses. These data streams provide some of the first empirical evidence describing the role of formative assessment and feedback in student learning.

Abstract # 178 (Short Talk Sat)
**Contrasting Faculty and Student Expectations in Flipped Classroom Video Lectures**
Jeffrey Klemens*, Philadelphia University

One challenge in implementing active learning pedagogies is delivering information that would otherwise be conveyed via classroom lecture. A solution to this problem is the flipped classroom, in which lecture content is delivered in the form of videos (or other instructional objects) that the student views outside of class time. One difficulty would-be flippers face is that although there are many methods for recording lecture content there is little experimental evidence regarding differences in effectiveness among the resulting video modes. To address this, a set of five short lecture videos were created from a common lecture script. These videos differed in mode, ranging from fully animated videos to voice-over-powerpoint presentations. Videos were delivered to students (N= 305) and faculty (N= 85) along with a survey that asked them to evaluate the videos with regard to several measures of engagement, as well as the extraction, retention, and contextualization of information. Both groups were asked to compare the video lectures to a hypothetical in-person lecture on the same material. Faculty and students both ranked animated videos as both the most engaging and most academically effective and voice-over-powerpoint videos as the least (p<0.01). Faculty members, however, overestimated the effect of format compared to students (p<0.001). For example, students reported the animations to be less and the powerpoints to be more engaging than the faculty estimated they would. With regard to extraction, retention, and contextualization of information, faculty consistently underrated the effectiveness of all video modes compared to student responses but still expected larger differences among the formats than reported by students. A potential shortcoming of the previous study was that the videos employed were much shorter than a typical course content unit and student performance was not measured. In a follow-up survey students (N= 128) were presented longer videos representing an entire course module. Students were randomly assigned either an animated or voice-over-powerpoint video and quizzed on the lecture content. Students showed a small but significant preference for the animated lecture (p<0.05), but quiz scores did not differ among the treatment groups. These results imply that faculty may overestimate student sensitivity to different modes of content delivery. A follow-up focus group indicated that students perceived certain virtues in the voice-over-powerpoint videos that the experimenters did not anticipate and that differences in student and faculty perceptions of video effectiveness may be the result of faculty overestimating the effectiveness of in-class lectures.
Infograms: Graphic Symbolic Summaries for Effective Learning
Vasiliy Kolchenko*, New York City College of Technology

Instructional graphics can be a powerful learning tool in biology education. On the other hand, some images can be confusing or overwhelming. Although graphics are ubiquitous in education materials, there is a gap in research on graphic literacy, visual cognition and optimizing graphic representation for better learning. This project is starting to address the gap by developing and testing a systemic way of using symbolic graphics for knowledge encoding and retrieval. The graphic symbolic summaries I called Infograms are unique learning materials developed at New York City College of Technology, an urban federally designated Hispanic Serving Institution with an open access policy. Infograms employ key terminology, abbreviations, pictograms, simple charts and diagrams to encode and condense information and translate curricular material into a series of graphic symbols. Learning activities make these symbols meaningful for students. The symbolic narrative then becomes a powerful tool for creating students’ own way of describing the story. Infogram materials for Anatomy and Physiology were developed in print, slideshow and video formats. The materials have been utilized for a few semesters and the learning outcomes have been evaluated in a comparative study using a pretest and posttest in Infogram and control groups. Pretest and posttest included multiple-choice questions that covered course curriculum. The end-of-semester survey focused on the student learning experiences. Comparison of the pretest and posttest data in Infogram and control groups demonstrated statistically significant improvement of the learning outcomes in Infogram group vs. control (p < 0.001). The pretest scores were about the same, as expected (Infogram group, n = 79, mean = 33%; control group, n = 78, mean = 29%; percentages represent correct answers in the test). The posttest results showed that Infogram group students consistently, every semester, outperformed students in the control group (Infogram group, mean = 74%; control group, mean = 53%). While the average scores improved in both groups, the Infogram group showed an increase in scores that was 70% greater than in the control group. Results of the end-of-semester survey indicated that students strongly supported the Infogram learning approach. Among all learning materials used in the course, Infogram graphics and accompanying text were ranked most useful. The traditional textbook, which was also required, was ranked least useful. 96% of students said that they learned better learning techniques while using Infograms. The project is also focused on diverse cognitive roles of graphic symbols and a variety of their uses that can contribute to student success. For further research, next steps are: A. To produce more and better Infogram materials and test them in different contexts, B. To investigate the cognitive mechanisms of the Infogram learning success. This work was supported by the NSF under Grant #1245655.

Examining Persistence in Faculty Learning Communities by Biology Faculty
Jill McCourt*, University of Georgia; Paula Lemons, University of Georgia; Tessa Andrews, University of Georgia; Jenny Knight, University of Colorado, Boulder; John Merrill, Michigan State University; Ross Nehm, Stony Brook University; Karen Pelletreau, University of Maine; Luanna Prevost, University of South Florida; Michelle Smith, University of Maine; Mark Urban-Lurain, Michigan State University

Teaching professional development for university faculty has been promoted as a means to improve the educational experiences of undergraduates in STEM (Bouwma-Gearhart, 2012). Faculty Learning Communities (FLCs) provide a strategy for teaching professional development that aligns with research-based recommendations for encouraging positive changes in college teaching (Cox 2004, Henderson et al. 2011), yet little is known about the motivations behind
participation in FLCs. Our research explores the question: what motivates faculty members to participate, and ultimately persist, in FLCs? We have used the Expectancy-Value Theory (EVT) of motivation to enhance our understanding of this phenomenon. In brief, EVT proposes that individuals’ motivation to take part in an activity depends upon the perceived ease of participation and probability of success along with the expected value gained from participation (Eccles, 2005). To address our research question, we are conducting a five-year, longitudinal study of 19 biology faculty participating in FLCs at six Research I universities. The FLCs complement the Automated Analysis of Constructed Response project (www.msu.edu/~aacr), which aims to provide faculty with insights to student thinking from constructed-response questions. In the first two years, we collected and analyzed data in the form of semi-structured interviews. We utilized standard qualitative methods and a grounded theory approach to analyze our data. In our first round of analysis we identified sections of each interview transcript salient to motivation; later we developed in vivo codes using the words of the participants. Finally, we grouped codes into unifying themes that described the main ideas present in the interviews. Interviews from Year 1 revealed that participants agreed to join the FLCs because they had respect for the facilitator and that they enjoyed the FLC meetings. In Year 2, we designed our interview questions to probe the motivations behind faculty choosing to persist. Our analyses of Year 1 and Year 2 data revealed the following about the AACR FLC faculty: the FLCs helped faculty use AACR, the FLC group composition matters, FLCs support teaching and provides an opportunity to discuss teaching with colleagues, and the FLCs do not take up too much time. We conclude that faculty are persisting in the FLCs because they provide great value with limited cost. This better understanding of faculty persistence in FLCs can contribute to more successful FLCs, thus yielding greater improvements in college biology teaching.

Abstract # 181 (Short Talk Sun)

Comparison of student learning gains in two versions of a SCALE-UP classroom
Sara Wyse*, Bethel University; Paula Soneral, Bethel University

Student-Centered Active Learning Environments for Undergraduate Programs (SCALE-UP) are widely implemented at institutions across the country. Learning gains from SCALE-UP classrooms have been well documented, but these classrooms are expensive to build and maintain. Responses from faculty and student surveys and focus groups identified that lower-cost features, such as collaborative seating arrangements and whiteboard drawing spaces were the most essential features of these SCALE-UP environments. Therefore, we set out to test these features on student learning in a high-cost, traditional SCALE-UP room compared to a low-cost, "mock-up" SCALE-UP room. We ask: how does student learning compare in the SCALE-UP room compared to a mock-up learning space? Two sections of the same introductory biology course at a liberal arts institution were taught identically by the same instructor in a SCALE-UP and Mock-Up classroom. The Mock-Up classroom reconfigured seating arrangements so they were collaborative, in pods of 6 students, and brought in portable white boards. Students also had access to LiteShow, to mimic the screen sharing capability of the traditional SCALE-UP classroom. Students in both sections of the course had similar demographics (gender, GPA, incoming ACT, DFW rate; p>0.05), except for year in college, where the Mock-up classroom enrolled significantly more freshman ($\chi^2 =35.3$, df=3, p<0.001). Year was included as a covariate for all analyses. Students scored similarly on the pre-instruction CLASS-Bio (T-test, p=0.41), and self-reported putting forth similar levels of effort in the course (T-test, p=0.2). Exam scores and course evaluations were compared between the two learning spaces. Course comments, including what students learned and whether or not they would take another course in a SCALE-UP space were coded using grounded theory. Average unit exam scores did not differ between the learning environments (Multiple R-squared =0.662, p=2.66x10^-10). Students, however, seemed to prefer learning in the mock-up
classroom based on qualitative comments; there were significantly fewer negative comments about the classroom in the mock-up section ($\chi^2=9.5$, df=4, $p=0.04$). Taken together, these data suggest that perceived and actual student learning gains were equally positive, if not better in the mock-up classroom. Students also identified and confirmed that collaboration and visualization of learning enhanced their learning experience. If these trends hold at other institutions, these findings suggest that the benefits derived from a SCALE-UP classroom could be achieved for lower-cost by changing the seating configuration and providing writable spaces for students, and designing pedagogies that make use of these classroom attributes.

Abstract # 182 (Round Table Sat )
The Role of Visual Cognition in Biology Education and Infograms: Less is More?
Vasiliy Kolchenko*, New York City College of Technology

The history of graphic representation predates modern educational practices and goes back to early cave paintings more than 30,000 years ago and the first pictogram-based writing systems about 7,000 years ago. Today, instructional graphics represent a popular type of cognitive scaffolding that makes it easier for students to encode, understand and retrieve information. At the same time, education studies show that we often overestimate the positive impact of graphics and underestimate the learning difficulties that students encounter in visual learning. The cognitive overload that many beautiful but overly detailed and complex instructional images impose on underprepared students has been discussed. The proposed innovation is the learning materials I called Infograms. It suggests the opposite approach: cleansing the images from confusing details as much as possible in order to create improved cognitive devices—graphic scaffolding, supports, or prompts—for information encoding and retrieval. At the same time, the unique nature of these graphic materials allows us to explore the fundamental questions of the cognitive theory: encoding and retrieval of information by the human mind in the context of the classroom. Graphics are excellent tools for this research because they are symbolic, representing a great amount of information with minimal representation. Additionally, they are abstract, which is important for the development of higher order abstract thinking skills. The goal of this NSF-funded project is to develop an instructional system based on innovative curricular materials (Infograms, or graphic symbolic summaries), implement it in undergraduate Biology classes and evaluate its effectiveness in improving learning outcomes using a comparative study. Plans for discussion include the following questions: 1. What are the types of instructional graphics used in biology? 2. What are we looking for in the educational image, animation or video? 3. What are your favorite visual instructional resources? 4. How can we use graphics to go beyond simple illustrations in order to facilitate better conceptual understanding? 5. What are the cognitive problems our students may experience while using educational graphics? 6. What are some effective ways to improve students’ visual literacy? 7. How can Infograms save class time, improve retention of knowledge and lead to better problem-solving skills? The round table would appeal to the wide audience of educators and researchers who are interested in more effective visual learning tools. This work was supported by the National Science Foundation under Grant #1245655.

Abstract # 183 (Poster Sat # 47)
Student processing and understanding of human cadaver dissection on the levels of cognitive, social, and emotional development
Bethany Munson*, Bethel University; Paula Soneral, Bethel University; Sara Wyse, Bethel University

Gross human anatomy is an important course for students headed into medical careers. However, the student learning process in relation to the study of human gross anatomy in the cadaver lab is largely understudied. This study explores the students’ perceived impact of
cadaver dissection on various levels development. Specifically, we asked: What is the perceived impact of cadaver dissection on the cognitive, social, and emotional development of undergraduate students? Furthermore, this research intends to understand aspects of the dissection process that will most benefit the students in their future professional career, asking the question: What aspects of the dissection process do students predict will be the most salient during the transition from undergraduate to medical professional? We administered a survey among undergraduate students at a small liberal arts college (n=13) and students associated with a regional Physician Assistant (PA) graduate program (n=46) asking questions directed to the stated goals of the research. Survey questions were piloted prior to administration. We developed a coding rubric to code the students' responses. The four categories used in the rubric are: Cognitive and Meta-cognitive; Affective and Meta-emotional; Socio-cognitive; and Psychomotor. The codes were then used to tabulate frequencies of the various categories. Data were compared using Chi-Squared analysis in order to determine relationship and significance of the findings between undergraduate and PA graduate data. The analysis showed that the category showing the most significant difference between the undergraduate students and PA students was in the Affective and Meta-emotional area; 31% (F=31%) of undergraduates mentioned this area while only 6% (F=6%) of the PA students mentioned the category (Chi-Square = 6.570, df=1, p<0.05). Students showed similarity in the processing of cognitive and meta-cognitive (Xcalc=0.201, p>0.05), socio-cognitive (Xcalc=1.331, p>0.05), and psychomotor (Xcalc=0.016, p>0.05). These results indicate the possibility of a difference in emotional processing between undergraduate and graduate level students. The PA students may be able to process their emotions in a more effective way than the undergraduate students. There may be value in professors allowing students the opportunity to openly process meta-emotional and affective aspects of cadaver dissection in order to further benefit their learning and understanding of the topic. Research in this area may help future teachers and learners understand aspects of the learning process that may need to be emphasized further in the classroom.

Abstract # 184 (Round Table Fri )

Similarity and Consistency of Language used between Student Conceptual Models and Written Explanations

Kari Blom*, Bethel University; Sara Wyse, Bethel University; Jennifer Momsen, North Dakota State University

Given the focus on teaching science as science is practiced, models have become an increasingly authentic tool within college biology classrooms. A variety of models can be used to explain, predict, and define systems. However, little research has been done considering model accuracy with student’s written explanations on the same topic, leaving few results telling how accurately models represent student knowledge or understanding. Our project compared student-constructed models and written explanations of carbon cycles to determine what, if any, similarities in language exist between these two distinct methods. Data comes from a final exam (post-instruction) asking introductory biology students (n=38) to create a model of the carbon cycle following a carbon atom from a dead wolf until it becomes a part of a moose cell. A subsequent question asked students to circle an area of the model representing the ways carbon could be released from the wolf’s body and explain the steps of the circled portion in essay format. Models and paragraphs were coded with a rubric by two raters with established inter-rater reliability (Cohen’s Kappa = 0.8471). The coding rubric classified models and written explanations on a scale from accurate to unclear/incomplete. Accurate statements incorporated the mechanism by which the carbon atom was moved throughout the system (e.g., photosynthesis, consumption). Models and paragraphs for each student were paired, and language similarity was analyzed using a Chi-Square test of independence. Students had
25.8% accurate statements in their models and 15.8% accurate statements in their written work. We found a significant association between students’ accuracy on the two question types ($X^2 (12) = 24.241, p = 0.0189, p < 0.05$). These results suggest that students who used accurate language in models are more likely to use accurate language in written explanations. Our results reflect work by Shaw and Bray Speth (unpublished), comparing model and written explanations for evolution, determining that models provide an accurate representation of students’ mental models of biological processes. These results also reflect work by Usoro (unpublished), comparing models and essays to see which subset of student thinking was elicited during each question type. Usoro found that models and essays show different strengths for different features, noting the importance of assessment type lining up with the learning goal. Overall, these results add to a growing body of work that suggests students’ language accuracy in models is significantly associated with the language accuracy used in written explanations.

Abstract # 185  (Poster Fri # 54)
**Breast Cancer and Precision Medicine: Strengthening CURE Pathways for Aspiring Physicians**
Paula Soneral*, Bethel University

Acceptance of national calls for biology education reform inspired the adoption the course-based undergraduate research experience (CURE) as a scalable model for research. We developed a CURE focusing on “precision” approaches for diagnosing and treating breast cancer disease. Students performed a 12-week workflow in which they experimentally and computationally analyzed the transcriptome of biopsied human breast cancer using DNA microarrays. Synthesizing clinical pathology with gene expression data and primary literature, students sub-typed breast tumors and modeled a diagnostic and prognostic “fingerprint” for the patient. The experience culminated in a mock molecular tumor board event, wherein students role-played as physicians to recommend personalized treatment. We asked, in which ways does this experience support learning most commonly associated with apprenticeship-style research experiences? The module’s efficacy was evaluated in terms of five design elements (1) novel discovery, (2) iteration and revision, (3) collaboration with peers, (4) project ownership, (5) scientific confidence. The Laboratory Course Assessment Survey (LCAS) and Project Ownership Survey (POS) indicated significant gains in aggregated measures of collaboration (T-test, $p<0.001$) and project ownership (T-test, $p=0.004$). In addition, pre-post analysis of science self-efficacy and attitude indicated a favorable shift as a result of the course (CLASS-BIO, T-test, $p=0.01$), with significant gains in student intention to pursue research careers (T-test, $p=0.01$). Interestingly, these gains are not associated with making novel scientific contributions (T-test, $p=.28$) or iterating the investigative process (T-test, $p=.53$). Content analysis of student comments corroborated survey results, emphasizing applicability to societal issues and decision-making. Together these data suggest that CUREs built on relevant proof-of-concept inquiry can be as effective as CURES centered on original research, signifying an alternative pathway toward increased science identity, career clarification, and persistence in science.

Abstract # 186  (Poster Sat # 5)
**The Effects of Random Assortment and Blinding on Qualitative Data Analysis**
Andrea Bierema*, Michigan State University; Anne-Marie Hoskinson, Michigan State University; Rosa Moscarella, Michigan State University; Kevin Haudek, Michigan State University; John Merrill, Michigan State University; Mark Urban-Lurain, Michigan State University

Qualitative data analysis contains some degree of error, and any research group that performs qualitative research should be aware of sources of bias. Our research group investigates computerized analysis of undergraduate students’ constructed responses to questions about
science and statistical concepts. In our development of predictive computer models, increasing the number of human-coded responses enhances the accuracy of these models. One way to increase the number of coded responses is to verify computer-predicted codes for each response instead of coding the responses blindly and randomly. However, human coders are also subject to confirmation bias, in which prior knowledge and expectations can bias their coding. We tested whether having computer-predicted codes available to human coders (i.e., no blinding) and sorting the responses in the order of the computer codes (i.e., no random assortment) facilitated confirmation bias in human coding. In the initial investigation, one coder coded 2,000 responses, which had codes predicted by a computer scoring model, to a three-part constructed response question and found an effect from both no blinding and no random assortment of the computer codes. To test whether this finding was a novel observation, three coders, including the initial coder, replicated the investigation with experimental improvements: we more clearly defined the coding rubric and we used a split-plot design instead of coding all responses for each treatment at one time. Another differing factor between the two investigations was that the coders were aware of the overall pattern of the initial coder’s findings that supported an effect of confirmation bias. During the second investigation—contrary to the results of the initial investigation—random assortment and blinding had little to no effect on bias across the three coders. The difference in the results of the two investigations may be due to any of the variations between the two investigations. In conclusion, blinding and random assortment may be effective methods for reducing the effects of confirmation bias in coding student responses but may be less important when other methodological aspects, such as rubric development, are rigorous. Moreover, knowing about one’s own bias may also reduce the effects of confirmation bias. In this poster, we will describe our methodological design in more detail and further discuss the implications of these results.

Abstract # 187 (Short Talk Sat )
Measuring student learning in genetics: A comparison of content, cognitive level, and performance on the Genetics Concept Assessment and course assessments
Jennifer Avena*, University of Colorado Boulder; Jenny Knight, University of Colorado, Boulder; Derek Briggs, University of Colorado Boulder; Robert Talbot, University of Colorado Denver

Can similar conclusions be drawn about student learning from both concept assessments and faculty-written course exams? If not, how are they different, and why? We are addressing these questions by examining the relationship between student performance on the Genetics Concept Assessment (GCA) and student performance on faculty-written course exams in undergraduate genetics courses. This study examines eight genetics courses at six different institutions across the nation, including research, liberal arts, and four-year education-centered institutions. In the first year of this two-year study, we collected student performance data for exams and for the GCA both pre- and post-instruction. In order to determine whether student performance varies by certain question characteristics, for both sets of assessments, we have categorized the questions by genetics concept using learning goals, and we have also coded questions with respect to the cognitive processes they target using the revised version of Bloom’s Taxonomy (Anderson et al., 2001). Preliminary data suggests 86% of course exam questions overlap with the eight learning goals found on the GCA. Bloom’s level for exam questions was predominantly level 3 (apply), with questions coded at all six Bloom’s levels. For GCA questions, the Bloom’s level was also predominantly level 3, but no questions were coded at levels 1, 5, and 6 (remember, evaluate, and create, respectively). Thus far, we have found that scores on the GCA post-test are associated with course exam scores, although this association varies by genetics concept. Across both course exams and the GCA, student scores vary by genetics concept and cognitive process targeted. Additionally, we are gathering data from instructors on their teaching, including teaching practices (question derived from the TPI) to
explore whether certain course characteristics are correlated with student performance. This study will shed light on the extent to which different types of assessments allow instructors to draw similar or different conclusions about student learning as well as identify factors that may be associated with student performance on such assessments.

Abstract # 188 (Poster Fri # 32)

**Assessment of Student Learning in Evolution based on the American Society for Microbiology Curriculum**

Chelsey Grassie*, North Dakota State University; Peter Bergholz, North Dakota State University; Jennifer Momsen, North Dakota State University; Lisa Wiltbank, North Dakota State University

Modern microbiology depends on genomics and evolutionary theory to advance fields from infectious disease to food quality. The American Society for Microbiology (ASM) has established a suggested curriculum for introductory microbiology courses that includes a focus on evolution. However, no data currently exist that describe how proficiently students are able to address the learning outcomes, in part because validated assessments do not exist. The goal of this project is to develop assessment prompts that capture student understanding with respect to three learning outcomes from the core concept of evolution in the ASM curriculum: “(1) explain what features of 16S rRNA make it useful to compare the evolutionary relationship between organisms, (2) determine the two most related and two least related organisms from a short list of 16S rRNA sequences, and (3) draw inferences about evolutionary relatedness of organisms based on phylogenetic trees.” We developed two items targeted at application and analysis of 16S rRNA gene sequence data, and analysis of phylogenetic trees. Written student responses (n=167) were collected from six upper-level microbiology courses for analysis. Students identified as microbiology majors (30.2%) and non-microbiology majors (69.8%), with pre-pharmacy students comprising the majority of respondents (44.0%). Rubric development via emergent coding on open responses is ongoing and will characterize how students describe the utility of 16S rRNA and how they analyze the short 16S rRNA sequence data and phylogenetic tree. For example, many students counted nodes to determine the most related species on the phylogram. Interrater reliability (Cohen’s weighted \( \kappa \)) on approximately 25% of open response items was moderate to high (0.66-0.95) across each item. However, coding within individual items had an IRR that fell below the 0.65 threshold. Thus, rubric revision is ongoing. Preliminary analysis suggests that approximately half of students are not able, or choose not to address the utility of 16S rRNA for determining species relatedness. Likewise, approximately half of students were unable to analyze species relatedness on the 16S rRNA gene sequence data or the phylogenetic tree. Future work will include statistical analysis of response accuracy on all data collected, and demographic analysis of factors associated with response accuracy.

Abstract # 189 (Round Table Fri )

**A new set of guidelines for using Bloom’s Taxonomy to evaluate the cognitive processes targeted in genetics questions**

Jennifer Avena*, University of Colorado Boulder; Jenny Knight, University of Colorado, Boulder; Derek Briggs, University of Colorado Boulder; Robert Talbot, University of Colorado Denver; Heidi Kroog, University of Colorado Denver; Janet Batzli, University of Wisconsin-Madison; Robert Brooker, University of Minnesota; Danielle Hamill, Ohio Wesleyan University; Michelle Smith, University of Maine

As part of a study examining the relationship between student performance on the Genetics Concept Assessment (GCA) and on faculty-written course exams in undergraduate genetics courses, we have been examining the cognitive processes targeted by assessment questions, as defined by Bloom’s Taxonomy. Over the course of one year, we worked to obtain an acceptable degree of inter-rater agreement in rating the Bloom’s level of GCA items, as well as
exam items from eight different genetics courses. The team of raters all had experience in teaching genetics and included both science-education researchers and basic biology researchers. During the initial training sessions, it became apparent that existing rating guidelines were insufficient for reaching high inter-rater agreement. Thus, we iteratively developed a new set of guidelines that focus on the cognitive process dimension of the revised version of Bloom’s Taxonomy (Anderson et al., 2001), building on the guidelines set forth by Crowe et al. (2008). A total of 144 genetics course exam questions and 25 GCA questions were rated by six experts. Despite the new guidelines, a high level of inter-rater agreement is still challenging to reach: after training, experts achieved an agreement of 78% for 20 questions rated using the final version of the rating guidelines. One difficulty in Bloom’s ratings that is particularly addressed in the new guidelines is how to differentiate among Bloom’s levels 2, 3, and 4 (understand, apply, and analyze, respectively), particularly when the question includes the presentation of data. We have obtained additional feedback on these guidelines from several science education experts outside of the study and will further test the guidelines with additional biology experts who are novices at using Bloom’s Taxonomy. We intend for these guidelines to be used by both novices and experts and request feedback regarding the training process and the perceived utility of the guidelines.

Abstract # 190 (Short Talk Fri)

Early Engagement in Course-based Research Increases Graduation Rates and Completion of Science, Engineering, and Mathematics Degrees
Stacia Rodenbusch*, UT Austin

National efforts to transform undergraduate biology education call for research experiences to be an integral component of learning for all students. Course-based Undergraduate Research Experiences, or CUREs, have been championed for engaging students in research at a scale that is not possible through apprenticeships in faculty research laboratories. Yet, there are few if any studies that examine the long-term effects of participating in CUREs on desired student outcomes, such as graduating from college and graduating with a STEM degree. One CURE program, the Freshman Research Initiative (FRI), has engaged >6,000 undergraduates over the past decade. Using propensity score matching to control for student-level differences, we tested the effect of participating in FRI on students’ probability of graduating with a STEM degree, probability of graduating within six years, and GPA at graduation. Students who completed FRI were significantly more likely than their non-FRI peers to earn a STEM degree and graduate within six years. FRI had no significant effect on students’ cumulative GPA at graduation. The effects were similar for diverse students. These results provide the most robust and best controlled evidence to date to support calls for widespread involvement of undergraduates in research early in their academic careers.

Abstract # 191 (Poster Fri # 33)

Immediate feedback and backward design improves learning outcomes for a computer module teaching natural selection
Jody Clarke-Midura, Utah State University; Denise Pope, SimBio; Susan Maruca*, SimBio; Kerry Kim, SimBio; Joel Abraham, CSU Fullerton; Eli Meir, SimBio

SimBio’s Darwinian Snails computer module has for many years taught evolution by natural selection to introductory biology students. Its original version featured computer simulations accompanied by a printed workbook with instructions and short-answer questions. Students write answers to workbook questions as they perform tasks in the virtual lab; the instructor then grades the questions at a later time. Previous research demonstrated the module’s effectiveness at improving student understanding of natural selection. In 2013 SimBio revised Darwinian Snails, converting the workbook to an onscreen “tutorial” format. Most formative
questions were changed from short-answer to multiple-choice with immediate feedback for students. Additionally, we used backward design to revise some of the module’s content to better target our key learning goals. The revised tutorial version of Darwinian Snails has been widely adopted by instructors, but some instructors continue to use the workbook version. Many instructors appreciate the workbook’s writing component, which they believe helps develop important skills for students. However, immediate feedback, such as that provided in the tutorial but not the workbook version, has been shown in many studies to improve student learning. Because of this, we expect that the tutorial version of the module enhances the learning experience for students. We compared student learning between the workbook and tutorial versions of Darwinian Snails two ways. First, in 2014-15, both versions of the module included the same set of final “graded questions” that are strictly summative (students get no immediate feedback). We compared student performance on this assessment: 1885 students from 18 classes used the tutorial version and 755 students from 22 classes used the workbook version. Students using the tutorial version scored significantly higher on these questions than students using the workbook version. Additionally, we estimated student learning gains for the revised tutorial version in Fall 2013 using pre/post test results, and compared these to gains measured in a similar manner for the workbook version in an earlier study. These comparisons focus on quantifying student expression of key concepts and misconceptions about natural selection. All of these side-by-side comparisons show more student improvement in the tutorial version of Darwinian Snails compared to workbook version. These results suggest that providing immediate feedback to students on their work can enhance learning about natural selection, and that the benefits of immediate feedback may override the benefits of open-ended written expressions in this context.

Abstract # 192 (Short Talk Fri )

Probabilistic Reasoning in Undergraduate Genetics Problem-Solving

Susan Hester, University of Arizona; Katelyn Southard, University of Arizona; Tyler Wince, Flowing Wells Junior High; Lisa Elfring, University of Arizona; Lisa Nagy, University of Arizona; Molly Bolger*, University of Arizona

Recent calls for improving undergraduate biology education have emphasized the importance of students learning to apply quantitative skills to biological problems. In previous work, members of our team focused on designing and testing instruction for an Introductory Molecular and Cellular Biology course integrating mathematical skills with biology content throughout all aspects of the course. The current study builds from previous work to understand students’ quantitative reasoning in the context of the course we designed by describing how they used quantitative reasoning to understand genetics. Specifically, we asked to what extent students relied on probabilistic reasoning when solving problems about genetics and inheritance, and what intuitions students had that helped or hindered productive reasoning about genetics, inheritance and probability. To address these questions, we designed a set of questions assessing (1) student problem-solving in a classical genetics context, (2) student problem-solving in a non-biological context parallel to the classical genetics context (a “transfer context”), (3) students’ understanding of independent events, and (4) students’ application of sample size when reasoning about inheritance patterns. We interviewed a small number of students (14) from our revised course on all of these questions. We also administered the first three of these questions in a multiple-choice/show-your-work format to 171 students in a different revised section. We found that students were able to solve a classical Mendelian genetics problem using a Punnett square, but that they were typically unable to spontaneously transfer the Punnett-square organizer to a parallel problem in a different context. Likewise, students were able to correctly apply a heuristic about independent events, though interviewed students had difficulty explaining why subsequent events would be independent in the context of the problem.
Finally, all interviewed students described the importance of sample size to confidently drawing conclusions. Despite this, some number of them (6/14) were willing to draw conclusions about a trait based on an overly small sample. In the cases of the transfer problem and the problem probing reasoning about sample size, we found that students’ conceptions about trait dominance interfered with their ability to reason productively. Our findings have implications for how to design instructional tools that take advantage of students’ productive intuitions and challenge the intuitions that hinder productive reasoning. Supported by Howard Hughes Medical Institute (52006942), and the Association of American Universities STEM Education.

Abstract # 193 (Short Talk Fri )
What can students learn from designing their own experiments and receiving immediate feedback?
Denise Pope*, SimBio; Susan Maruca, SimBio; Kerry Kim, SimBio; Jen Palacio, SimBio; Jenna Conversano, SimBio; Jody Clarke-Midura, Utah State University; Eli Meir, SimBio

Teaching experimental design is an important but challenging goal. In this three-year project, we tested one promising approach: a computer module that provides students with immediate feedback on experiments they design. We conducted an iterative process of development, testing, and refinement of the module. We faced a design challenge: we wanted to allow students freedom in designing experiments, but providing immediate feedback requires that we classify their experiments, which in turn necessitates constraining possible experimental designs. We tested our first iteration of the module, which did not include feedback, with student interviews (n=27) and implementation in college classes (n=684 students; 17 classes); used this to develop feedback for student experiments; then tested with more classes (n=460 students; 13 classes). Students who received feedback showed improved final experiments, with more replication and systematic variation, compared to students who did not receive feedback. However, students retained some confusions, such as not understanding the difference between control treatments and confounding variables that are controlled. We used these results to develop our current module, Understanding Experimental Design (UED). UED introduces principles of good experimental design, reinforced with formative assessment, and challenges students to design experiments with a simulated population, providing feedback throughout the process. The simulation involves disease in a hypothetical species, so students have no expectation of the outcome. The constraints we imposed on student designs in order to classify and give feedback may themselves help students learn, independent of feedback. Therefore our final study differentiates between the effects of constraints and the effect of constraints + feedback, using a controlled, single-blind experiment. We created 3 UED versions: full constraint + feedback, full-constraint/no-feedback, and low-constraint/no-feedback. To assess the module’s introductory material we use a pre/post multiple-choice test on vocabulary and basic principles of experimental design. Preliminary data (n=19) shows a small improvement on performance between pre and posttest (mean normalized change=0.14). To comprehensively measure student thinking before and after the module, we conduct semi-structured interviews consisting of a written task and follow-up interview. Preliminary results (n=7) suggests that in their post-interviews, students are more likely to use systematic variation and replication, and are better able to articulate the purpose of control treatments, replication, and holding potentially confounding variables constant. We will use pre/post interviews to compare learning gains among treatments. We hypothesize that the full version will show the greatest gains and the low-constraint/no-feedback version will show the lowest gains.
Abstract # 194 (Poster )

**What made the difference? Improved career outcomes of underrepresented students participating in a small biomedical research program**

Cherilynn Shadding*, Washington University in St. Louis School of Medicine

Opportunities in Genomics Research (OGR), is an NIH funded program that provides research experiences to underrepresented students (UR), to directly address disparities in education and exposure in STEM (science, technology, engineering, and mathematics). The key goal of OGR is to increase the number of UR students who pursue PhD’s in STEM. Many programs exist with similar goals yet; establishing program effectiveness remains an issue and an area of intense study. We wanted to determine if there was improvement in desired outcomes for OGR as we refined the program through internal and external evaluation. OGR has two main programs: an eight-week summer internship, Undergraduate Scholars, and a one-year post baccalaureate program, Extensive Study. In both programs, students conduct independent research with investigators at our institution and participate in activities focused on STEM career success. To date, OGR has been funded for two grant cycles: 2007-2011 (cycle 1) and 2012-2015 (cycle 2).

We compared career outcomes of 81 program alumni by cycle for both programs combined and separately. Independent chi-square tests were used to test the difference between program types, career outcomes and grant cycle. The crosstab function within SPSS determined significance. Our data show that in our summer program there was a significant increase in alumni pursuing the PhD vs. other career outcomes in cycle 2 (25% vs. 47.7%; $X^2=8.061$, df=3, $p=.045$). There was a 15% increase in cycle 2 in PhD pursuit for post baccalaureate alumni, although this was not significant. Combined data of both programs showed a significant increase of PhD pursuants in cycle 2 (26.5% vs. 50%; $X^2=8.027$, df=3, $p=.045$). To determine if school quality factored into the observed change, we examined the U.S. News and World Report rankings of graduate schools alumni were attending. Data for the post baccalaureate program indicate a significant improvement in the average ranking for graduate schools attended (52nd vs. 18th) but not a significant difference in the average ranking for the summer program or combined data. There was no significant difference in other variables by cycle such as: ethnicity, gender, undergraduate GPA, or Carnegie class of undergraduate institution. These data prompt a closer look at our program components to determine any correlation with these improved outcomes.

Abstract # 195 (Short Talk Sun )

**Online pre-medical courses as a platform for controlled research on instructional methods**

Marshall Thomas*, Harvard Medical School; Selen Turkay, Harvard University; Michael Parker, Harvard Medical School

Laboratory studies have established an evidence base of best practices in multimedia instruction, but few of these studies utilize instructional materials derived from actual courses. Moreover, studies focusing on learning as an outcome usually overlook students’ experiences (for example, interest and engagement). Engagement is a particularly pressing concern in online courses, which can have high attrition rates. In this study, we focus on HMX Fundamentals: fully online courses targeted at learners interested in health care careers (e.g. pre-nursing or pre-medical). We describe a new paradigm of integrating research on best practices in online instruction into the process of course development and improvement. We measured the effects of varying the blend of instructional materials from the HMX Fundamentals Immunology course on participants’ subjective experiences (measured by a survey) and retention (measured by a follow-up test). The testing effect has been widely established and replicated, but students’ perceptions of online formative assessments are not well understood.
We recruited study participants from Amazon Mechanical Turk. We screened over 1,700 individuals with a short biology pre-test. Those who passed the pre-test (~19%) were invited into the study and randomized into one of the four conditions: explanatory text, assessment, assessment plus explanation, or assessment plus interactive multimedia. All participants watched the same sequence of short immunology videos interspersed with one of the four activities. Groups were compared using nonparametric rank order statistical tests. In our preliminary analyses we compared all assessment conditions as a group to the text condition. Interspersed assessment had a significant positive effect on students’ subjective experience relative to interspersed text. Participants in the assessment conditions reported lower levels of mind wandering and found the material more interesting, even though all groups found the material equally difficult. Interspersed assessment also increased time on task. Our results have clear implications for online course development teams. In particular, resource-lean additions to courses (machine-gradable formative assessments with clear explanations) positively impact experiences. This rebuts the belief that assessments have a neutral or negative effect on students’ experiences. In the future, we aim to use this approach to measure the impact of other variables, such as the quantity of assessment, the types of resources, and the sequencing of resources. This study establishes a generalizable and scalable model for studying real online courses in controlled environments to hone best practices in teaching online.

Abstract # 196 (Round Table Sat)
**Discussing the future: Including a career panel discussion in a graduate program seminar series**

Justine Liepkalns*, Emory University; Shayla Shorter, Emory University

The proportion of recent PhD graduates in the biomedical sciences with faculty jobs (a “traditional” career) dropped from 40% (1973) to 14% (1995) and remains at 14% even 5-6 years post-graduation (2012). To investigate career preferences amongst graduate students, we assessed the response to a panel-discussion that highlighted a variety of careers as part of the Immunology and Molecular Pathogenesis (IMP) program seminar series. The panelists were IMP alumni with traditional (research faculty) or non-traditional (patent law, government administration, education, policy, and communication) careers. Within the 40 respondents, 18 had not yet passed their qualifying exams and 20 were working on their dissertation research. While 12 were about to or were actively job searching, most students revealed they spend little time on exploring career options. Participants indicated that they were (very) aware of how to prepare for faculty positions. However, preference for careers within research and development tended towards government and established firms (particularly advanced-stage students), with faculty positions as the only careers selected as “extremely unattractive.” In pre-surveys, 5-13 respondents were completely unaware of these non-traditional careers as viable career options in their field. This number decreased in post-surveys as participants agreed they had learned more about non-traditional careers and about how to prepare for them. They agreed that the panel discussion was helpful in gaining awareness, providing a networking opportunity, and informing them about expectations in different careers. The majority (strongly) agreed that they wanted more panel discussions and seminar guest speakers from diverse post-doctoral career paths. Most IMP participants strongly agreed that they could identify with the panelists as alums and that director support is needed for pursuing different career options during their PhD careers. These surveys reveal simple ways to enhance Emory graduate training within an existing format to better prepare trainees for the job market.
Abstract # 197 (Poster Sat # 48)
**Mentoring undergraduates: Challenges and choices in a unique experience**
Justine Liepkalns*, Emory University

So much of being a good teacher is being a good mentor. Undergraduate research has the benefit of helping students make a transition from passive learning to active learning; however, students new to research are presented with a catch-22 when trying to identify a research laboratory to work in. I present a case study of a unique mentoring experience and what I have been learning about mentoring writ large. Among issues faced included fostering independent thinking and enthusiasm, attribution of credit, calibrating mentor involvement, establishing “protected time” and regular meetings, and building a relationship while still maintaining authority (particularly as a woman with two male students). This case includes an added layer of complexity: entrepreneurship. During the Ebola outbreak, two freshmen and I began a fundraising campaign to test a rapid detection method for Ebola. Our success in raising funds brought awareness to our project and campus-wide support. With lab space provided by a supportive biology department, we filed a preliminary patent and a protocol on which I am the principal investigator (while still being a post doctoral fellow in another laboratory). We were interviewed widely in the media, were asked to give a talk at a conference and were awarded a booth at the Atlanta Science Festival. One of the students has received an award and gave an invited TEDx talk; the other wrote an essay published in a peer-reviewed journal. We have submitted a patent application through the office of technology transfer to the U.S. Patent and Trademark Office for the method we have developed. We have also applied for additional funding in order to continue moving our work forward with an honors thesis in the future. This unorthodox start to a project and laboratory has created experiences that have engaged, motivated and trained these students on the various facets of research. Maintaining a trusting mentoring relationship was important in shaping a platform from which to propel these students’ careers forward.

Abstract # 198 (Poster Fri # 10)
**What student characteristics influence buy-in toward formative assessment techniques?**
Kati Brazeal*, "University of Nebraska, Lincoln"; Brian Couch, University of Nebraska-Lincoln

The use of formative assessment (FA) techniques, such as pre-class assignments, in-class activities, or post-class homework, has been shown to improve student learning. Previous work suggests that while many students find these techniques to be beneficial, some are resistant toward them. However, little is known about what factors influence whether students buy-in to or resist FAs. Student buy-in can potentially affect whether students fully engage with and learn from FAs. Therefore, improving our understanding of FA buy-in has important implications for helping students. We conducted a study of FAs in 14 different undergraduate biology courses, spanning introductory to senior level, examining whether student buy-in toward FAs was influenced by a variety of student characteristics. These characteristics include gender, ethnicity, class standing, major, incoming ability, exam performance, previous experience with a FA technique, and utilization of FAs. To measure student buy-in toward FAs, we administered a mid-semester survey which probed student perceptions about several different FA types that were being used in the courses (e.g., Just-in-Time-Teaching, pre-class online assignments, clicker questions, in-class activities, quizzes, homework). The survey included closed-ended questions aligned with a theoretical framework that outlines five key objectives of FA: 1) clarify learning expectations for students, 2) reveal levels of student understanding to the instructor, 3) provide students with feedback that promotes learning, 4) facilitate peer interactions, and 5) encourage self-regulated learning (Black and William, 2009). We used principal axis factoring to identify which survey items best represented student buy-in and to create an overall buy-in
score for each student. We used multiple linear regressions to determine which student characteristics significantly predicted greater buy-in toward each FA type. This work will have important implications for understanding how to maximize student buy-in toward FAs.

Abstract # 199 (Short Talk Fri)
Investigating how students create and use models to interpret authentic biological data in the context of the TRIM (Teaching Real data Interpretation using Models) curriculum
Patricia Zagallo, University of Arizona; Samantha Zaepfel, University of Arizona; Molly Bolger*, University of Arizona

A primary goal in reform of biology instruction is integration of scientific reasoning skills and content knowledge. We developed a curriculum designed to foster the development of such skills in a large-enrollment, upper-division biology content course called Teaching undergraduates Real data Interpretation using Models (TRIM). We provide students with biological models that convey key course topics to aid in their interpretation of published data figures and to provide practice with model-based reasoning, a primary disciplinary skill. In a previous study, we evaluated the TRIM method by analyzing student work and recorded in-class discussions. These data revealed that students could collaboratively develop quality data interpretations, using models to expand the biological significance of those interpretations. However, questions still remain about the merits of providing models or allowing students to practice drawing their own models in order to foster model/data connections. In this study, we ask 1) Can students draw their own productive models to interpret authentic biological data? And 2) How do students coordinate the use of models (provided or self-generated) with data interpretation? How do the two conditions compare? To answer these questions, we recruited TRIM students (n=30) to participate in clinical think-aloud interviews where individuals, tasked to interpret data figures, were randomly assigned to an experimental group given a provided model (n=16) or given the opportunity to draw a model (n=14). Another group of graduate students and postdocs in relevant fields were interviewed for comparison (n=10). We found that students were able to draw and refine their own models as they made sense of data figures. Their model drawings ranged from text-based to schematics to spatially organized layouts resembling the models presented to the provided-model group. Next, we developed a coding scheme to assess the quality of students’ data interpretations. Coding analysis (2 coders; 86.2% agreement) revealed no statistical difference in the interpretation quality between provided-model and draw-model groups (p= 0.20, Student’s t-Test), suggesting that student-derived models may be equally productive as instructor-provided models for fostering students’ interpretations of novel data. Components of data interpretation that were more challenging for undergraduates than the comparison group included understanding experiment controls, and aspects requiring complex tracking of authors’ arguments represented through data figures. Ongoing qualitative coding analysis includes further comparison between treatment groups of students’ coordination of data and models. Our work aims to inform instructional design decisions for integrating disciplinary practices such as modeling and data interpretation in undergraduate biology classrooms.

Abstract # 200 (Short Talk Fri)
Creative Thinking about Novel Biological Phenomena: Fostering Generative Mechanistic Reasoning among Undergraduates
Katelyn Southard*, University of Arizona; Melissa Espindola, University of Arizona; Samantha Zaepfel, University of Arizona; Molly Bolger, University of Arizona

As biology educators we must extend beyond disseminating content information, and aim to foster creative thinking and problem-solving strategies among our students. One way to accomplish this is to present students with problems in novel biological contexts, prompting them to practice reasoning strategies used by biology experts to create mechanistic
In this study, we explore how undergraduate molecular and cellular biology (MCB) students engaged in generative mechanistic reasoning when approaching two novel phenomena: bacterial chemotaxis and plant development and evolution. Drawing heavily from the philosophy of science, we use several known components of expert reasoning in biology to explore the potential for expert-like reasoning among students, including multi-level molecular mechanistic reasoning, functional modules as mental organizers, and explanation building heuristics (Van Mil et al., 2013). Using this framework we ask: 1) what are observable components of expert-like reasoning among undergraduate MCB students constructing explanations in novel contexts?, and 2) what are common patterns observed in students’ use of generative mechanistic reasoning? Clinical think-aloud interviews were conducted with introductory (N=17) and upper-division (N=27) students at a large public university. Analysis included iterative transcript read-throughs and qualitative coding analysis. Results demonstrate several features of domain-specific expertise that allowed students to hypothesize plausible explanations, in particular: functionally subdividing the phenomena by asking “how” questions, instantiating mechanistic schema by postulating the involvement of key entities and their properties, and flexible thinking across biophysical levels. While these problems encouraged most students to engage in generative mechanistic reasoning, several features distinguished differing levels of expertise. Results of coding analysis revealed that only the top quartile of students generated cohesive molecular mechanistic explanations. Another subset of students used incomplete generative mechanistic reasoning, for example, suggesting the involvement of key molecular entities or identifying the need for a functional schema but providing no causal mechanism. Still other students created non-molecular mechanisms often observed at the K-12 level, or focused on teleological explanations. Overall, findings suggest that many features of student reasoning in a problem-solving context are analogous to the forms of reasoning used by scientists to solve authentic problems in MCB. Therefore, problems that require construction of an explanation hold promise as useful tools for promoting and assessing students’ generative mechanistic reasoning. Van Mil MH, Boerwinkel DJ, Waarlo AJ (2013). Modelling molecular mechanisms: a framework of scientific reasoning to construct molecular-level explanations for cellular behaviour. Sci Educ 22, 93-118.

Abstract # 201 (Poster Sat # 31)

**Hybrid Labs: Integrating experiments and computer simulations in introductory biology labs**

Julia Gouvea*, Tufts University; Aditi Wagh, Tufts University; Matthew Simon, Tufts University; Brendan Sullivan, Tufts University; Robert Hayes, Tufts University

The aim of the Hybrid Labs project is to integrate two core components of biological practice, experimentation and computer simulations (Vision & Change, 2011) in introductory biology labs. In this poster we describe the design of hybrid labs in a second semester introductory biology lab focused on organismal and population biology, and report on results from end-of-term surveys administered to students. The motivation underlying the design of hybrid labs is integration of these two components. This involves students shifting back and forth between conducting physical experiments and investigating computer models and simulations to reason about the underlying biological system. For instance, recording and analyzing data from hands-on experiments can lead to several interpretations and additional questions that might not be feasible to test in a physical experiment. However, such kinds of questions could be rapidly investigated in a computer model by manipulating or controlling multiple (often invisible) parameters. In turn, the ideas generated through running experiments in computer models can generate the need for empirical data and controlled comparisons, which in turn can inform experimental design. In this way, students’ physical experiments and investigations in a computer model can motivate and inform each other. We illustrate this integration in the hybrid
lab approach with examples of activities from three 3-week long labs. These three labs were implemented with approximately 300 undergraduate biology students over a semester as a first iteration of design research. In addition, we report on students’ attitudes and reactions to the hybrid lab approach by analyzing an open-ended end-of-term survey. In this survey, we asked students to describe how the two central components of the lab impacted their learning and interest in biology. We also asked them to comment on their understanding of the purpose of hybridity in labs and the extent to which the labs met their expectations for what kind of learning should happen in lab. We use this data to present our reflections on the design of hybrid labs, and their impact on student attitudes and interest and invite the community to reflect on the potential of the hybrid lab approach at the introductory level.

Abstract # 202 (Short Talk Fri )
A Course-based Undergraduate Research Experience (CURE) Focused on Health Disparities in Immigrant / Refugee Communities Improves Scientific Literacy, Cultural Competency and Teamwork
Kelsie Bernot*, North Carolina A&T State University; Michele Malotky, Guilford College

Our goal is to better prepare students for a global STEM workforce. We based our intervention on the theoretical framework of Dewey’s experiential learning through which students learn by “doing” as a social community. Numerous studies have demonstrated that students who participate in high impact practices like undergraduate research are more likely to persist and progress in STEM education. However, due to the physical limitations of mentoring all undergraduates in independent research, there has been growing interest in course-based undergraduate research experiences (CUREs). In our course design, we sought to combine two high-impact activities - service learning and undergraduate research - within a single course and measure learning gains not only in scientific skills, but also in soft skills such as cultural competency and team work. The course included students from two institutions – a public, historically black university and a private Quaker, liberal arts college. Together, students worked on a novel, authentic research project assessing the prevalence of hypertension in an immigrant/refugee community and correlating it with biometrics such as cortisol levels as well as social risk factors such as food and financial insecurity. The students engaged in interpreting primary literature, discussing human subjects research ethics, collecting data, performing statistical analyses, and writing a primary scientific article. We used a mixed-methods approach to assess the impact of this course, including: • Pre/Post exam: direct assessment of scientific literacy • Pre/Post indirect assessment of cultural competency (Global Perspectives Inventory, GPI) • Direct assessment of group journal club presentations and individual research papers • Indirect assessment of student learning gains (Student Assessment of Learning Gains, SALG) • Qualitative assessment through a focus group and open-ended questions on the SALG survey
Mean student performance increased from 64.4% to 78.2% on the pre/post direct assessment (p<0.0001). Although the GPI assessment did not show differences from pre to post test, this may be limited by the fact that it was originally designed for a study abroad experience. Students reported very strong gains in cultural competency and ability to work in a group. Together these data suggest that this application of science to a real world problem resulted in significant student learning in traditional scientific skills as well as soft skills. Future directions will assess the impact on persistence and progression in STEM as a result of the course.
Abstract # 203 (Short Talk Sat)

A Comparative Study of Assessment Formats in an Undergraduate Anatomy and Physiology Course
Adriel Cruz*, California State University Sacramento; Kelly McDonald, California State University, Sacramento

Assessments are invaluable tools both in the classroom and for the purpose of educational research. However, research in this area has shown that every assessment format has limitations. It is important to consider these limitations when assessments are used for summative purposes, as these are often used to form judgments about students’ conceptual understandings and mastery of skills. This study compared three assessments formats – multiple-choice, written, and oral – in an undergraduate anatomy and physiology course. The study (1) revisited the question of reliability by quantitatively comparing student scores across the three formats, (2) determined if demographic variables were associated with differences in student performance, (3) identified student difficulties in the written and oral formats, and (4) examined student attitudes towards the written and oral formats. Question sets on the topics of hemodynamics and hemoglobin dissociation were developed and administered in the multiple-choice, written, and oral formats to 67 number of students. Quantitative analyses – Kruskal-Wallis, Mann-Whitney U, correlations, and mean absolute differences – showed differential scoring between the multiple-choice and either of the open-ended formats, despite identical questions. Most of the quantitative methods demonstrated equivalent performance between the written and oral formats, although mean absolute differences indicated slight, yet significant, differences. Two-way ANOVA analysis incorporating student demographic data detected no significant associations with most demographic variables, including gender (hemodynamics: P=0.82; hemoglobin: P=0.071) and whether English was spoken as a primary language (hemodynamics: P=0.98; hemoglobin: P=0.952). The only variable with a significant association was self-reported confidence level in the students that answered the hemoglobin questions (P=0.041). Qualitative analysis of the written and oral exams revealed student difficulties and misconceptions for both the hemodynamics and hemoglobin topics, with some student difficulties identified exclusively through the oral exam. Student difficulties included the inability to define basic terms and appropriately apply mathematical models in explaining physiological concepts. Likert-like style surveys revealed a diversity of attitudes toward the assessment formats. Most students felt uncomfortable, unable to organize their thoughts, and rushed on the oral exam. However, other students preferred the oral exam, indicating that verbalizing their answers helped them better organize and elaborate on their thoughts. This study demonstrates that not all assessment formats are equal and highlights the importance of using a variety of formats to accurately assessing learning in a diverse student population. The study also offers data on misconceptions that could lead to the development of a concept inventory in anatomy and physiology.

Abstract # 204 (Poster Fri # 49)
Characterizing the Activities of Learning Assistants in Large Enrollment Science Courses
Laurel Hartley*, CU Denver; Robert Talbot, University of Colorado Denver; Jeff Boyer, North Dakota State University; Leanne Doughty, University of Colorado Denver; Paul Le, University of Colorado Denver; Amreen Nasim, University of Colorado Denver; Hagit Korneich-Leshem, Florida International University

The Learning Assistant (LA) model is a reform context intended to promote use of student centered pedagogies in STEM courses. Learning Assistants (LAs) are undergraduates who have been successful in the course for which they are an LA. Faculty and LAs work closely together to plan, implement, and assess course activities. Concurrent with their experience, LAs
take a course in STEM pedagogy. Thus LAs serve as pedagogical resources and as interpreters of and bridges to students. Research continues to confirm that the LA Model can accomplish the goals of positively impacting student learning, satisfaction and retention, but questions remain about *how* the LA model results in course transformation. We are currently examining the role of LAs in large enrollment STEM courses at three large state universities. Our goal is to characterize the activities that LAs engage in so that we can then examine how LA activities influence student learning. We used a modified version of the Classroom Observation Protocol for Undergraduate STEM (COPUS) (Smith et al. 2014) to quantitatively observe what LAs were doing during class (e.g. listening, lecturing, working with groups, interacting with other LAs). These observations took place three to five times per semester in lower division Biology, Chemistry, and Physics courses (2-3 courses per discipline per university). We also asked LAs to complete a daily course log for each course to capture what activities LAs engaged in during class using codes similar to the COPUS codes for LAs. Finally, we asked instructors and LAs to complete a one-time survey about the activities that occurred during the weekly Instructor-LA Team preparatory meetings. The three most common activities for LAs in a course were listening (over 50% of time), moving through groups, and one-on-one conversations with students. LAs in courses taught by faculty who had employed the LA model for two or more semesters spent more time moving through groups and engaged in one-on-one conversations than LAs who were in courses with first time LA faculty. LAs reported frequently to very frequently spending time engaging in reflection about past classes and preparing for future classes during their course team meetings. They reported that they occasionally to rarely spend time co-developing classroom activities. There was wide variation across courses with respect to how much LAs reported discussing their pedagogy course with each other and their content course instructor during preparatory meetings.

Abstract # 205 (Poster Sat # 32)
Using Metacognition Activities to Improve Higher Order Thinking Skills in Introductory Biology
Christelle Sabatier*, Santa Clara University

Students with strong metacognitive skills are aware of their strengths/weaknesses and of different learning strategies (metacognitive knowledge). They are also able to identify obstacles and implement appropriate learning strategies to increase their chances at success (metacognitive regulation). Metacognition is particularly important as students transition to courses requiring higher order cognitive skills (HOCs) where learning strategies associated with memorization are no longer sufficient. Students in introductory courses possess a range of metacognitive skills (Stanton et al, 2015) with some students being willing to reflect on their learning and recognizing that their learning approaches need to change but not having sufficient metacognitive knowledge to make those changes. In a first term freshman introductory physiology course, most students employed learning strategies targeting lower order cognitive skills (reading, flashcards…) and struggled with HOCs. I hypothesized that if students set learning strategy goals and reflected on those goals, they would be more successful in the course. To improve their metacognitive knowledge, students were exposed to a list of recommended study strategies that emphasized active learning and they practiced these strategies during class. Students completed an activity to calculate their success in answering HOCs questions on an exam (based on their exam score) and set new learning strategy goals. At the end of the term, students reflected on their success in meeting those goals. To determine the correlation between setting and achieving goals, I coded student goals as “higher order” if their learning strategy goals were associated with HOCs or “lower order” if they referred to reading, taking notes or memorizing. If students reported employing those learning strategies at the end of term, they were coded as “regulating” and if they did not meet their learning goals,
they were coded as "non-regulating". Students who set "lower order" goals were 30% more likely to achieve those goals (regulating). However, students who set "higher order" goals and achieved them (regulating) were 60% more likely to be proficient in higher order questions on the summative assessment (60% correct or better) compared to "non-regulating" students who had set "higher order" goals. Knowing what learning strategies to employ in conjunction with developing metacognitive regulation is necessary to maximize improvement in HOCs. I hope to use the results of this pilot study to design a more comprehensive analysis of the development of metacognitive regulation in introductory biology courses. I will discuss and seek feedback on my proposed study design.

Abstract # 206 (Poster Fri # 34)

Student perceptions of student-centered learning techniques in large introductory STEM courses at a non-traditional university

ERIN SHORTLIDGE*, PORTLAND STATE UNIVERSITY; Emily Olsen, Portland State University; Liz Griffith, Portland State University; Gwen Shusterman, Portland State University

In an effort to broadly improve STEM education and meet the nation’s goals of preparing a diverse and skilled STEM workforce, classroom use of student-centered techniques have gained momentum, with data generally supporting positive student outcomes. Inevitably, such techniques come in a spectrum of implementation styles, presumably impacting student outcomes. As part of a HHMI-supported effort to transform and evaluate introductory STEM courses (Biology, Chemistry, and Physics) at a large, non-traditional urban-serving public research institution, we continued use of already embedded active learning strategies, and implemented a newly developed strategy called Deliberative Democracy. As part of the first-year of evaluation of a multi-year intervention, we can begin to ask questions regarding how implementation style and technique may differentially impact student perceptions and outcomes of student-centered learning. Further we ask these questions of a non-traditional student population, adding an understudied dimension to biology education research. To explore this question we ask: What aspects of STEM courses influence students’ interest and learning of science, and how do students perceive student-centered learning techniques? For nominal extra credit, students in the introductory STEM courses participated in a previously validated survey aimed at quantitatively probing student motivation and science identity. At the end of the survey, two open-ended questions were asked of the students, here we report on those qualitative results. Using grounded theory, we identified themes in the open-ended responses regarding: 1) what influences student learning and interest in science (n = 452) and, 2) student perspectives on active learning techniques (n = 500). Through iterative effort, researchers reached >85% inter-rater reliability in coding student responses under the emergent themes. Preliminary results reveal that students generally credit: in-class activities for their learning and interest in science (41%), group-work (25%), and many discussed aspects of specific instructors (22%). Student responses to the second question revealed a diversity of perspectives on the techniques themselves, with generally positive perceptions of tools such as clickers (36%), but outwardly negative perspectives on techniques such as POGIL (27%). Interestingly, “group-work” was generally positive, yet some of the "group-work" was actually modified POGIL. These results reveal that how materials are presented matter. We also analyze these data related to student’s final course grades, course-type, and demographics. These results support the notion that the kind of student-centered learning implemented may distinctly influence student outcomes. There is much to learn from our non-traditional students regarding the impacts, both positive and negative, of our efforts to transform STEM classrooms to student-centered learning environments.
Abstract # 207 (Poster Sat # 44)

**Perfecting the flip: An exploration of preparatory activities for active learning**

Erika Offerdahl*, North Dakota State University; Noah Schroeder, Wright State; Christina Johnson, North Dakota State University; Phil McClean, North Dakota State University; Katie Reindl, North Dakota State University; Alan White, University of South Carolina; Eric Goff, University of South Carolina

Flipped approaches to undergraduate instruction, where content traditionally covered in class is provided to students before class, are attractive because they free up precious in class time for active learning activities. Currently, there is limited literature to inform best practices in “flipping”. The goal of this pilot study is to explore the efficacy of two treatments on student preparation for active learning. Students in an introductory cell biology course were randomly assigned to one of two instructional groups. Both treatments were provided with learning objectives and overarching conceptual questions related to a unit on meiosis. One treatment completed a learning module comprised of an animation of meiosis segmented with multiple-choice questions about the most recent completed video segment. The other treatment was instructed to watch the animation, but the multiple-choice questions were provided as a hand-out at the start of the animation. Pre and post test data were collected for each treatment. Both treatments engaged in the same active learning exercises on meiosis, completed an embedded assessment at the end of the active learning exercise, and completed a formal assessment one week later. This poster will present an analysis of the pre/post test data as well as overall performance on the embedded and delayed assessment.

Abstract # 208 (Short Talk Sun)

**Testing the ICAP hypothesis in a large lecture environment: Interactive activities lead to greater student learning gains than constructive activities**

Ben Wiggins, University of Washington; Sarah Eddy, University of Texas at Austin; Daniel Grunspan, University of Washington; Alison Crowe*, University of Washington

Although many studies have demonstrated the benefit of active learning over traditional lecturing (Freeman et al., 2014), there have been few studies that compare the relative effectiveness of different types of active learning approaches. Chi et al. has developed a framework for categorizing different learning tasks in terms of what students are doing when they complete a task (Chi 2009; Chi & Wylie 2014). As outlined in this “ICAP” framework, there are four levels of activity, ranging from most engaged to least engaged: 1) Interactive 2) Constructive 3) Active 4) Passive. Starting with passive, each subsequent category involves an increased level of activity, with the highest amount of learning predicted to come from Interactive activities. A number of studies in controlled laboratory settings lend support to the hypothesis that increased engagement is associated with increased learning. However, there is only limited support for the prediction that interactive activities promote higher student learning gains compared to constructive activities in a college classroom. In addition, no studies have explored whether the predicted benefits stemming from increased interaction are observed equally for different demographic populations. This study addresses the following questions: 1) Are interactive activities more effective than constructive activities at promoting student learning in a large introductory biology classroom? 2) Do different demographic populations respond similarly to these interventions? To address these questions we designed paired sets of in-class activities that differ only in their mode of student engagement: constructive or interactive. The activities were implemented in two different sections of an introductory biology course. Each student engaged serially in constructive and interactive activities on different topics enabling us to analyze student performance using a repeated measures approach. Demographic and student performance data were used to assess potential interactions between activity-type and student characteristics. We find that students who engage in interactive
activities are 1.25 times more likely to answer at least one additional question correct on an 8-question post-test (p=0.01), providing additional support for the ICAP hypothesis in an ecologically relevant setting. Likelihood ratio test results reveal that adding a main effect group, or interaction term between treatment and group, did not increase the fit of the model to the data for socioeconomic class (p=0.99), gender (p=0.33), or race/ethnicity/nationality (p=0.97). Thus, we find no significant evidence that the impact of completing an interactive instead of a constructive activity varied between student groups.

Abstract # 209 (Poster Sat # 52)
**What is evidence? How students support a main point from primary literature.**
Kirk Hepburn, Simon Fraser University; Emily Leaman, Simon Fraser University; Nienke van Houten*, Simon Fraser University

This investigation uncovers student approaches to reading life sciences primary literature. Personal, anecdotal (Spiegelberg, 2014), and systematic (van Lacum, Ossevoort, Buikema & Goedhart, 2012) observations suggest that undergraduate students follow a text-based reading strategy, and avoid making independent conclusions based on results and methodology. While the student process of deep vs. surface learning has been examined for several decades (Marton & Säljö, 1976), it needs more investigation into student practices of interpreting biomedical literature (van Lacum, et al.). In this inquiry, 9 novice (having read 3 papers or less) and 9 experienced (having read 10 or more papers) health sciences undergraduate students volunteered to demonstrate their reading approaches through a think-aloud interview, an answer to a written question in which they provided evidence to support the main points of an article, and a semi-structured interview. Student written responses to the question “find two main points of the article and identify supporting evidence for those points” were assessed for characteristics of evidence that students used to support the main points. We identified a spectrum of quality in the supporting evidence used by students. The extreme ends of the spectrum ranged from providing broad superficial descriptions to more desirable practices in which students made reasonable conclusions, and referred to specific figures and data points as evidence. Students in the middle of the spectrum made accurate conclusions, but the supporting evidence was not mentioned or they cited text-based evidence. Interestingly, some students cited figures as evidence but interpreted the figures incorrectly. In this session, we will discuss these results, and report an analysis from the interviews aimed at identifying reading behaviours that support desirable approaches to providing evidence. We will also consider how these data could be applied to interventions that will enhance student reading skills.


Abstract # 210 (Poster Sat # 33)
**Assessing the Impact of Metacognitive Review Sessions for Academically At-risk Students in a Sophomore Genetics Class**
Taylor McLean*, University of North Dakota; Steven Ralph, University of North Dakota; Chris Felege, University of North Dakota

Many students arrive on campus with an incomplete toolkit of good study habits and/or decision-making skills for monitoring their own learning. To address this concern, we undertook the
development, implementation and assessment of a teacher-driven academic intervention. Prior research has shown that the acquisition of advanced metacognitive skills and knowledge improves student academic performance across multiple settings and content areas. Therefore, we designed a series of metacognitive exercises to help academically at-risk students (grade of C, D, F or W) increase their performance in class. Our study was conducted in fall 2015 using a large enrollment (~200 students), sophomore-level Genetics course. We offered 12 weekly 50-minute review sessions, optional and open to all students, as a supplement to the regularly scheduled class times. The review sessions were divided equally into two parts: 1) presentation of metacognitive material; and 2) review of class material. Each session included a presentation introducing a metacognitive strategy, as well as an activity for students to learn how to implement the strategy in practice. During the semester, 59 unique students attended a total of 266 sessions combined, with a weekly average of 22 students. At the end of the semester, 41.2% of students in Genetics were at-risk. Among students who attended at least three review sessions only 10.5% were at-risk. This suggests that our recruitment procedures need refinement to appeal more effectively to at-risk students in the future. We analyzed the effect of the intervention on class performance as a case-control study where case students (n=38) attended at least three review sessions and control students (n= 76) did not attend any review sessions (groups matched for first midterm scores). Case students scored 84.0% on the first midterm and 83.2% on the final midterm (0.95% drop), compared to 83.4% and 79.1% (5.16% drop), respectively, for control students (p=0.063, one-tailed student’s t-test; effect size=0.287). Overall, these results suggest a modest positive effect from the academic intervention. To explore student motivations for attending review sessions and the perceived benefits, we conducted semi-structured interviews with ten case students. Common themes that emerged were: 1) the format of the review session was effective; 2) most students applied the lessons to Genetics; and 3) most students believed these skills would be transferable to other courses. We plan to offer review sessions again in fall 2016, expanded to an additional Biology course for non-majors, with an emphasis on improved recruitment of at-risk students. 131

Abstract # 211 (Poster Sat # 29)
The Sky is the Limit: development of a new learning community to increase Open Option student interest and retention in STEM disciplines
Jenifer Saldanha*, Iowa State University

The problems our world currently faces requires people who can excel in a variety of environments, and can incorporate multidisciplinary perspectives. Open Option students, students that have not declared a major, often have diverse interests and skill sets and are seeking ways to best utilize them. Our learning community, ‘The Sky is the Limit’, seeks to provide Open Option students with resources and a sense of community during their transition into college as they explore majors and career options. We developed this new learning community in fall 2015. Students could choose from four different learning teams: (Section 1). Save Planet Earth: A sustainability-themed learning community through which students participated in a monarch butterfly conservation service learning project; (Section 2). Helping People: The Healthcare Career Spectrum: Students learned about a multitude of health-related career options, including new or non-traditional professions; (Section 3). Seeking Solutions to the Challenges of Climate Change: Students explored the many facets of climate change, and worked in small groups to identify experts and organizations in the local and global community that deal with different aspects of climate change; (Section 4). Engaging Multidisciplinary Approaches to Today’s Problems: Through activities, guest speakers, tours, and discussions the students identified career paths that were well-suited to their skills and interests, possibly merging fields or adding a second major or minor. An overarching goal of the learning community involves engaging the students, making them aware of majors and related
multidisciplinary career options with a strong focus on the fields of science, technology, engineering, and mathematics (STEM). To gauge the effectiveness of our approaches we employed pre-semester and post-semester assessments to measure student attitudes towards and general awareness of STEM fields, their career decision making self-efficacy, work preferences and life goals, networks and connections, and their integration into the university and local community. As a long-term measure of community success we are also tracking student retention in STEM disciplines at the university. The results we are presenting will provide a comprehensive overview of the outcomes of these assessments. We aim to use the results from our assessments to improve and fine-tune our work so as to achieve maximum effectiveness in the learning communities. In the fall of 2016 we will be launching an additional learning team: (Section 5). Numbers Come to Life: This learning team will focus on the importance and applications of careers in mathematics, statistics, economics, and quantitative sciences.

Abstract # 213 (Poster Sat # 6)
Ecological Conceptual Knowledge of Science Majors: Progressions of Misconceptions
Angelique Troelstrup*, Middle Tennessee State University; Grant Gardner, Middle Tennessee State University

The purpose of this study was to investigate the ecological conceptual knowledge among undergraduate science majors over the course of an academic program. Misconceptions are defined as inaccurate explanations of phenomena constructed by students (D’Avanzo 2003). As biology students progress through their undergraduate programs, it is hypothesized that they develop deeper understanding of ecological concepts and a subsequent decrease in ecological misconceptions. To explore this hypothesis, ecological misconceptions of science majors enrolled in General Biology I, General Biology II, and Ecology were assessed at the beginning and end of the semester using a cross-sectional survey research design. Only students who completed all questions on the pre and post assessment were included in the final analysis. Additionally, graduate students were assessed to provide an upper bound on student understanding of ecology. Results showed a steady increase in scores as course level increased indicating a positive progression of conceptual understanding. Significant differences were found between all groups with the exception of General Biology II and Ecology F(3,65.83) = 28.48, MSE = 541.58, p < .001. Wilcoxon Rank-Sum tests revealed several items with an increase in student understanding. However, several items remained constant over time which further supported evidence that misconceptions are resistant to change throughout an undergraduate biology students’ career (Modell, Michael, & Wenderoth, 2005). This study provides an initial understanding of learning progressions of ecological misconceptions for science majors.

Abstract # 214 (Short Talk Sat )
Educator, Researcher, and Student Benefits Resulting from Embedding Metacognitive Practices Within Class Structure
Kelsey Metzger*, University of Minnesota Rochester; Brittany Smith, Minnesota State University Mankato; Paula Soneral, Bethel University

Metacognition plays an essential role in the learning process and is associated with being an effective learner, yet students often lack metacognitive skills. To investigate student metacognitive profiles, study habits, and perception of performance, a scaffolded and integrated approach was taken to intentionally incorporate regular student reflection about study habits and performance on summative assessments within the structure of biology courses at three undergraduate institutions. Our work has resulted in construction and validation of a research instrument, the Student Metacognition and Study Habits (SMaSH) survey, designed to elicit and
monitor aspects of student metacognition, study habits, and student evaluation of their performance on summative assessments. The instrument provides opportunities for instructors to incorporate metacognitive activities within the context of their course without large investment of class time or resources, is adaptable for use as a diagnostic tool, and is designed to be part of the normal assessment cycle in the course. In our validation study, student responses to items in three of the factors identified through principal components analysis – “Perceived Difficulty”, “Use of Learning Supports”, and “Study Habits” - show a predictive relationship with student performance metrics including the first exam of the semester, average exam performance across the semester, and overall performance in an introductory biology course, demonstrating the utility of the SMaSH instrument in predicting student success in a semester-long learning experience. Analysis from multiple student populations has found middle-performing students’ study habits, metacognition and perception of performance to be context-dependent. Middle-performing students also exhibit the greatest tendency to oscillate between over- or under-estimating their performance, and being surprised by their earned grades, although mid-range performers are capable of producing comparable-quality reflections on their assessments. Results further suggest that promoting student metacognition yields the greatest impact during the first half of the semester, with diminishing returns later in the semester. This could suggest complacency, end-of-semester fatigue, or some other phenomenon yet to be explored. This work is useful for educators who wish to cultivate a more intentional approach to reflection and metacognition in their courses, or to researchers interested in investigating aspects of metacognition in other student populations. In addition, our teaching has been informed and changed as a result of our research on student metacognition. Future investigations will include a closer examination of the role and impact of student demographic characteristics including gender, ethnicity, as well as other performance metrics such as ACT and incoming GPA.

Abstract # 215 (Poster Sat # 7)
GenBio-MAPS: A programmatic assessment to measure student understanding of core biology concepts across a general biology curriculum
Brian Couch*, University of Nebraska-Lincoln; Christian Wright, Arizona State University; Scott Freeman, University of Washington; Jenny Knight, MCDB; Katharine Semsar, University of Colorado, Boulder; Michelle Smith, University of Maine; Mindi Summers, University of Maine; Yi Zheng, Arizona State University; Alison Crowe, University of Washington; Sara Brownell, Arizona State University

The Vision and Change report provides instructors with a nationally agreed upon framework of core concepts that all undergraduate biology students should master by the time they graduate from college. Although establishing these learning outcomes was a critical first step, it is equally important that departments be able to assess student mastery of these concepts. To address this need, we have established a multi-institution collaboration to develop a suite of assessment tools (BioMAPS) that will measure student learning across a biology curriculum, focusing on the core concepts outlined in the Vision and Change report and further articulated by the BioCore Guide. These tools are designed to be implemented at multiple time points during an undergraduate curriculum, allowing departments to measure changes in students’ conceptual understanding as they progress through the major. Here, we present one of the BioMAPS assessments, the General Biology Bio-MAPS (GenBio-MAPS), which is aimed at assessing general biology students’ understanding of the core concepts of biology. Questions on the GenBio-MAPS assessment consist of a stem followed by 4-5 true/false statements. Students take a random subset of 15 questions from a pool of 39 possible questions to achieve widespread content coverage while minimizing test burden. Departments then pool data from student cohorts at specific time points to assess changes in conceptual understanding across
the curriculum. We followed an iterative process to develop the stems and statements, which included (1) revising based on student feedback from over 200 think-aloud interviews, (2) piloting a draft version to over 2,600 students at 10 institutions, and (3) incorporating expert feedback from 39 biologists. Our pilot of the final version is taking place during the spring and fall of 2016 and will include roughly 8,000 students from 14 institutions. We present the current status of the GenBio-MAPS assessment, including pilot results, and discuss the possible implementation of this assessment for biology departments across the country.

Abstract # 216 (Round Table Fri )
Investigating Effects of Graduated Engagement Tools and Hybrid Flipped Classroom Format on Student Success in a Large Diverse Introductory Physiology Course
Sarah Malmquist*, Stony Brook University; William Collins III, Stony Brook University

In order to meet the need for both a STEM-competent workforce, and a STEM-literate electorate, efforts must be made to increase retention and performance of students from groups historically underrepresented in STEM, including women, low-income students, and minority groups. Active learning strategies have been shown to narrow the achievement gap for such students, but the effects of specific strategies are relatively understudied. In addition, recent studies have shown improvements in student success in courses using alternative formats (e.g., flipped classes), although these gains may be due to the inherent inclusion of active learning, rather than a result of the flipped format itself. As part of a curricular shift toward active learning and increased equity in a very large (~1300), diverse introductory physiology course, we developed iterative scaffolded activities, called Graduated Engagement Tools (GET), to provide multiple points for student engagement during each week-long course unit through (1) online and in-class activities of increasing levels of Bloom’s taxonomy and (2) directed metacognitive exercises to promote student self-examination of strategies and motivations for learning. We will study their effects on student success outcomes in both traditional lecture and hybrid flipped classroom course formats. In Fall 2015, we offered concurrent traditional lecture and hybrid flipped sections of the course, and used the GET activities in the hybrid section only. Preliminary results suggest that hybrid section students had increased and sustained engagement with course material compared to the lecture students. We found no statistical difference in raw scores on common exams between sections, but did find a trend toward increased exam scores among low-achieving hybrid students; we plan to develop a model of predicted exam scores using linear regression analysis to make more accurate comparisons. In Fall 2016, we plan to implement the GET activities in both traditional lecture and hybrid flipped sections of the course, and to compare exam performance and failure rates between the lecture and hybrid sections offered in 2015 and 2016. We will assess the effectiveness of these strategies across students to measure differential effects on specific demographic groups, and any longitudinal effects on retention and success in upper division courses. We also plan to investigate the effect of the GET activities and course format on self-efficacy gains, using two validated instruments. Self-efficacy has been shown to correlate with academic success and retention, and is relatively low in students from groups historically underrepresented in STEM; preliminary analyses show differences in self-efficacy gains between students in Fall 2015 lecture and hybrid sections. We present examples of the GET activities, preliminary data on student outcomes, our strategy for managing the activities in a large classroom, and our data collection plan.
Abstract # 217 (Poster Fri # 35)

Does student cognition in problem solving match the intended cognitive level of a question?

Jenny Knight*, MCDB; Maggie Gannon, University of Colorado Boulder; Jennifer Avena, University of Colorado Boulder

Evaluating assessment items by difficulty level and cognitive level (Bloom’s Taxonomy) may help instructors understand whether students struggle on certain topics or with certain kinds of questions. Such evaluation is also important for aligning assessment items with learning objectives and ultimately improving student learning. Bloom’s Taxonomy has been widely used to categorize questions by the level of cognitive skill required. However, it is not known if students actually answer questions using the cognitive level expected by the instructor. Do students use shortcuts to answer a question, which we think is a higher-order question, at the level of understanding? Or, conversely, do they use higher-order skills to deduce the answer to an understand-level question when they don’t remember the facts? To answer these questions, we have conducted think-aloud interviews using a set of ten genetics and molecular biology exam questions previously rated by genetics faculty to be at Bloom’s levels 2-5. We first interviewed three teaching assistants of an undergraduate introductory genetics course (the “expert students”) to gauge question readability and capture expert student problem solving patterns. We then interviewed ten undergraduate students taking the same introductory genetics course (the “novice students”), paying attention to the skills students used, as well as their ability to correctly answer the question. We will be comparing four aspects of each question: the pre-assigned Bloom’s level of the question, the Bloom’s level the student is actually using to answer the question, the difficulty of the question (percent of students who answer the question correctly), and the learning goal the question addresses. Preliminary results suggest that the expert students more frequently used a matching cognitive skill level to that rated by genetics faculty than did novice students. Novice students were most effective in answering understand-level questions and often were unable to answer questions at the apply, analyze, and evaluate levels. Some novice students did use apply and analyze level skills in answering questions but obtained an incorrect answer. Additional interviews and analyses will be presented, with a focus on identifying patterns in students’ cognition and whether the cognitive level they achieve predicts a correct answer. Ultimately these analyses will help in writing better assessment questions and in helping students successfully solve problems.

Abstract # 218 (Round Table Fri )

How students interpret claims, analyze data, and link evidence to claims about carbon-transforming processes

Emily Scott*, Michigan State University

A Framework for K-12 Science Education identified eight essential practices for students to develop in order to form a cohesive understanding of science. In this study, we highlight how four of those practices, specifically formulating model-based explanations, interpreting and analyzing data, critiquing arguments from evidence, and asking questions are integrated when students engage in inquiry investigations. We build off previous work investigating how students engage in these practices to construct a revised and expanded learning progression framework that characterizes how these practices are connected as students’ reason about multiple carbon-transforming processes. We interviewed ten undergraduate non-science and science majors about hypothetical investigations focused on tracing matter in animal growth, plant growth, decomposition, and combustion. For each investigation we asked students to construct explanations about each phenomenon, interpret and analyze 2-3 conflicting claims about how matter moves through a system, analyze a data table about the same phenomenon, use the data to reevaluate the claims, and identify unanswered questions about the system. Additional
interviews with undergraduate and high school students will be conducted to further refine the framework. We developed a preliminary learning progression framework that contains five progress that directly link to the Framework’s essential practices: 1) Formulating explanations; 2) Interpreting and analyzing claims; 3) Interpreting and analyzing data; 4) Critiquing arguments with evidence; and 5) Asking questions. We describe three levels within each progress variable that characterizes students’ increasingly sophisticated reasoning strategies about inquiry investigations. Ultimately, this framework will offer a pathway illustrating the kinds of reasoning students engage in when constructing increasingly sophisticated, data-driven arguments about scientific processes and using evidence to evaluate scientific hypotheses.

Abstract # 219 (Poster Sat # 28)
**Institutionalizing Evidence-Based STEM Reform: Faculty Development Structures and Student Impact**
Rocio Benabentos*, Florida International University; Laird Kramer, Florida International University; Marcy Kravec, Florida International University; Julian Edward, Florida International University; Geoff Potvin, Florida International University; Kathleen Rein, Florida International University

The Collaborative for Institutionalizing Scientific Learning (CISL) is an HHMI-funded program to reform undergraduate science education at a large Hispanic-Serving public research university. CISL uses a multipronged approach to transform institutional teaching practices across science and mathematic disciplines. We will present program evaluation data on faculty and institutional development, and a quantitative analysis of the impact of the project on student success. CISL focuses both on supporting faculty change and promoting an institutional culture of evidence-based instructional strategies. The program established a Faculty Scholar model to expand the number of science and mathematics faculty using evidence-based practices and integrate effective measures of classroom learning into STEM courses. Through this program, faculty members apply and are selected to undertake a transformation of a STEM course of their choice and conduct an assessment of the impact of the reform on students. Scholars are provided with multiple resources to reform their courses including summer salaries, professional development, discipline-based education researcher support, and opportunities to develop manuscripts on their course transformations. Additionally, Faculty Scholars take part in regular meetings of a growing community of discipline-based education researchers. This project offers exciting opportunities in research of teaching practices and faculty change. We are particularly interested in investigating the program elements and support systems that encourage and promote faculty change, as well as the challenges faculty members face during course reform. Additionally, we are interested in the impact of faculty change on student performance, retention, and STEM degree completion. We will present qualitative evaluation data focused on the impact of the program at the faculty level. Additionally, we will describe quantitative work investigating the effect of the Faculty Scholar program on student performance metrics. This work will inform institutional mechanisms that aim to foster successful and lasting faculty change. *This work was supported by Howard Hughes Medical Institute (HHMI 52006924).

Abstract # 220 (Poster Fri # 55)
**A course-based undergraduate research experience on endocrine disruptors**
Hsiao-Ping Moore, Lawrence Technological University; Julie Zwiesler-Vollick*, Lawrence Technological University

Course-based undergraduate research experiences have emerged as a powerful tool to provide students with authentic research experiences in the teaching laboratory. These experiences have been shown to increase retention in science as well as improving student engagement.
We were also interested in ensuring that students experienced the process of research as well as a sense of ownership. We also wanted to provide students with a research experience which could improve their chances of being accepted for summer research experiences and/or graduate school. To create an authentic, course-based undergraduate experience, we chose to allow students to use a cell culture system to investigate the impact of potential endocrine disruptors. Endocrine disruptors are substances that interfere with hormone signaling in animals. Students were allowed to define their potential endocrine disruptor after surveying the literature. A wide variety of substances were chosen, including rice flour extract (potentially containing arsenic), e-cigarette liquid, deodorant, and water heated in plastic containers. Students then planned how to solubilize and sterilize their potential endocrine disruptor. Because some substances chosen were potentially cytotoxic, the students identified a non-lethal dose using a luminescent cell viability assay. Once a non-lethal dose was identified, students exposed human adrenal cells to their potential endocrine disruptors and collected the media. They used a competitive immunoassay to measure the amount of estradiol and/or testosterone present in the media. They compared cells exposed to the potential endocrine disruptors to cells which were not exposed and cells exposed to a known endocrine disruptor. The students were required to present their findings at a campus-wide research day poster session. Students took pre- and post-course surveys about the research experience and their attitudes toward science. Students also took course objective surveys related to specific learning outcomes for the course. Results of these surveys will be discussed. Keywords: Authentic research experiences, Laboratory Instruction, Science process skills

Abstract # 221 (opening Thu)
Insight into Student Thinking: Informing Instruction with the Automated Analysis of Constructed Response Assessments
Mark Urban-Lurain*, Michigan State University; Jenny Knight, University of Colorado, Boulder; Paula Lemons, University of Georgia; John Merrill, Michigan State University; Ross Nehm, Stony Brook University; Luanna Prevost, University of South Florida; Michelle Smith, University of Maine; Kevin Haudek, Michigan State University; Andrea Bierema, Michigan State University; Anne-Marie Hoskinson, Michigan State University; Rosa Moscarella, Michigan State University; Jill McCourt, University of Georgia; Matt Steele, Michigan State University; Alexandria Mazur, Michigan State University

Faculty who wish to respond to, and build upon, students’ thinking about key biology concepts must first know what and how students think about the concepts. Multiple-choice assessments are easy to administer, but cannot measure students’ abilities to organize individual bits of knowledge into a coherent explanatory structure. Writing is an authentic task that can reveal student thinking but is time-consuming to evaluate and therefore difficult to implement in large-enrollment, introductory biology courses. The Automated Analysis of Constructed Response (AACR) project is a large, multi-institutional collaboration that explores using computerized linguistic analysis to rapidly evaluate student writing in order to generate useful and timely feedback to inform instruction. AACR has two primary activities: 1) research-driven cycles of generating, testing, and implementing constructed-response (CR) questions and 2) Faculty Learning Communities (FLCs) that reflect on student learning challenges and ways to improve student conceptual understanding. We develop questions to assess critical concepts in biology that ask students to explain or predict a phenomenon. We then use a variety of computerized lexical analysis and machine learning tools to aid in qualitative analysis of the writing and create statistical models that predict expert rating of student writing, with computer:expert (human) as good as expert:expert inter-rater reliability (Cohen’s kappa >0.8). We use these models to generate reports for faculty that detail both scientific and alternative conceptions in their students’ responses. Reports present visualizations that identify common conceptual patterns in
student writing (thinking). AACR supports local FLCs at our participating institutions that administer AACR questions, meet to discuss and reflect on the results, and implement revised instruction. To expand the impact of our work, we are developing a web portal that will allow any instructor to select from available questions, upload their students’ responses to that question for analysis, and receive feedback reports about their students’ conceptual understanding. Our research has led to new insights into students’ struggles with key concepts, such as the fundamentals of metabolism and the flow of genetic information. In response, FLC participants collectively created new instructional materials to address student difficulties, with significant improvements in conceptual understanding. FLC participating instructors moved from asking “How many students got the right answer?” to reflecting on student thinking and modifying their instruction to address common learning challenges. In this talk, we will present: 1) the theoretic foundations for the automated analysis of writing, 2) an overview of how we develop AACR questions, 3) examples of the information AACR reports provide to faculty, 4) lessons learned about engaging faculty in evidence-based practices in the FLCs.

Abstract # 222 (Poster Fri # 63)
The Influence of Student Diversity on Social Network Formation
Paul Le*, University of Colorado Denver; Robert Talbot, University of Colorado Denver; Laurel Hartley, CU Denver; Amreen Nasim, University of Colorado Denver; Leanne Doughty, University of Colorado Denver

The Learning Assistant (LA) model has been adopted across the country to facilitate interactive engagement among students in undergraduate classes as a means to promote student success and satisfaction. There has not yet been substantial discussion of the impacts of the LA model on the interactions of diverse learners. We present a social network analysis that characterizes student engagement in an LA supported class as it relates to gender identity, race, first generation status, English language learner status, and employment status. We use these interactions as a proxy for interactive engagement and conceptualize the classroom community as a social network to help measure student engagement and identify discernible trends related to a student’s demographics. Data were collected in an approximately 250 person General Biology course in weeks 3, 8, and 13. Students were given a paper survey in class that asked students to identify individuals they talk to about classroom material. The survey also asked students to characterize those interactions in terms of the amount of time spent interacting with others and the value of the interactions. Additionally, students were asked demographic questions. Student response data were entered into a sociomatrix for analysis. This matrix is symmetrical, and denotes directional communications (“edges”) between individuals (“nodes”). Regression and community analyses were conducted using R. Our analysis of the in class networks at each time point show that the class level network is highly interconnected from early on in the semester. Density and other network characteristics did not change much in all surveys, even when edges were weighted by value. Community clique analyses show that students typically group by gender. Additionally, Asian-American students are more likely to group with other Asian-American students. This work reinforces that groups form early in the semester and that students are likely to form groups with others similar to them. Future analyses will include interviews to better understand a student’s experience with their interactions and how and why they choose who to interact with.
Abstract # 223  (Poster Fri # 36)

**Creation of an analytic rubric to evaluate content changes in students’ responses about the flow of genetic information**

Rosa Moscarella*, Michigan State University; Andrea Bierema, Michigan State University; Anne-Marie Hoskinson, Michigan State University; Jenny Knight, University of Colorado, Boulder; Karen Pelletreau, University of Maine; Luanna Prevost, University of South Florida; Michelle Smith, University of Maine; Matt Steele, Michigan State University; Kevin Haudek, Michigan State University; Mark Urban-Lurain, Michigan State University; John Merrill, Michigan State University

Our research group is investigating undergraduate students’ difficulties in understanding the flow of genetic information. We have analyzed several thousand responses to a constructed response (CR) question, adapted from the Genetics Concept Assessment that asks students to predict the effects of a mutation creating an early stop codon on the processes of replication, transcription, and translation. To evaluate student responses, we developed a computerized scoring model based on a holistic rubric. This model assigns a score to each response as completely correct, incomplete/irrelevant, or incorrect. Our results show that students from both lower and upper division biology courses, across five institutions in the U.S., struggle to respond correctly to this set of three questions. Faculty involved in Faculty Learning Communities at these five institutions created a classroom activity to help students improve their understanding of the processes involved in the central dogma of biology. After implementation of the activity in several courses, students were asked the same CR question, and we evaluated the responses using the same scoring model. Results showed a remarkable improvement in students’ performance. We are interested in investigating whether the quality, not just “correctness”, of students’ responses also changed after the intervention. Because students can display different degrees of knowledge, scoring the content of their answers as simply correct/incomplete/incorrect can be challenging. In response, we created an analytic rubric using an inductive approach. This analytic rubric evaluates the content of each response and focuses on the presence of both a claim and an explanation. This rubric makes it possible to characterize students’ responses in greater detail to reveal their alternative conceptions by simultaneously evaluating whether the claim is based on the molecular product (e.g. DNA) or the process (e.g., replication), and whether the students provide an explanation that supports the claim and if the explanation is correct. This information is relevant for researchers and faculty interested in better understanding students’ challenges to comprehend the flow of genetic information, and it would also be helpful for improving the instruction of this topic in biology courses at different levels.

Abstract # 224  (Poster Fri # 6)

**Connecting critical thinking skills to disposition in undergraduate introductory biology**

Amanda Sebesta*, Saint Louis University; Elena Bray Speth, Saint Louis University

Critical thinking (CT), a desired outcome of undergraduate science education, is characterized by the application of higher-order cognitive skills (HOCS: applying, analyzing, creating, evaluating) and the disposition to use these skills (Halpern 1998). While instruction, feedback, and assessment can be designed to promote HOCS’ practice and development, students’ inclination toward CT can impact success in implementing relevant skills. Individuals’ tendency towards CT may be attributed to stable, overarching traits, such as the need for cognition (NFC; Cacioppo and Petty 1982), defined as the engagement in and enjoyment of challenging cognitive tasks. Furthermore, students’ willingness to think critically and to elaborate on knowledge (CT/E disposition) may depend on the context of a particular discipline or course—for instance, introductory biology. We hypothesize that introductory biology students’ NFC and
CT/E disposition influence achievement on assessments requiring CT. We conducted this study in a large-enrollment introductory biology course for majors, where instructors implemented an active-learning, model-based pedagogy that engaged students with case-based problem solving, articulating explanations, and constructing conceptual models of biological systems. Students completed a survey that included the Need for Cognition scale (NFC) and the Critical Thinking and Elaboration subscales (CT/E disposition) from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al. 1991). High-stakes course assessments—three midterms and a cumulative final exam—included items designed to assess HOCS (model construction or interpretation, and two-tiered multiple choice questions that required students to explain their reasoning). We are analyzing the exam items requiring CT (models and two-tiered MC questions); student-generated models will be evaluated for the logical flow of biological processes and for the accuracy of the articulated relationships. The two-tiered questions will be scored for correctness of the selected answer and for the reasoning in selecting it. Analysis of the survey and exams will test relationships among NFC, CT/E disposition, and CT ability. In an instructional context that emphasizes CT practices, it is crucial to understand to what extent learners' dispositional characteristics influence their acquisition of, and fluency with, CT skills. This understanding will lead to more inclusive instructional design, aimed at closing achievement gaps that may be due to differences in students' inclination towards CT.

Abstract # 225 (Round Table Sat)
Investigating the role of motivation in students' understanding of complex biology concepts
Rosa Moscarella*, Michigan State University; Alexandria Mazur, Michigan State University; John Merrill, Michigan State University; Mark Urban-Lurain, Michigan State University

Motivation is important for learning. Younger students may have extrinsic motivation to perform well in a class, (e.g., maintaining a good GPA to apply to Med School); while more advanced students may be more interested in understanding and mastering a subject they may perceive as important for their future career (i.e., intrinsic motivation). Prior research suggests that motivation can have a positive effect on learning by increasing effort and persistence, and enhancing performance. We are interested in evaluating the influence of intrinsic motivation on student understanding of challenging concepts in biology. In our research investigating students’ difficulties understanding the processes involved in the central dogma, we conducted thirty-five semi-structured interviews with undergraduate students from seventeen majors in three different biology courses. During the interviews, students were asked about their study habits, their future plans, whether the biology class they took was required for their major and if they thought this class was going to be useful in their future career. We plan to evaluate the relationship between their performances in the class (e.g., final grade) and their understanding of the biology concepts as shown during the interview with their intrinsic, extrinsic, or lack of motivation. During the round table we would like to discuss with the audience the interpretation of some of the results and obtain suggestions about additional analyses or considerations based on our data.

Abstract # 226 (Poster Sat # 39)
Undergraduate Student Sense-Making during Modeling Activities
Andrea Bierema*, Michigan State University; Jon Stoltzfus, Michigan State University; Christina Schwarz, Michigan State University

National calls for reform in science education (e.g., Vision and Change, AAAS, 2011) emphasize the need to focus on disciplinary core ideas while using scientific practices during instruction. To meet this call, we implemented modeling activities in two large-enrollment undergraduate introductory biology courses. During the modeling activities, students worked in
groups of three during class for 30 to 75 minutes to create diagrammatic, mechanistic models of biological phenomena. We selected the phenomena of each activity from scientific press releases that students read before class. These modeling activities were intended to foster sense-making of biological phenomena since a key aspect of scientific modeling is the use of models to make sense of natural phenomena. In order to assess the extent to which students use these modeling activities to make sense of phenomena, we recorded student group discussion and screen capture as they developed their models on electronic tablets. We recorded groups during two activities in a non-biology majors course and two activities in a science majors course, totaling 16 recordings. For our purposes, we defined sense-making as students working to understand 1) what a component in the model is or does, 2) how components in the model work together to create a function, or 3) how the components interact within a system. While making sense of these concepts, students may use logic and previous knowledge, look for new information, review material, or ask for assistance. We discovered that students worked throughout each of these activities to make sense of the phenomena. For instance, one of the activities modeled three scenarios: 1) how cell signaling caused by growth factors triggered cell division, 2) how a mutation in a G-protein caused cell signaling to continue without growth factors, and 3) how a drug that attaches to mutated G-proteins prevents uncontrolled cell division. During this activity, students worked to make sense of the key concepts of the model: what the differences were across these three scenarios, how the G-protein functions, and how the drug works. Overall, we found that these modeling activities offered students opportunities to work together in order to make sense of biological phenomena. This presentation will describe in more detail how we coded for sense-making and examples of sense-making from these activities.

Abstract # 227 (Short Talk Fri)

Building learning agendas and evaluating undergraduate research accomplishments using PLURIS (Purposeful Learning in Undergraduate Research and Independent Studies)

Kathy Williams*, San Diego State University; Brock Allen, San Diego State University

The PLURIS process aims to improve cost-effectiveness, academic consistency, and auditability of undergraduate STEM research and independent study activities (URISs) by helping faculty and students design experiences that clarify purposeful learning. We propose this process can be applied to various independent studies, like research projects within courses, internship activities, and supervised lab- or field-based research projects. STEM faculty and administrators often consider credit-bearing URISs as complementary to didactic instruction. Yet expenses and time required to select and supervise students is growing prohibitive. Additionally, accreditors desire explicit learning outcomes, alignment, and assessment of these experiences. PLURIS can provide descriptions of rich URISs with outcomes that can be evaluated by curriculum committees, accreditors, and potential employers, similar to traditional courses. This project aims to help faculty and students: elucidate opportunities for learning in host projects and to recruit students; align individual student learning agendas with goals of faculty or institutional requirements; clarify intended student learning outcomes; and use clear assessments to monitor and document actual learning. Using an online survey, PLURIS queries student work preferences and builds learning agenda by linking with an online database tool, the Occupational Information Network (O*NET; http://www.onetcenter.org), the nation's primary source of occupational information. The PLURIS Student Profile Builder challenges students to explicate work-related values, interests, and activities, as they answer approximately 60 items. Using O*NET, students are guided to describe capacities they wish to develop within their learning agenda. Finally, the Profile Builder emails students a report of their responses they can share with academic advisers, peers,
parents, and use in preparing applications. A primary outcome of PLURIS is to provide evidence that URISs merit academic credit, an issue educators face. We predict that students who clearly describe capacities gained in URIS experiences will be judged as having more valuable experiences than students who simply describe their procedural activities. If so, then we should help students clarify and personalize learning agendas by identifying the capacities they intend to, and do, acquire. To test this prediction, over 200 student and 20 faculty and graduate research mentors have completed surveys rating their perceptions of hypothetical student descriptions of projects and accomplishments. Initial results from students and mentors supported the prediction above, with one interesting difference in how they communicate to different audiences. Hopefully this encourages students and faculty to use the PLURIS system to build learning agendas, both to improve recruitment of students and recognition of learning accomplishments.

Abstract # 228 (Poster Fri # 37)
**Investigating Undergraduate Students’ Use of Intuitive Reasoning and Evolution Knowledge in Explanations of Antibiotic Resistance**
Melissa Richard*, SFSU

Natural selection is a central and critical concept throughout biology; however, it is also a process frequently misunderstood. Bacterial resistance to antibiotic medications provides a contextual example of the relevance of evolutionary theory outside of a biology classroom and is also commonly poorly understood. While research has shed light on common student misconceptions of natural selection, minimal research has focused on the degree to which misconceptions may be based in intuitive, deep-seated cognitive patterns rather than in the complexity of evolutionary concepts themselves. These intuitive patterns are studied in the field of cognitive psychology as informal assumptions developed at an early age to make sense of the world (Coley and Tanner 2015). In this study, we investigated undergraduate students’ application of three modes of intuitive reasoning — teleological, essentialist, and anthropocentric thinking — to the concept of antibiotic resistance. To what extent do students embrace misconceptions, and to what extent is intuitive thinking evident in student responses? Does acceptance of misconceptions correlate with intuitive reasoning? To investigate these questions, we created a novel assessment tool designed to probe students’ understanding of natural selection and application of intuitive reasoning framed in the context of antibiotic resistance. Responses were collected from 484 students representing non-biology majors (n=58), entering biology majors (n=319), and advanced biology majors (n=107), as well as from biology faculty (n=14). Participants were asked to provide a written explanation of antibiotic resistance and then agree or disagree with three misconception statements, explaining their reasoning. Presented here are four key findings: 1) Approximately 50% of students in all populations produced misconceptions and language evidencing intuitive reasoning unprompted. 2) When presented with misconceptions hypothesized to be rooted in intuitive thinking, over 94% of all students agreed with one or more of these misconceptions. 3) Over 90% of students used at least one instance of intuitive thinking in their written responses to misconceptions. 4) Most strikingly, chi-squared analyses showed significant associations in all student populations between acceptance of a misconception and production of the hypothesized form of intuitive thinking (all p ≤0.05). The associations between intuitive thinking and misconceptions elucidate ways in which inaccurate biological ideas may persist even throughout formal biology education. Since the language of intuitive thinking may represent a subtle but innately appealing verbal shorthand in conveying concepts, instructor awareness of how intuitive thinking could fuel student misunderstandings can inform evolution educators’ addressing of persistent misconceptions.
Investigating Instructor Talk in Community College Biology Classrooms
Tiffy Nguyen*, SFSU; Shannon Seidel, Pacific Lutheran University; Kimberly Tanner, San Francisco State University

Instructors have the significant responsibility of not only teaching coursework, but also structuring a safe and accessible learning environment. Evidence shows that how an instructor frames an assessment can affect student performance, and evidence also suggests that student learning can be affected by instructor immediacy, the perceived closeness a student feels to their instructor. One previous study has investigated and characterized Instructor Talk, the non-content related language instructors use to shape learning environment, in one 4-year university introductory biology classroom (Seidel et al, 2015). Although Instructor Talk was utilized in this classroom, to what extent is it utilized in other classrooms? We aimed to investigate the prevalence of Instructor Talk in community college biology classrooms and to discover whether new categories of Instructor Talk arose from this dataset compared to the previously described study. To accomplish this, eight community college biology instructors recorded audio from every class session for the span of one term, averaging 27.4 ± 2.1 hours (16.5-33.9) of recording. Audio was analyzed for instances of Instructor Talk, then coded into categories and subcategories characterized by previous research. If a statement did not fall into one of the previously described subcategories, new subcategories were developed using a grounded-theory approach similar to the former framework. Strikingly, all eight instructors utilized Instructor Talk, with an average of 15±3 (1.3-18.8) quotes/hour. First day of instruction had the highest or second-highest rate of Instructor Talk. Building the Instructor/Student Relationship was the most prevalent category found, present in 87±8% (36-100%) of class sessions, and Unmasking Science was the least prevalent category found, only in 23±8% (0-74%) of class sessions. A new subcategory of Instructor Talk was discovered: Fostering Wonder in Science. In addition, non-productive Instructor Talk emerged, including quotes that could be perceived as disrespecting students, discouraging community among students, or using convenience to drive pedagogical choices. All instructors used non-productive Instructor Talk, with an average of 1.2±0.5 (0.2-4.1) quotes/hour. We observed a trend that instructors with higher rates of productive Instructor Talk were also more likely to have higher rates of non-productive Instructor Talk. These findings demonstrate that Instructor Talk is widely present in community college biology courses and describe first instances of non-productive Instructor Talk. Instructor Talk is a specific tool instructors can use to structure classroom environments. It may potentially mitigate Stereotype Threat, increase Instructor Immediacy, and/or decrease Student Resistance to active learning techniques.

Beginning to Explore the Effect of a Relevance Intervention to Reduce Achievement Gaps in Introductory Biology
Sy Truong*, Cal Poly Pomona; Paul Beardsley, Cal Poly Pomona

Short-term, targeted psychological interventions can have a dramatic effect on lowering the achievement gap by improving achievement, especially for disadvantaged groups. Research shows that relevance interventions (especially utility value) can increase the value component of motivation, thereby increasing academic achievement. Our on-going study is being conducted at a large, public university. The student body is 59% women, 54% are first generation (FG) college students, 45% are underrepresented minorities (URM); 37% Hispanic, 27% Asian, 19% White, 3% Black and < 1% others. Achievement gaps exist among URM vs. non-URM (Cohen’s d = .29), gender (d = 0.22), and FG vs. continuing (d = 0.26). Our research question is: To what extent does a short-term relevance intervention affect achievement gaps among disadvantaged groups? We conducted a pilot study in the first introductory course for Biology majors. We
recorded pre-course preparation in biology using a questionnaire based on high school standards. Participating students were randomly assigned to a treatment or control group. The control condition asked students a series of questions about how they participate in the course. In the treatment condition, students read five quotes and ranked them by those to which they best relate and described the reasons for their ranking. We collected data in a pilot study during one quarter (N=196) to develop a survey administration protocol, test the usefulness of our recruitment, and to explore the impact of the intervention. The pilot study involved administering one of the two interventions we plan to use in a full study. Our recruitment methods were effective (88% participation) and the survey platform worked well (162 / 173 reported no problems). We obtained students’ final course points and demographic data. Preliminary analyses involved standardizing students’ total points (z-scores) and calculating effect sizes for mean differences of groups with unequal sample sizes with a pre-post-control design. We found a trend toward the relevance intervention increasing students’ final points in the course for the treatment versus the control group overall (dppc2 = 0.14), FG students (dppc2 FG = 0.33, dppc2 Continuing = -0.01), and students with low and high expectancies for success (dppc2 low = 0.24, mid =0.06, high = 0.24). The ten minute intervention reduced the achievement gap by 55% for FG students and 33% for students with low expectancies for success. Our preliminary findings support that this motivational intervention has promise, however, differences between treatment and control were not significant in initial analyses (p>0.05).

Abstract # 231 (Poster Fri # 38)
Variation in active learning environments: What are instructors doing when they FUp (Follow Up)?
Erika Offerdahl*, North Dakota State University; Melody McConnell, North Dakota State University; Jeff Boyer, North Dakota State University; Lisa Wiltbank, North Dakota State; Jennifer Momsen, North Dakota State University; Rachel Salter, North Dakota State University

With the growing acknowledgment of the efficacy of active learning has come an increased interest in understanding the conditions under which variations of active learning work, and for whom. The COPUS is one observation instrument that measures instructor and student behaviors. It has been used to categorize instruction into one of ten different profiles, the collection of which represents a continuum of reformed teaching practice ranging from lecturing with slides to collaborative learning in small groups (Lund et al. 2015). Instructors with profiles more consistent with active learning spend more time on "follow up" activities (coded as FUp on the COPUS) and less time lecturing than instructors with more traditional profiles. Though active learning has demonstrated advantages over traditional, not all active learning instruction is equal. Indeed, Andrews et al. (2011) documented cases in which active learning does NOT produce significant differences in student learning. We hypothesized that the ways in which an instructor follows up on student learning (FUp) is an important contributor to the effectiveness of active learning. This hypothesis is grounded in the literature on formative assessment, which emphasizes the role of instructor feedback (a type of follow up) on student learning. The goal of this pilot study was to explore how instructors with similar COPUS profiles follow up (FUp) after eliciting evidence of student understanding (i.e. posing formative assessment prompts) in active learning environments. The COPUS protocol was applied to video-recorded observations, and instructors with similar COPUS profiles were identified. We then applied a modified version of the ESRU formative assessment framework (Ruiz-Primo & Furtak, 2006) to analyze 6-9 video recordings of each instructor. The modified ESRU allowed us to (a) identify when instructors followed up (e.g. after clicker questions, after verbal questions) and (b) distinguish the ways in which they followed up (e.g. explore student reasoning, clarify a student response). Preliminary findings indicate variability not only in the types of follow-up activities used by instructors with similar COPUS profiles, but also distinct patterns between instructors in how they elicit and
follow up in class. This work is part of a larger study seeking to empirically document the link between formative assessment practices and student learning. As such, these data are a first step in determining how variation in the enactment of active learning translates into variation in the efficacy of active learning.

Abstract # 232 (Poster Sat # 34)
**Undergraduate Students Perceptions of Performance in Relation to Metacognition**
Brittany Smith*, Minnesota State University Mankato; Paula Soneral, Bethel University; Kelsey Metzger, University of Minnesota Rochester

Metacognition plays an essential role in the learning process and is associated with being an effective learner, yet students often lack metacognitive skills. This study examines relationships between students’ perceptions of and performance on exams, aspects of metacognition and study habits in a large enrollment non-majors introductory biology course. Students completed an instrument designed to measure metacognition and study habits (SMaSH) after completing lecture exams then completed a post-assessment reflection after learning their exam score. The instruments used were tied to assessment and implemented at multiple points within the course. The results show a significant positive relationship between postdicted and determined exam scores. Students significantly over predicted their performance on the first and third exam but not the second and were most accurate in predicting their score for the second exam. There was a significant difference in student responses in regards to content difficulty and whether students planned to adjust their study habits. More students indicating the content was difficult as the course progressed while more students disagreed that they planned to adjust their study habits in preparation for future exams. Although fewer students indicated they planned to adjust study habits as the course progressed, of those who did, the majority responded that they followed through in their adjustments on the next exam. High-performing students significantly under-predicted their scores while low-performing significantly over-predicted their scores on all exams. Low- and middle-performing students were not different in their predictions but they were significantly lower than the high-performing students. Middle-performing students were the only group to show significant improvement in their accuracy to predict exam scores, but then relapsed as the course continued. High-performing students were significantly more likely to indicate their study habits were effective on both the SMaSH and post-assessment reflection. This study provides insight into student metacognition and study habits, as well as the discrepancies that exist between student perception of performance and actual performance on exams, and also provides a model of coupling instruction and assessment with metacognitive reflective exercises.

Abstract # 233 (Poster Fri # 39)
**Assessing Learning Style Diversity as a Potential Key to Student Success in Biology**
Carol Chaffee*, California State University Fullerton; Merri Lynn Casem, California State University Fullerton

While numerous studies have examined the correlation between student learning styles and academic success, less is known about the relationship between learning styles and academic success in various disciplines. As faculty directly involved in efforts to improve student success in introductory biology courses, we were interested in the relationship between student learning styles and success in biology. Preliminary data gathered during a limited pilot project suggested that patterns existed in the first semester of the introductory biology course for majors. The current project focused on three related aspects of this broad question: 1. Did student learning styles show a pattern related to success in: a. Introductory biology courses for majors? b. General education biology courses for non-majors? c. Upper-division biology courses for majors? 2. How did these patterns compare? 3. Could a predictive model be developed that
relates learning style to potential success in a biology course? To evaluate learning styles, we used the Index of Learning Styles Questionnaire (ILSQ) developed by Solomon and Felder at North Carolina State University. Students in the targeted courses were offered a small amount of extra credit for completing this online questionnaire, and submitting their results page. This instrument uses student preferences to develop a learning styles profile that separates eight dimensions into four scales: active-reflective, sensing-intuitive, visual-verbal, and sequential-global. Academic success was evaluated based on final grade in the course. All data were entered into R for analysis and model development. Our results found similar patterns in the relationship between learning style and academic success for all introductory students. No significant differences between the majors and non-majors courses were found. Distribution of results along the four axes of the ILSQ model was skewed toward the sensing, visual, and sequential dimensions, whereas students with preferences closer to the mid-range of the active-reflective scale tended to be more successful in these biology courses. These findings have implications for pedagogy, since they suggest that students will be more successful in courses that emphasize facts (sensing) presented in a logical order (sequential) using many pictures and diagrams (visual), with activities and assessments balanced between application (active) and evaluation (reflective) of knowledge.

Abstract # 234 (Short Talk Fri )
Fostering Change from Within: Science Faculty with Education Specialties (SFES) Influence Teaching Practices of Departmental Colleagues
Kathy Williams*, San Diego State University; Seth Bush, California Polytechnic State University, San Luis Obispo; James Rudd, California State University, Los Angeles; Michael Stevens, Utah Valley University; Kimberly Tanner, San Francisco State University

On an international scale, calls for the improvement of science education are frequent and ardent. At the same time, the phenomenon of having Science Faculty with Education Specialties (SFES) within post-secondary science departments appears to have grown. To investigate both the SFES phenomenon across the United States, and SFES perceptions of their professional impact in science education, we conducted an in-depth interview study among a randomized, stratified sample of 50 U.S. SFES across a variety of US higher education institution types and science disciplines. Previous investigations of SFES have primarily employed online survey methods to investigate large numbers of SFES and attempt to include diverse perspectives. Here, the research design was purposefully interview-based, using a mixed methods approach to data analysis, to explore experiences of a subset of SFES and to share their insights using their own words. Interview transcripts were analyzed using constant comparative methods and a grounded theory approach. When appropriate, Pearson’s chi square tests were used to compare subpopulations of SFES. Quantifying the proportion of SFES reporting impacts in the three arenas of science education we discovered that 82% of SFES interviewed reported professional impacts in the realm of improving undergraduate science education, especially by influencing the teaching practices of their departmental colleagues. Those perceived effects on improving undergraduate science education significantly surpassed reported impacts on research in science education (reported by 62%) or on K-12 science education (reported by 50%). Six emergent themes of undergraduate science education impacts were identified: influencing faculty teaching practice, changing curriculum, supporting teaching assistants, contributing to academic assessment, fostering involvement of undergraduates in research, and promoting student diversity and retention. Although SFES reported those diverse efforts to improve undergraduate science education, by far the most prevalent reported impact was influencing the teaching practices of their departmental colleagues (reported by 62%). The majority of SFES appeared to have impacts on undergraduate education as local change agents. Key to facilitating change within departments
may be that SFES often are like other scientists in their departments, being faculty with research programs and skills and knowledge that support departmental goals for instructional improvement and change. Since colleges and universities continue to hire science faculty with little training in effective science teaching, these results indicate how the seeding of science departments with disciplinary faculty who specialize in science education holds promise for fostering change in science education from within biology, chemistry, geoscience, and physics departments.

Abstract # 235  (Poster Fri # 7)
Examining the relationship between student success and view of biology based on measures of urbanicity
Brittany Smith*, Minnesota State University Mankato; Kyle Mullen, MSU Mankato

There currently is opposing evidence about the impact of a rural and urban educational settings on student education. Even though research has examined rural and urban education, studies have not thoroughly investigated the relationship between rural and urban settings with student views and attitudes, their perception of preparedness in relation to their rural/urban settings or with how rural/urban classification is related to academic performance in college. The main research objective of this study was to utilize geospatial analysis to examine student academic performance and their views and attitudes towards college and biology in relation to urbanicity in a non-majors introductory biology course. Students’ academic performance and permanent home address were obtained and a subset of participants completed a survey designed to elicit their views related to stereotype threat, biology, high school experiences, information about urbancity, and demographic information. Preliminary results show a significant negative relationship between lecture exam score and population density with student’s performance increasing as population decreased. There was a difference in academic performance between males and females based on whether students lived within or not within city limits, with males performing significantly better than females. Similar results were found when examining whether students who lived in rural, urban clusters or urbanized areas with rural males performing significant better than rural females. In addition, there were significant differences in students’ views or attitudes related to biology based on measures of urbanicity with significantly more students in rural settings disagreeing that being successful in college is related to how smart you are while more students from rural settings were confident in their ability to be successful compared to students from urbanized area or urban clusters. There were not significant relationships between academic performance and demographics measures (sex, year in school, age, race/ethnicity etc.). This study provides preliminary data in the investigation of issues related to rural-urban classification. Although, the rural-urban dichotomy is complex this study aims to relate measures of urbancity to students’ views of biology and academic success in a non-majors introductory biology course.

Abstract # 236  (Round Table Fri )
Facilitating the Development of Science Literature Identification and Evaluation Skills in Undergraduate Biology Students
Sayali Kukday*, Iowa State University

The importance of information literacy in college students is emphasized by findings that there is a discrepancy between students’ perception of their ability to locate credible scientific sources and their actual ability to do so (Maughan, 2001). The transition from library catalogs to online databases has exacerbated the problem especially since this skill is emphasized even in the high school curriculum (Julien and Barker, 2009). Science faculty view information literacy as important feature of undergraduate research experiences (Lopatto, 2003). As a result, significant efforts have been made to facilitate the development of these skills in students in...
advanced biology courses (Wright and Boggs, 2002; Porter, 2005; Flasphler et al., 2007), but to a lesser extent in introductory courses (Porter et al., 2010). Incorporating approaches to foster the development of these skills earlier on within the undergraduate curriculum is essential, since consistent engagement in the practice of these skills is not only an important aspect of training students to become scientists, but also to be informed consumers of scientific information. This study is being conducted within the context of a large-enrollment undergraduate introductory biology course. Students work in teams on a semester-long project with the goal of creating a poster with information derived from peer-reviewed science journals on a topic of interest to them. Our research question is currently focused on assessing the effect of the team project on the development of Science Literature Identification and Evaluation Skills (SLIES) in students. Student responses to questions about scientific literature were collected pre- and post- semester for two consecutive semesters. We are currently using qualitative coding methods (Saldana, 2009) to analyze the data and identify themes that emerge. This study will inform the design and implementation of effective strategies to facilitate the development of these important literacy skills in introductory biology students with implications for the broader undergraduate curriculum.

Abstract # 237 (Round Table Fri )

Using a flipped design for learning in a large-enrollment biochemistry course to help students appreciate the role of creativity in scientific inquiry

Isabelle Barrette-Ng*, University of Calgary

Formulating research questions and proposing hypotheses are highly creative skills that few students learn through lecture-based high-enrollment courses. This is a serious problem, because a lack of understanding of the critical importance of creativity in scientific inquiry leads many students to undervalue the role of creativity in scientific discovery. As a result, there is a clear need to develop new strategies to help students grasp the critical importance of creativity and other higher level cognitive skills like problem solving and critical thinking to scientific inquiry. To meet this challenge, we hypothesized that flipped learning approaches could provide rich, new opportunities for students to develop a greater appreciation of the role of creative skills in scientific inquiry (Bergmann and Sams, 2014). To assess the effectiveness of this strategy, we are conducting a research study that compares cohorts of students who have been exposed either to a flipped design or a lecture-based approach. Using previously validated surveys, we assessed understanding of scientific inquiry (Lederman et al., 2014) and basic content acquisition (Villafane et al., 2011); in addition, we conducted end of term focus groups. Some of our key, initial findings include improvements in both content acquisition and a greater understanding and appreciation of the importance of creativity in the process of scientific inquiry. We report on our preliminary results from this ongoing study and discuss ways in which other high-enrollment courses in biology may be able to foster the development of creative problem solving. Most surprisingly, we find that a more highly structured learning environment seems to provide the most supportive environment to allow students to become more creative.

Abstract # 239 (Poster Fri # 11)

**Studying the communication and teaching of biotechnology at a land-grant university**

Brittany Anderton*, UC Davis; Pamela Ronald, UC Davis

Abstract: Biotechnology is commonly used in innovations ranging from agriculture to medicine. However, some biotechnology applications are unfavorably viewed by the public. Thus, effective communication and education strategies are needed to improve public acceptance of these beneficial technologies. In this case study, we have tested whether peer-led instruction in a Genetics and Society course at a large, land-grant university affects student positions on several biotechnology applications. We have also used frame analysis to understand how students justify their positions. We found that peer-led discussion resulted in significant position changes for two of seven biotechnology topics (Sign test, p < 0.0001). Further, we identified common frames that changed following discussion of four topics, regardless of whether student positions also changed. We conclude that peer-led, science-informed discourse is effective at changing student opinions for some biotechnology topics. The common frames we identified may help undergraduates develop a more complete understanding of biotechnology’s benefits to society. A second focus of our research is the establishment of a tool that enables biotechnology researchers to provide crowd-sourced, post-publication review of mainstream media accounts of biotechnology. The long-term research goal of this tool, Biotech Feedback, is to identify scientifically credible (and non credible) news articles for semantic network analyses. Additionally, Biotech Feedback will be publicly available for use in science communication and journalism education.

Abstract # 240 (Poster Sat # 45)

**The effectiveness of Interactive Video Vignettes as tools for teaching and for insight into student thinking**

Jean Cardinale*, Alfred University; Dina Newman, RIT; Kate Wright, Rochester Institute of Technology; Robert Teese, Rochester Institute of Technology

Interactive Video Vignettes (IVVs) are a new genre of web-based learning tools that employ live-action and real-world settings familiar to a wide range of biology learners. IVVs are an innovative medium that engage users by incorporating prediction questions, data analysis and comprehension questions in an engaging and accessible way. IVVs use principles of cognitive learning theories such as elicit-confront-resolve and constructivism to support deep learning of core concepts in biology. We are developing a set of high-quality online educational materials that promote active, hands-on science learning to aid in teaching of core concepts for introductory biology at the college level. The ultimate goal of this project is to incorporate each IVV into a Module for Interactive Teaching (MINT) of biology concepts. This work details testing the effectiveness of IVVs as teaching tools in several different classroom settings and also in think-aloud interview sessions. The research group created and revised multiple select style assessment questions that aligned with the learning goals covered in each IVV. These questions were used as a way to measure learning gains pre/post IVV. We tested the effectiveness of the IVVs in several different classroom settings: Three IVVs each were tested in 2 semesters of Biological Foundations (N=115 students) and in Cell Biology (N=48 students) courses at a small, private rural college. We also tested seven IVVs in an honors-level Introduction to Biology course (N=24 students) and three IVVs were tested in a non-honors level Introduction to Biology course (N=43) at a large, private comprehensive institution. In addition, think-aloud interviews (N=21) were conducted with undergraduate STEM students in order to capture student thinking and ideas brought up in the IVV. Results demonstrated that IVVs can lead to learning gains, and students enjoy the experience. Deep analysis of the multiple select questions revealed parts of the IVVs that were most effective but also revealed areas in which
students still hold incorrect ideas. For example, the term “dominance”, in the context of genetics, was still problematic for students even after watching an IVV designed to help students grasp essential concepts in genetics. Analysis of the results also revealed interesting ideas that students hold and helped shed light on topics that give students particular difficulties. Results from this analysis will be used to develop the in-class activities and instructor notes that, in addition to the IVV, will comprise a complete MINT.

Abstract # 241 (Round Table Sat )

**Faculty Professional Development for Inclusive STEM classrooms**

Tess Killpack*, Wellesley College

As access to postsecondary education rises, the demographic profiles of degree-granting institutions are slowly coming to reflect those of the country as a whole. Private and public policies are increasingly aimed at broadening participation of a diverse body of students in higher education in general, and STEM in particular. As colleges and universities increase compositional diversity, they must also ensure that they cultivate intellectual and social environments where all students have the opportunity to achieve academic success. Positive classroom climates and teaching practices have been shown to improve academic and emotional development, as well as persistence, among diverse college students interested STEM fields. However, there is often a paucity of meaningful faculty professional development surrounding our personal roles in creating inclusive classroom environments. We designed a professional development workshop for graduate students, postdocs, and faculty focused on inclusive excellence in the STEM classroom. The focus of the workshop was on faculty privilege, implicit bias, and cues for stereotype threat that we all bring to the classroom. The workshop included activities related to examining our own privileges and unconscious biases as instructors, and how they may influence our course design and interactions with students. We also presented data regarding stereotype threat interventions, growth mindset, and other approaches that increase student performance and retention in the sciences. Finally, we provided time for participants to engage in guided group work to brainstorm changes related to their course design (e.g. office hours, grading criteria, number/types of assignments) and classroom culture (e.g. nature of in-class activities and student-student interactions). The workshop was interactive and participants left with implementable strategies as well as increased awareness of their responsibilities as instructors. We feel that this workshop could be modified/implemented to serve the needs of many STEM departments and career development programs for faculty, and we aim to assess the impacts of the workshop on STEM faculty participants, as well as the students who they teach.

Abstract # 242 (Poster Fri # 40)

**Development of a Biological Science Quantitative Reasoning Exam**

Paul Overvoorde*, Macalester College

Multiple studies link insufficient mathematical preparation to the failure of beginning undergraduates to persist in STEM-related degrees. In addition, the increased use of quantitative methods in the biological sciences has prompted calls for introductory undergraduate biology courses to reflect this shift in order to ensure the persistence of students from a variety of backgrounds. This paper defines a tool to support such innovation. We describe the development and piloting of a freely available, selected-response assessment instrument to measure the quantitative skills of undergraduate students within a biological context. The Biological Science Quantitative Reasoning Exam (BioSQuaRE) arose from the collaboration of individuals at eight institutions with the goal of addressing three distinct audiences. Frst, the instrument communicates to entering life science students their domains of quantitative strength and weakness. Second, the output from the instrument provides data to
faculty on what students do and do now know. Finally, at a programmatic level, the BioSQuaRE makes explicit the quantitative skills that biology instructors consider important and provides a framework to assess curricula across departmental boundaries. We describe the motivation behind this work, detail the process of developing the BioSQuaRE instrument, and provide qualitative and quantitative evidence (CTT, score reliability, and IRT analyses) for the validity of the inferences made from the BioSQuaRE. Finally we discuss the potential uses of the BioSQuaRE in understanding the quantitative preparation of life science students and invite others to use this instrument at their own institutions.