SABER 2020 Short Talk Abstracts Friday July 24th

Time: 1:00-1:20 PM EDT • 12:00-12:20 PM CDT • 11:00-11:20 AM MDT • 10:00-10:20 AM PDT

Session A: Abstract #3

Title: Demystifying the Meaning of Active Learning in Undergraduate Biology Education

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

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

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

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

The term active learning can be used to generate awareness and collaboration among those interested in improving their teaching. However, because the term is rarely defined and can have many different meanings, those who use active learning should include their definition and strategies when they report their practices. These additional details will allow the community to address more nuanced questions (e.g. do specific active learning instructional strategies promote student learning in multiple environments?). These questions can be more effectively answered when the approach and context of the learning environment has been precisely defined.
Session B: Abstract #2

Title: Mind the Gap: Narrowing STEM achievement gaps with active learning

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

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

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

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

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

In all, this work has two tangible conclusions: first, historical achievement gaps in STEM can be reduced or eliminated with evidence-based instruction. Second, instructors teaching statistics and data science courses, in biology contexts or not, should consider experimentally innovating their teaching methods, and publishing student outcomes.
Session C: Abstract #13

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

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

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

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

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

These findings indicate a need to revisit the goals of instruction for non-science majors - the vast majority of our citizens.
Session D: Abstract #117

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

Authors: David Esparza (Cornell University)*; Amy Wagler (The University of Texas at El Paso); Aimee Hernandez (University of Texas at El Paso); Jeffrey T. Olimpo (The University of Texas at El Paso)

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

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

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

Collectively, the results of this study can inform best practices to promote equitable instruction and treatment of all students enrolled in CUREs.
Session A: Abstract #17

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

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

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

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

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

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

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

This work closely examines mechanisms of what students do to prepare for class and what may influence preparation. This work may help inform instructors on how to guide their students to prepare for class and potentially influence the effectiveness of active engagement during class.
**Title:** Accessible active learning: To what extent is active learning inclusive for science undergraduates with disabilities?

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

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

Our research questions for this study were: What active learning-related challenges have DRC directors identified for students with disabilities in college science courses? What approaches have DRCs taken to alleviate challenges for students with disabilities in active learning science courses?

In this in-depth interview study, we conducted semi-structured interviews with directors of DRCs from 37 universities with large undergraduate student populations and large enrollment science courses. We interviewed DRC directors about how they are accommodating students with disabilities in active learning classrooms and the barriers associated with active learning environments. Two researchers analyzed the interviews using inductive coding methods to determine the challenges associated with active learning and the ways in which DRC directors have mitigated such challenges in college science courses. They developed a coding rubric to analyze the data with an inter-rater reliability score of $\kappa = 0.89$. We used a theoretical framework of Universal Design for Learning, an approach that guides how to improve learning environments to enhance the learning for all individuals, in order to explore how active learning could be made more inclusive for students with disabilities.

We identified that 100% of directors were aware of active learning. However, only 16% of DRCs were able to highlight an example when their DRC provided students with a specific accommodation for active learning before the course started. Most accommodations for active learning are determined retroactively or on a case-by-case basis, which requires students to be responsible for identifying aspects of active learning courses that they struggle with and report these challenges in order to receive appropriate accommodations. We identified a set of common challenges that DRC directors reported regarding specific active learning practices such as small group work, clicker questions, cold call, and online activities. We also identified common solutions that are being used by DRCs across the U.S. to accommodate students with disabilities who experience challenges with small group work, clicker questions, cold call, and online activities. However, despite their previous knowledge of active learning and experiences with student challenges, there were no DRCs that provided standardized accommodations specific to active learning. With this study, we hope to provoke a conversation about creating more inclusive active learning classrooms for students with disabilities.
Session C: Abstract #153

Title: What types of groups facilitate the best active learning?

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

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

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

Students completed three online surveys: content inventory (pre-post), group discussion satisfaction survey (post), and a self-efficacy survey (pre-post with reflective pre). These surveys were analyzed using a one-way ANOVA and Tukey’s means comparison test. The last discussion activity of the semester was video recorded for analysis. Videos were analyzed using the validated Assessment of Scientific Argumentation in the Classroom (ASAC; Sampson et al 2012) protocol. The ASAC protocol includes 19 codes, broken into three themes – cognitive (how a group develops understanding around a scientific concept), epistemic (how consistent the discussion is with the norms of argumentation) and social (e.g. respect and leadership) aspects of scientific argumentation. Each code was rated on a 3-point scale of “never,” “sometimes,” or “always.” Two researchers coded each video and resolved inter-rater reliability. We compared each theme’s score by group type using a one-way ANOVA analysis. We recorded data for 487 students: 31 all-female, 22 all-male, and 38 mixed gender groups. Due to a lack of data on gender non-conforming students, our analysis will focus on “male” and “female” students.

We found no significant difference in the percent-change in content inventory scores or the self-efficacy scores based on student gender or group type. We found a significant difference in the satisfaction scores based on group type (p=0.0221), but not based on gender. A comparing between group types indicates a significantly lower satisfaction mean score for all-male groups (p=0.045) compared to mixed-gender and all-female groups. In other words, students in all-male groups reported much lower satisfaction with their group discussions than students in the other group types. Within mixed-gender groups, both male and female students reported similar, non-significant, levels of satisfaction with their group discussions, leading us to conclude that the group dynamic of all-male groups contributed to lower satisfaction scores. We found no significant difference in cognitive or social scores between group types. However, we did find significantly lower cumulative epistemic scores (p=0.0286) for all-male groups compared to other group types. The lower epistemic scores indicate that all-male groups may be engaging in less productive scientific arguments in terms of supporting statements with evidence, challenging unscientific statements and placing their conclusions in the context of scientific theories, despite students in these active-learning classes having been trained in and practicing productive argumentation throughout the semester.

These results indicate that to foster productive arguments, active-learning instructors should make mixed-gender groups and avoid all-male groups. In the future, we will use network analysis to determine if there is a difference in the argument contributions by gender in the different group types.
Title: Identifying the Impact of the Tigriopus CURE at Multiple Institutions with Diverse Student Populations Authors: Ginger R Fisher (University of Northern Colorado)*

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

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

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

These results provide insight into the differential impact of CUREs on students from diverse backgrounds and indicate that, in many respects, CUREs may have similar benefits for all students. This information is critical for CURE developers and facilitators.
Session A: Abstract #182

Title: Effective application of team-based learning in the online classroom Authors: Lina M Arcila_Hernandez (Cornell University)*

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

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

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

This study shows that TBL has positive effects on two of the main challenges in online learning: it was a factor helping to increase student retention in a STEM online course and helped support students’ performances when learning goals and curriculum were the same as the F2F offerings. In response to the COVID-19 pandemic, many institutions are transitioning courses to online offerings, our study supports the use of TBL strategies when delivering online courses.
Session B: Abstract #201

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

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

Abstract: Research in social psychology has illustrated the negative outcomes of those with Concealable Stigmatized Identities (CSI) and how this research could be useful for studying the experiences of underrepresented groups in biology. A Concealable Stigmatized Identity (CSI) is an identity that is socially devalued in a particular context that can be hidden from others such as LGBTQ+, socioeconomic status, and religious identity – all of which are underrepresented identities in academic biology. We used the CSI framework to study one identity that is both concealable and potentially stigmatized in biology – Christian religious beliefs of biology graduate students. Although Christianity is the cultural norm in the American public, Christians in academic biology are in the minority and have been stereotyped as less competent than other groups in science, which may lead them to conceal their Christianity in biology. Further, prior research with undergraduates and professors indicates that Christians may hide their identity because they are afraid of being stigmatized within the biology community.

In this study, we conducted semi-structured interviews with 33 Christian graduate students at 16 research institutions nationwide using questions derived from the CSI framework to (1) study the experiences of a potentially stigmatized group in biology and (2) explore the utility of the CSI framework in studying the experiences of underrepresented graduate students in biology. To these ends, we asked the Christian graduate students to describe how Christians are perceived within the biology community and their experiences revealing and/or concealing their Christian identity in the biology community. We analyzed the interviews using both deductive and inductive coding to explore the presence of experiences that reflect the CSI framework in our interviews.

Our interviews indicate that Christianity operates as a Concealable Stigmatized Identity (CSI) in the context of biology graduate programs. Students perceived that Christians are negatively stereotyped as unintelligent and unaccepting of science in the biology community. Students also reported that Christians are stereotyped as extremists and fundamentalists. Christian students were afraid that those in the biology community would stereotype them as bigoted or intolerant if they were to reveal that they are Christian. Most students reported that Christians are made fun of in the biology community or that people in biology community responded negatively when the student revealed their Christianity. Many students described having to reveal their identity to correct negative stereotypes about Christians in the biology community. Students indicated that they feel more comfortable revealing their identity around other Christians or around those who seem genuinely interested and respectful of their identity. Students often said they were not overt about their Christianity, but did not actively hide it, while other students described being actively covert about their identity, particularly around anti-religious individuals or individuals higher on the social hierarchy such as senior graduate students or professors. These interviews indicate that using the CSI framework may be a useful tool for studying the experiences of underrepresented groups in STEM with concealable identities.
Time: 1:40-2:00 PM EDT • 12:40-1:00 PM CDT • 11:40-12:00 PM MDT • 10:40-11:00 AM PDT

Session C: Abstract #130

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

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

Abstract: Factors that influence the persistence of undergraduate STEM students have been the focus of many reform efforts. Students with higher anxiety in introductory Biology are less likely to persist in the Biology major. Average class anxiety levels are negatively correlated with student perception of instructor autonomy-supportive practices. Autonomy-supportive practices maintain students’ motivation via listening to students, providing explanations, using non-controlling language, allowing self-paced learning, and acknowledging student feedback. But how do students perceive these supports? The purpose of this study was to identify student-perceived characteristics of supportive instructors in Introductory Biology classes at an R1 institution. Our research questions were: What are characteristics of high instructor support, and what distinguishes student-rated high- and low-support instructors?

In Fall 2019, we surveyed students in 6 220-student introductory Biology classes (3 organismal and 3 cellular). We asked them to rate their perception of the level of support their instructor provided (1-10, low to high) and why they rated their instructor that way. We chose 2 instructors with the lowest average support ratings and 2 instructors with the highest average support ratings to analyze (N=635). Each set of instructors included one organismal and one cellular biology instructor. All authors read and discussed the student open-ended responses to develop a consensus codebook of instructor supportiveness categories. Responses were then independently coded by the authors. One author coded all student responses (primary coder), and the four co-authors provided a second set of codes (secondary coders). Initial code agreement was 76%; the primary and two secondary coders then reconciled all disagreements. Codes were sorted and tallied by support rating and by instructor.

Five categories of support codes were identified: 1) relational (e.g. approachability, perception of caring / not caring), 2) instrumental (e.g. office hours, review sessions), 3) pedagogical (e.g. good / poor teaching), 4) personality (e.g. nice or mean), and 5) ambiguous (e.g. no personal contact / don’t know). Relational, pedagogical, and personality codes could be positive or negative; no students indicated negative instrumental support. As student support ratings increased, the percent of negative relational and pedagogical codes declined and positive relational, instrumental, pedagogical, and personality codes increased. Comparing instructors with high- and low-support ratings, high-support instructors had more positive relational codes. Positive pedagogical codes were more frequent for high-support instructors, but the main difference was a lack of negative pedagogical codes for high-support instructors. Instrumental, personality, and ambiguous codes were less useful in defining differences.

These results suggest that relational and pedagogical support drove these students’ perceptions of instructional support. These results align with research on autonomy-supportive practices, indicating a useful framework for future studies. In the future, classroom practices leading to these ratings need to be explored via classroom observations, course document analysis, and student interviews. This may support suggestions for instructor practices that increase perceptions of support, decrease average class anxiety levels, and improve persistence in Biology.
Title: Exploring student science identity in a place-based, experiential marine science research program

Authors: Christine Ambrosino (Hawai‘i Institute of Marine Biology)*; Mackenzie M Manning (Kapiolani Community College); Malia Rivera (Hawai‘i Institute of Marine Biology)

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

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

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

These results support previous studies that have shown students who feel connected with scientific content perform better in the classroom and have more positive attitudes toward science in general. The project is also an effective example of integrating of rigorous scientific methodology and inclusive place-based pedagogies within a unique cultural framework. Most of our students transition to local community colleges after high school. Our goal is to facilitate successful transitions to these campuses by empowering their self-confidence and sense of identity in STEM. Success for Hawai‘i’s students at the college and ultimately professional levels in the marine and ocean science, conservation and management fields is critical to the ongoing protection and sustainability of valuable Hawaiian and Pacific cultural and natural resources.
Session A: Abstract #116

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

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

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

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

We compared all four pedagogies for basic knowledge performance and near-transfer problem solving. Due to logistical constraints, we compared productive failure and scaffolded guidance for far-transfer problem solving. All learning outcomes were analyzed using ANCOVA with semester as the block effect, basic knowledge pretest performance as a covariate, and instructional condition as the independent variable. Our comparison showed that 1) the four pedagogies did not differentially impact basic knowledge performance, 2) worked examples plus practice, productive failure, and scaffolded guidance led to greater near-transfer problem-solving performance compared to unscaffolded guidance, and 3) productive failure and scaffolded guidance did not differentially impact far-transfer problem-solving performance. Our data advances the guidance debate by suggesting that some variability in the nature and timing of guidance may be fine for student learning, while cautioning active-learning instructors against the unintentional use of unscaffolded guidance.
Session B: Abstract #222

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

Authors: Gena C Sbeglia*, Ross Nehm (Stony Brook University)

Abstract: Evolution acceptance is lowest in groups poorly represented in the evolutionary sciences (e.g., women, underrepresented minorities; Mead et al. 2015) raising questions about its role in degree persistence and career choice. Although a large body of work has used correlation and regression to explore associations among religiosity, conflict perception, evolution knowledge, acceptance, race, and gender, these methods are poorly suited for analyzing indirect effects, collinear variables, and latent constructs. Our work employs latent variable path modeling to shed new light on the causal mechanisms driving evolution acceptance, with a particular focus on the role of conflict. The perception of conflict between one’s personal beliefs and evolution is hypothesized to impact acceptance, but empirical work remains limited. We ask: 1) Does conflict perception impact evolution acceptance? 2) Does conflict perception mediate the causal link between (a) evolution knowledge and acceptance, and (b) religiosity and acceptance? And 3) Does race contribute to acceptance when controlling for all other variables?

We used latent modeling to investigate interrelationships among key variables hypothesized to drive patterns of evolution acceptance in biology undergraduates (n=1276). Latent constructs were estimated using validated measures of acceptance (I-SEA-3 scales: micro, macro, human evolution), knowledge (CANS), perception of conflict (SECM-3 scales: perceptions of community, family, and individual), and religiosity (2 scales: identity, participation). We used Rasch analysis to evaluate productive measurement of constructs. A literature review was used to integrate constructs into latent variable path models in R (Lavaan). We modeled direct and indirect links between latent constructs. Covariates included race, gender, ELL status, reading/writing ability, and major.

All instruments functioned well and the path model had acceptable fit (Robust CFI=0.95, Robust RMSEA=0.03, SRMR=0.04). Individual (but not family or community) conflict had a direct causal relationship with all scales of acceptance (β=-0.65 to -0.56, p<0.01). Evolution knowledge had both a direct (β=0.14 to 0.19, p< 0.01) and indirect relationship mediated by individual conflict perception (β=0.07 to 0.13, p< 0.01) with all acceptance scales. The total impact of knowledge on acceptance was similar across evolution scales (β=0.22 to 0.30, p<0.01), and half of this impact was mediated through individual conflict perception. Religious identity did not directly impact evolution acceptance, but participation did impact microevolution acceptance (β =−0.11, p<0.05). Both religiosity scales had indirect relationships with acceptance mediated by individual conflict perception (β =−0.22 to −0.10, p<0.01). The total impact of the religiosity scales on acceptance (β =0.09 to 0.36, p<0.05) was similar to the impact of knowledge. Finally, race contributed to macro and human evolution acceptance even when controlling for religiosity and conflict perception (β =0.05, p<0.05). Overall, individual conflict perception was an important mechanism driving acceptance.

This study highlights the strengths of methodological approaches for building causal models that explain educational patterns, and reveals new relationships among core constructs central to understanding evolution acceptance in biology undergraduates.
Session C: Abstract #179

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

Authors: Heather D. Vance-Chalcraft*, Carol Goodwillie (East Carolina University)

Abstract: Service learning (SL) integrates service opportunities into course curricula in partnership with a community organization. We asked whether students who participate in service learning in a plant biology course demonstrate greater content knowledge, classroom connectedness, and self-efficacy for environmental action than students who do not participate in service learning. Experiential learning theory suggests that real-world participation in service may be associated with deep learning while social learning theory adds that working together on community service may better engage and motivate participants. Therefore, we hypothesized that participation in SL would improve student content knowledge, enhance positive perceptions of course climate, and increase student empowerment to environmental action.

We tested this hypothesis in an SL course in plant biology. The SL section was initiated in 2014, in association with our city Parks Department, to involve undergraduates in removal of an invasive species along a local greenway. SL field trips complement traditional lecture sessions on basic plant biology. We compared student outcomes in two course sections (one with, one without, SL) with the same instructor during fall 2019. Data on student content knowledge, perceptions of classroom climate, and views of one’s ability to positively impact the environment were collected through surveys given at the beginning and end of the semester. Content questions were instructor-generated and focused on basic topics in plant biology; two published, validated surveys, the Connected Classroom Climate Inventory (CCCI) and Self-Efficacy for Environmental Action (SEEA) scale, were also used.

Using one-factor ANOVA, the content pre-test, post-test, and learning gain scores did not differ (all p>0.05) between SL and non-SL sections even though some class time was used for SL instead of content in the SL section. Paired t-tests on scores from the CCCI showed significant increases in the SL section’s students’ perception of their peers’ respect for one another (t26=2.73, p=0.0113), opinion that students smiled (t26=2.51, p=0.0187) and laughed (t25=6.02, p<0.0001) together, and view that students in the class cooperated with one another (t26=4.56, p=0.0001). In contrast, classroom connectedness scores in the non-SL section did not change over the semester. Finally, paired t-tests on SEEA scores showed significant increases in the SL students’ confidence in their ability to help protect the planet (t26=2.13, p=0.0431) and their feelings that they could positively impact the environment (t26=2.80, p=0.0095), while students in the non-SL section exhibited no significant changes in self-efficacy for environmental action over the semester. Therefore, our hypothesis that participation in SL would enhance positive perceptions of the classroom climate and increase student feelings of empowerment to environmental action compared to students who did not participate in SL was supported. Class time devoted to service learning did not detract from learning gains on other course content.

This study provides evidence for the benefits of SL in biology courses, outside of the ecological benefit of invasive species control. In agreement with social learning theory, the collaborative SL experience created a more positive course environment that appeared to engage and empower the students.
Abstract: Depression is a top mental health concern among undergraduates and has been shown to disproportionately affect individuals who are underserved in science. As we aim to create a more inclusive scientific community, we argue that we need to examine the relationship between depression and undergraduate research experiences. While studies have identified aspects of research that affect graduate student depression, in response to the dubbed “graduate student mental health crisis,” we know of no studies that have explored the relationship between depression and undergraduate research. We used a theoretical lens of concealable stigmatized identities (CSI) to explore depression in the context of undergraduate research. Because depression is a covert identity, individuals often have the choice to reveal this identity and given the stigma associated with this identity, individuals may be reluctant to reveal even if sharing this identity could be beneficial.

In this study, our specific research questions were: (1) how do undergraduates’ symptoms of depression affect their research experience? (2) how do undergraduate research experiences affects students’ feelings of depression? and (3) What recommendations, based on undergraduates’ reported experiences, can promote a positive research experience for students with depression in undergraduate research?

Using a national sampling approach, we recruited 35 undergraduate researchers majoring in the life sciences from 12 research-intensive public universities across the United States who self-identified with having depression; we did not require students to be formally diagnosed with depression since mental healthcare is disproportionately available to privileged individuals in the U.S. We conducted hour-long semi-structured interviews with students about their experience with depression in an undergraduate research experience. Interviews were transcribed and two independent raters used inductive and deductive coding to identify prominent themes throughout the interviews and achieve inter-rater reliability ($\kappa = 0.88$).

We found that students’ depression affected undergraduate researchers’ motivation and productivity, creativity and risk-taking, engagement and concentration, and self-perception and socializing in undergraduate research experiences. We also found that students’ social connections, failing in science, getting help, receiving feedback, and the demands of research affected students’ depression. Notably, we demonstrated that students who felt comfortable revealing their depression identity perceived more positive experiences. However, students could name few faculty members in science who had depression and did not know if one could be successful in research and have depression.

This highlights the stigma associated with this identity and the need for students to have role models. Based on this work, we articulate an initial set of evidence-based recommendations for research mentors to consider in promoting an inclusive research experience for students with depression.
Session A: Abstract #215

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

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

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

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

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

Our findings call into question the instructional sampling intensity (SI) utilized by Stains et al. to make claims about the current state of STEM instruction in the United States. Instructors transitioning from didactic to evidence-based instruction—which is likely to be common—required double the number of COPUS observations as suggested by Stains et al. to accurately characterize teaching strategies. Sampling intensity emerges as a crucial but poorly studied variable central to measuring progress towards the recommendations advanced by Vision and Change.
Session B: Abstract #139

Title: Culturally Responsive Teaching in Undergraduate Science Labs

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

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

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

This study applied a grounded theory methodology to address the following research question: in what ways do biology teaching assistants enact culturally responsive science teaching? Grounded theory is an approach to qualitative analysis that aims to develop an abstract or theoretical understanding of an experience or set of experiences. Mitch, Katie, Chad, and Greg (pseudonyms) participated in a semester-long fellowship during which they received targeted, base-level supports surrounding concepts of CRST. They were each observed weekly in their labs where they were teaching and the data sources obtained were TA reflections, observation field notes, post-observation interviews, and focus groups. Grounded theory employs a three-pronged approach to qualitative analysis: open coding, line-by-line coding, and axial coding. During open coding, data were broken down into discrete parts in order to examine, compare, and find salient indicators of CRST. Next, we engaged in line-by-line coding to assign codes to words and phrases, and then organized codes that seemed similar into potential categories. Lastly, we completed axial coding by using constant comparison methods to explore more deeply the dimensions of each potential category. As we engaged in the constant-comparison process, we looked across elements of the categories, such as similarities, differences, and outliers in codes. We then intensively examined the properties and dimensions of code to identify how they relate to their respective category. This lends itself to the development of interpretive themes. The resulting themes were Funds of Knowledge, Connections, Differentiating Instruction, Intentional Scaffolding, and Reducing Student Anxiety.

The purpose of this study was to better understand the ways undergraduate biology teaching assistants (TAs) enacted CRST, a pedagogical framework that has yet to be formally explored in postsecondary science spaces. This study demonstrated that, with targeted supports, biology TAs can enact CRST in undergraduate science learning spaces in distinct ways. The implications of this work are important both in science education research and in discipline-based education research where accessible and inclusive undergraduate science education is still developing. We contend that these findings provide new insights into the ways undergraduate science education might be reimagined to create equitable science learning opportunities for all students.
Session C: Abstract #219

Title:

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

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

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

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

Our data show that random call may increase student participation during class discussions and potentially decrease behaviors associated with communication apprehension (i.e. skipping class). Our data expands upon, and is in contrast to other studies that show students will skip class to avoid being called on (Cooper et al. 2018). We suggest that how instructors implement random call in a classroom can increase equity and may influence the effect of random call on communication apprehension. These data generate new insight into the impact of random call. In particular, this work will be of interest to instructors as they attempt to increase inclusion and equity in the classroom through the practice of random call during class discussions.
Session D: Abstract #54

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

Authors: Jessica Dewey*, Anita Schuchardt (University of Minnesota)

Abstract: When undergraduates first take laboratory courses or participate in direct mentorship research opportunities, they are asked to move into the world of scientific research and interact with its culture. This process, called border crossing, can be challenging for students (Aikenhead, 1996). One avenue for helping students successfully border cross into the culture of scientific research is identifying the specific cultural aspects that may support (i.e. entry points) or challenge (i.e. barriers) border crossing. Before the cultural aspects involved in border crossing can be identified, a framework that specifies the cultural aspects of scientific research must first be established.

Our research questions were 1) what aspects make up the culture of scientific research? And 2) what aspects of the culture of scientific research do students perceive after participation in a CURE?

Research Q1: A systematic literature review was performed to synthesize cultural aspects of scientific research from the literature. Culture was defined as the practices, norms/expectations, and values/beliefs of a group (Phelan et al., 1991). Practices are the day-to-day activities of a group, Norms/Expectations are the standards that influence how a group and its members behave, and Values/Beliefs are broad ideas that help define a group. The databases of Google Scholar and ERIC were searched to identify peer reviewed articles that include or references to keywords such as “culture AND science”, “practices of scientific research”, “norms of scientific research”, and “values of scientific research”. These articles were screened through full-text review. The snowball approach was used to find additional articles that either referenced or were referenced by these articles. Sixty-eight articles were included in the final review. Analyses and

Interpretations Q1: The cultural aspects identified in these articles were sorted into the three culture categories based on their fit with the definition of each category. Then, the aspects within each category were thematically grouped. In the end, the Culture of Scientific Research (CSR) Framework comprised nine Practices, nine Norms/Expectations, and eight Values/Beliefs.

Research Q2: Informal interviews were conducted with students (N=190) at a large Midwestern university during poster sessions held at the end of a second semester introductory laboratory course designed as a CURE. Students presented their research projects and were asked three broad questions about what they liked, found challenging, and took away from their experiences in this course. These interviews were audio recorded and transcribed.

Analyses and Interpretations Q2: Five hundred and eighty-two student responses were coded based on the CSR Framework. Students mentioned 21/26 aspects in the framework. Values/Beliefs were mentioned less frequently (5% of responses) than Practices (37%) and Norms/Expectations (58%) as challenging or valued aspects. Additionally, we found differences in students’ perceptions based on their gender and project topic.

Our work establishes a new analytical framework for understanding the culture of scientific research. With this framework, more research can be done to identify cultural barriers and entry points that students may experience when border crossing into scientific research.
Title: Using Learning Assistants to Systematically Gather and Analyse Formative Assessment Data in Large STEM Classes

Authors: Young Ae Kim*, Katelyn Southard, Jonathan Cox, Lisa Elfring, Paul Blowers, Vicente Talanquer, (University of Arizona)

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

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

Our analyses indicate that the quality of the LR s' written reports varied, but in general, most LR s demonstrated ability to notice and report on important aspects of student thinking. They provided detailed descriptions of what students could or could not do, including evidence in the form of students’ questions and responses during class activities. LR s were also able to make general suggestions for fostering student understanding. Our analyses revealed that LR s' initial approach to the assessment of student thinking tended to be more descriptive than interpretive. When they built inferences, claims about student learning were presented without much supporting evidence and explicit rationale. LR s often commented on the correctness of task products, adopting an evaluative stance rather than trying to make sense of student reasoning in the assessment of students’ ideas. LR s struggled to generate specific suggestions for task design and instruction based on student thinking. They more commonly suggested actions that focused on improving managerial and engagement issues. In general, undergraduate LR s demonstrated ability for systematically gathering formative assessment data in large STEM classrooms but struggled to analyze these data in responsive ways.
**Session B: Abstract #225**

**Title:** Religious Students' Perceptions in Biology

**Authors:** Ryan Dunk*, Mia Pepi, Jason Wiles (Syracuse University)

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

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

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

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

This work complements and adds to recent work on studying religious populations in biology by testing a theoretical framework through qualitative interviews with religious students. We are hopeful that the results presented here will be useful for all members of the SABER community, especially those interested in representation of religious students and/or the use of qualitative inquiry for exploring science teaching problems.
Session C: Abstract #77

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

Authors: Emma C Goodwin*, Jessica Cary, Erin E Shortlidge (Portland State University)

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

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

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

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

The impact that TAs have on their CURE students are largely unexplored. This study finds that individual TAs can impact their students’ comfort in class and perceptions of experiences critical to the CURE framework, like iteration and collaboration. These data will be of interest to faculty who train CURE TAs and coordinate CURE programs, and ultimately could inform professional development efforts for CURE TAs.
Session D: Abstract #18

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

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

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

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

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