25th Annual ASM Conference for Undergraduate Educators (ASMCUE)

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ANNUAL CONFERENCE ABSTRACTS

The following abstracts were presented in poster sessions at the American Society for Microbiology’s Conference for Undergraduate Educators (ASMCUE) on Saturday, July 28, 2018.

The 2018 abstracts are organized by both content and pedagogy to help participants navigate more easily through the poster session. The content themes are based upon the ASM Recommended Curriculum Guidelines for Undergraduate Microbiology Education found at https://www.asm.org/curriculum-guidelines. The pedagogy themes are organized into five categories: course design, hands-on projects, student learning, teaching approaches, and teaching tools.

A-29
Agar Art as a Canvas for Discovery in the Microbiology Laboratory Classroom
Sarah J. Adkins, Rachel K. Rock, and Jeff Morris, University of Alabama at Birmingham

ASM Curriculum Guideline Concept(s): Systems, Advancing STEM education and research
Pedagogical Category(ies): Course design, Student learning, Teaching tools

A-13
Implementation of an Entrepreneurial Minded Learning Activity in General Biology Classes
Michelle L. Ammerman and Cheryl Samaniego, Kettering University

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Teaching approaches

B-8
The Interactive Platform BioBeyond Did Not Increase Student Learning in an Accelerated Online Setting
Ana Maria Barral, Veronica Ardi-Pastores, Christopher Hendrickson, and Rachel E. Simmons, National University

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

A-5
Active Engagement, Not Exposure Time, Accounts for Gains in Understanding in a Flipped Introductory Biology Course
Mary Bass, Jennifer Cromley, and Benjamin Clegg, University of Illinois at Urbana-Champaign

ASM Curriculum Guideline Concept(s): Evolution
Pedagogical Category(ies): Student learning, Teaching approaches

B-12
Active Learning and Online Interactive Assignments Improve Learning Outcomes when Introduced into the Curriculum of a Large Introductory Microbiology Course
Daniel H. Buckley, Samuel E. Barnett, and Esther R. Angert, Cornell University

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Course design, Student learning, Teaching approaches, Teaching tools

A-21
Assessment of a CURE-Based Module for Protein Interactions
Stefanie H. Chen and Carlos C. Goller, NC State University

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design

A-7
The Role of Team-Based Learning Environments in Closing Performance Gaps in a Large Introductory Biology Course
Benjamin Clegg, University of Illinois at Urbana-Champaign

ASM Curriculum Guideline Concept(s): Evolution, Structure and function
Pedagogical Category(ies): Teaching approaches

B-16
The Effect of Case Study and Flipped Classroom Pedagogy, in a First-Year Cell Biology Class, on Self-Assessed Learning Gains and Class Performance
Sean T. Coleman, University of the Ozarks

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design, Teaching approaches

B-30
ENCOUR: Establishing a Network for the Integration of Ethics/RCR Education into CUREs in the Biological Sciences
Laura Diaz-Martinez (1), Ginger R. Fisher (2), Jay M. Bhatt (1), David Esparza (1), Aimee Hernandez (1), and Jeffrey T. Olimpo (1), (1) The University of Texas at El Paso, (2) University of Northern Colorado

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design

B-36
The BIOMAN Academy: A Multi-College Approach to Enlightening High School Students to the Field of Biotechnology and Careers in Bioscience
Hetal Doshi (1), Cianna Cooper (2), Linda Rehfuss (2), and Margaret Bryans (1), (1) Montgomery County Community College, (2) Bucks County Community College

ASM Curriculum Guideline Concept(s): Advancing STEM education and research

A-23
Bridging the Gaps: an Innovative and Integrated Undergraduate Fermentation Science Course
Paul M. Duffin and Kyle Schnitzenbaumer, Transylvania University

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Course design

A-1
Learning Strategies and Problem-Solving Performance in Microbiology
Josephine Ebomoyi, Northern Illinois University

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Student learning, Teaching approaches

B-10
Enhancing Introductory Biology Students’ Conceptual Understanding of and Attitudes Toward Osmosis and Diffusion through an Interactive Learning Module
David Esparza (1), Sebastian Schormann (2), Anna Jones (2), Samiksha A. Raut (2), and Jeffrey T. Olimpo (1), (1) The University of Texas at El Paso, (2) University of Alabama at Birmingham

ASM Curriculum Guideline Concept(s): Structure and function, Advancing STEM education and research
Pedagogical Category(ies): Teaching tools

A-37
Making Evolution Stick: Evaluating the Use of Sticky Notes to Teach Evolution
Sarah Fankhauser (1), Teresa Lee (2), and Kathleen Grogan (3), (1) Oxford College of Emory University, (2) Emory University, (3) Pennsylvania State University

ASM Curriculum Guideline Concept(s): Evolution
Pedagogical Category(ies): Student learning, Teaching tools

A-33
Teaching Scientific Communication in the 21st Century: Using Website Design as a Classroom Tool
Dawn Foster-Hartnett, Patricia Goodman-Mamula, Timothy Johnson, Daniela Vidovic, and Greta Henry, University of Minnesota

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Teaching approaches
A-19
Survey of the Endemic Fungi of the Great Basin: Incorporating Original Research into an Undergraduate Microbiology Laboratory Experience
Ruth Gault, University of Nevada

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Hands-on projects

B-40
Incorporating Service-Learning into STEM
Ruth Gault (1), Meghan Schiedel (2), Abbey Grimmer (1), and Stacey Muse (1), (1) University of Nevada, (2) Terry Lee Wells Nevada Discovery Museum

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design

B-22
Easing Perceived Barriers to Course-Based Research Experiences: Impact of the PARE Project
Elizabeth Genné-Bacon, Jessica Henry, and Carol Bascom-Slack, Tufts University School of Medicine

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design, Teaching approaches, Teaching tools

A-9
The Implementation and Assessment of a Learning Assistant Program in a High-Enrollment Microbiology Lecture Course
Kimberly Gomez and Miriam Martin, University of California Davis

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

A-31
Art in the Microbiology Classroom: a Useful Tool to Motivate Students and Teach Complex Processes
Patricia Goodman-Mamula, Lisa Bofencamp, Greta Henry, and Dawn Foster-Hartnett, University of Minnesota

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Teaching tools

A-35
Bacterial Survivor: An Interactive Game that Combats Misconceptions about Antibiotic Resistance
Brinda Govindan, San Francisco State University

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-34
Achieve Career Success in Science through Excellence (ACSScellence): Impacts of a Longitudinal, Research-Intensive Program on Students’ Development of Scientific Process Skills, Science Identity, and Attitudes in STEM
Aimee Hernandez, Laura Diaz-Martinez, and Jeffrey T. Olimpo, The University of Texas at El Paso

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

A-15
Using Repetitive Summative Assessment to Increase Learning of Basic Calculations in an Introductory Biology Lab
John H. Horne, Henry W. Woolley, Jerome J. Howard, and Wendy M. Schluchter, University of New Orleans

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design

A-41
Environmental Sampling: An Approach to Integrate Education and Research
Rupa Iyer, University of Houston

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-2
Study Habits that Set the Bar: Identifying Effective Study Methods of High-Performing Students
Leilani Jones, Kavi Tan, Tiffany Johnson, and Miriam Martin, University of California Davis

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-32
Impacts of the NSF STEM Scholars Program on Community College Student Success and Degree Completion
Renu B. Kumar and Maire Sustacek, Minneapolis Community and Technical College

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-20
The Effects of a Molecular Modeling Seminar on Visual–Spatial Reasoning and Science Identity
Maureen Leonard, Colleen Conway, and Laurel End, Mount Mary University

ASM Curriculum Guideline Concept(s): Structure and function, Advancing STEM education and research
Pedagogical Category(ies): Course design, Student learning

B-26
The Benefits of Using Iterative Practices in a Microbial Biofilm Course-Based Undergraduate Research Experience
Caitlin Light, Megan Fegley, and Nancy Stamp, Binghamton University

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Teaching approaches

B-38
Health Sciences Microbiology Case Studies to Develop 21st Century Skills
Lisa Loeffelholz, San Jacinto College

ASM Curriculum Guideline Concept(s): Structure and function, Systems
Pedagogical Category(ies): Teaching approaches

A-27
The Student-Centered Classroom: Probiotics and the Human Microbiome
Jennifer K. Lyles (1) and Monika Oli (2), (1) Francis Marion University, (2) University of Florida

ASM Curriculum Guideline Concept(s): Impact of microorganisms
Pedagogical Category(ies): Hands-on projects

B-6
Student Perspectives on the Efficacy of Anticipatory Activities and a New Bioinformatics App
Tina Marcroft, Scott Kelley, and Chris Rasmussen, San Diego State University

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Teaching tools

A-25
PUMA: Pipeline for Undergraduate Microbiome Analysis
Jordan Moberg Parker, Keith Mitchell, Christopher Dao, Jiem Ronas, and Amanda Freise, University of California, Los Angeles

ASM Curriculum Guideline Concept(s): Information flow
Pedagogical Category(ies): Teaching tools

A-17
Horizontal Infusion of Arctic/Polar Science Research into a Quantitative Methods in Ecology Course Results in Enhancement of Students’ Statistical Reasoning Abilities, Statistics Attitudes, and Scientific Process Skills
Jeffrey T. Olimpo, Vanessa L. Lougheed, and Craig E. Tweedie, The University of Texas at El Paso

ASM Curriculum Guideline Concept(s): Systems, Advancing STEM education and research
Pedagogical Category(ies): Course design

B-28
Metacognition and Critical Thinking Emerge as Key Goals in a Microbial Ecology CURE Lab
Samantha T. Parks, Georgia State University

ASM Curriculum Guideline Concept(s): Impact of microorganisms
Pedagogical Category(ies): Teaching approaches

B-18
Impact of a Semester with Three Design-and-Improve Lab Modules on Introductory Students’ Statistical Reasoning and Experimental Design Skills and Sense of Autonomy
Iglika Pavlova, The University of North Carolina at Greensboro

ASM Curriculum Guideline Concept(s): Systems, Advancing STEM education and research
Pedagogical Category(ies): Course design, Teaching approaches

A-39
Analyzing the Impact of Service Learning on Civic Engagement and Sustainable Practices in a Large-Enrollment Nonmajors Biology Class
Samiksha Raut, Daniel Mendoza, Sarah Adkins, and J. Jeffrey Morris, The University of Alabama at Birmingham

ASM Curriculum Guideline Concept(s): Information flow, Advancing STEM education and research
Pedagogical Category(ies): Course design, Teaching approaches

B-4
Managing Cognitive Load to Improve Student Performance
Tracy Ruscetti, Erika Sweet, David McMillan, and Christelle Sabatier, Santa Clara University
BACKGROUND

Agar art—i.e., drawing with microorganisms—has gained international attention through the ASM Agar Art contest. Since the creation of agar art by penicillin discoverer Alexander Fleming, agar art has played a role as an insightful and aesthetic activity for scientists and educators alike. However, agar art’s potential as a tool for scientific discovery, especially in the university classroom, has yet to be explored.

AGAR ART AS CURE

We reformed a traditional cookbook microbiology lab into a Course-Based Undergraduate Research Experience (CURE) that uses agar art as a platform for scientific discovery. Students use soil isolates to create agar art and use ecological observations from their art to inform their own scientific investigation. Students generate potentially publishable data through novel experimentation and present their work to their peers.

EDUCATIONAL ASSESSMENT

We used pre- and post-course Likert Nature of Science and ASPECT survey instruments, the ASM concept inventory, and interviews to test our hypothesis that students in our CURE classes (n = 67) who were more engaged with the educational aspects of the course would have more affirming understandings and attitudes about science. Results showed that students who reported higher engagement in the art activity in the ASPECT survey were more likely to have higher ASM concept inventory scores (p = 0.0001) and affirming attitudes about science through the Nature of Science survey (p = 0.0001). In our interviews, led by peers instead of the instructor to reduce bias, over half of the students confirmed engagement in the course without being explicitly prompted to. [Student quote]: “It really does show you that not only is science academic like they always taught you that it was, but it’s also a creative endeavor—you have to be able to think through things.” We conclude through quantitative and qualitative results that creativity and student-led discovery is a promising way to have students engage with authentic science. We suggest that agar art is not only an engaging aesthetic activity but offer it as unique tool for the future of education and microbiological research.

A-13
Implementation of an Entrepreneurial-Minded Learning Activity in General Biology Classes
Michelle L. Ammerman and Cheryl Samaniego, Kettering University

A module was designed to introduce General Biology students to the topic of microbiology, stimulate an awareness of how this topic affects their daily lives, and then evaluate the ability of the students to work in groups to create marketable products that relate to microbiology. The General Biology class and lab is approximately 25% freshman science majors and 75% engineering students. Activities that build cross-disciplinary relationships between engineering and the sciences as well as introduce entrepreneurial-minded learning (EML) to STEM students were integrated into the module to demonstrate the interdisciplinary nature of innovations in STEM fields. The entire module consists of a microbiology lecture, a microbial quantification activity, a group brainstorming session on inventions involving microbes resulting...
in preparation of a proposal, and finally, interdisciplinary team reviews of each of the proposals. The review session required one member from each proposal group to join a new group of 5–6 students where each student presents their proposal, answers questions, and gets feedback. We hypothesized that the cross-disciplinary projects would help students, both science and engineering majors, to develop an entrepreneurial mindset and see the relevance of biology to both their major and everyday life. The module was run in two different terms and assessment was performed through post-activity interviews and questionnaires in one term, and surveys in both terms. The indirect assessment questions covered Biology program, ABET, and KEEN (Kern Entrepreneurial Engineering Network) objectives. The 11 survey questions were scored on a scale from 1–6 (1 = 100% disagree, 6 = 100% agree) with the average score ranging from 4.59 to 5.16, indicating the majority of students saw this activity as beneficial. The students’ perceived greatest gains (score >5) involved students’ application of their knowledge of STEM, improved communication skills, and development of an enterprising attitude.

**ASM Curriculum Guideline Concept(s):** Impact of microorganisms, Advancing STEM education and research

**Pedagogical Category(ies):** Teaching approaches

**B-24**

**Engagement in a Place-Based Health Disparities CURE Increases Students’ Science Process Skills Development, Grit, and Intra-community Collaborations**

Jennifer Apodaca, Yok-Fong Paat, Almee Hernandez, and Jeffrey T. Olimpo, The University of Texas at El Paso

Course-based undergraduate research experiences (CUREs) offer innovative avenues for engaging students in the process of scientific discovery. While prior studies have capitalized upon the impact of CUREs on students’ professional growth and ability to “think like a scientist,” little is known about the interactions that occur within CURE contexts and the broader impact of CUREs on student grit and science process skills development in the discipline. In an effort to address these concerns, we created and implemented a place-based experience focused on health disparities in the border region, which enrolled students (n = 18) from diverse majors (e.g., biological sciences; computer science; sociology) in the fall 2017 semester. A quasi-experimental, pre-/post-intervention design was used to evaluate the impact of the CURE on students’ development of science process skills, grit, and intra-community collaborations, as measured via the Science Process Flowchart Assessment (Wilson and Rigakos, 2016), Grit Scale (Duckworth et al., 2007), and Network Survey (Hanauer and Hatfull, 2015), respectively. Paired t-test analyses revealed a statistically significant increase in students’ experimental design skills and understanding of the nature of science (p < 0.010 for all comparisons) as well as a positive shift in student resilience over the course of the semester (p < 0.005). With respect to contextual elements of the CURE, descriptive analysis revealed that participants self-reported interacting with other students outside of the CURE (89% of sample), parents/guardians (67% of sample), campus faculty (67% of sample), and external stakeholders (89% of sample). Collectively, these data suggest that place-based CUREs, such as the one described herein, have the potential to positively augment students’ development as researchers within their community and the broader scientific landscape.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research

**Pedagogical Category(ies):** Course design

**B-8**

**The Interactive Platform BioBeyond Did Not Increase Student Learning in an Accelerated Online Setting**

Ana Maria Barral, Veronica Ardi-Pastores, Christopher Hendrickson, and Rachel E. Simmons, National University

We piloted the BioBeyond (BB) platform in a fully online, accelerated (one-month) non-majors general biology course at a non-traditional university. The platform allows students to learn in an inquiry-based format, using an interactive platform by SmartSparrow. Sections using the currently-assigned textbook with ancillary activities such as adaptive quizzes were employed as controls. In the BB course format, assignments were embedded into the material, effectively requiring students to complete the readings. In contrast, students in control sections could skip ahead.

We hypothesized that use of BB would result in enhanced student learning as assessed by a 12-question pre/post quiz based on course learning objectives.

Four BB and three control courses taught by the same instructors were evaluated. Average student age was 33, typical of a non-traditional student population. Matched pre-post quiz results were obtained for 70 BB and 36 control students.

Wilcoxon signed-rank tests were used to compare modalities (BB vs. control). The two groups were not significantly different at Pre (Z = 0.868, p = 0.385) but were at Post (Z = 3.171, p = 0.0015). The Akaike Information Criterion analysis was used to determine which factors to include in multivariate analysis. With no differences identified between instructors, time and modality were analyzed via repeated-measures ANOVA. Modality, Time, and an interaction between Time and Modality were all significant (F(93) = 6.17, 21.29, and 5.49 and p = 0.0147, < 0.0001, and = 0.0213, respectively). All students performed significantly better in the Post quiz, and control students also improved more over time than BB.

In summary, our study showed the need for a stringent assessment of novel educational approaches, especially in a setting and/or populations for which they are
not designed. BioBeyond has been shown to be effective in a number of other higher education institutions but did not significantly improve student learning in this study. It should be noted that the BB sections were affected by technical issues that negatively affected student engagement and impacted students’ time management in an accelerated format.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research  
**Pedagogical Category(ies):** Student learning

**A-5**  
**Active Engagement, Not Exposure Time, Accounts for Gains in Understanding in a Flipped Introductory Biology Course**  
Mary Bass, Jennifer Cromley, and Benjamin Clegg, University of Illinois at Urbana-Champaign

This study is among the first to examine the individual contributions to learning gains associated with pre-lesson content-delivery via interactive video modules (PLV) and with active, peer-to-peer engagement using case studies during face-to-face (F2F) lessons in a flipped, large, introductory biology course (657 students) (IRB 16127). The study was motivated by extensive literature that demonstrates improved exam and course grades in courses with a flipped classroom design, but a dearth of data on how individual course components of a flipped class contribute to these gains. In fall 2016, we collected data on student learning gains for natural selection, a concept known to challenge freshman biology students, in order to test whether flipped lectures promote deeper understanding due to H1: increased number of lessons (pre-lessons and F2F) or due to H2: active engagement with material in F2F lessons. An open response assessment tool was applied using a pre- and post-assessment scheme to assess changes in student understanding at four points over the course of the unit: 1) pre-assessment, 2) after content delivery via PLV, 3) after a F2F data-driven case study, and 4) on the exam. Assessments were scored separately for the number of correct conceptions (a measure of the number of memorizable content items), and the number of misconceptions students held (a measure of the lack of understanding of concepts). A Wilcoxon-Signed Ranks test reveals significant changes in the number of correct conceptions on each assessment ($p < 0.001$, $N = 218, 146$, and $119$, respectively), with the largest increase following content delivery in PLV, while the number of misconceptions only significantly declines following F2F active engagement ($p = 0.005$, $N = 146$). These results support H2 in that a single content-delivery-based lesson sufficed to increase the number of memorizable items students were able to draw on, without however altering the number of misconceptions, indicating gains due to memorization, not increased understanding. Only active, data-driven engagement in the context of an interactive case study allowed students to correct false prior mental models.

**ASM Curriculum Guideline Concept(s):** Evolution  
**Pedagogical Category(ies):** Student learning, Teaching approaches

**B-12**  
**Active Learning and Online Interactive Assignments Improve Learning Outcomes when Introduced into the Curriculum of a Large Introductory Microbiology Course**  
Daniel H. Buckley, Samuel E. Barnett, and Esther R. Angert, Cornell University

Introductory Microbiology is often taught in a large lecture class format with grading based on exams and quizzes. We hypothesized that introduction of active learning and online interactive assignments would improve learning outcomes for our students. Active learning uses student engagement and peer-to-peer interaction to enhance learning outcomes. Mastering Microbiology is an online platform for developing interactive, low stakes, assignments where feedback is instantaneous. From 2015 to 2018, we implemented active learning and Mastering Microbiology within the curriculum of a large ($n = 185$) Introductory Microbiology course. Active learning was implemented in optional course discussion sections (50 min per week). Mastering Microbiology problem sets (5 questions each) were assigned after each lecture. We assessed the impact of these interventions on learning outcomes by analyzing their effects on exam grades, by using value-added assessment, and by using subjective student self-assessment. We found that students in active learning discussion sections performed better on both exams ($80.1\% \pm 10.3\%$ versus $74.2\% \pm 16.9\%$ (avg $\pm$ SD), + and - sections, respectively; $p = 0.0007$) and on value-added assessment (no initial significant difference; $+19.3\%$ for sections at semester’s end, $p = 0.005$). Students in section also rated the course higher in subjective assessment ($4.33 \pm 0.6$ versus $3.77 \pm 1.0$; 5-point scale, + and - sections, respectively; $p = 0.004$). In addition, we found a significant correlation between use of Mastering Microbiology and performance on both exams ($r = 0.50$, $p < 0.001$) and final value-added assessments ($r = 0.59$, $p < 0.001$). We discuss the impact of self-selection on these results and assess this issue by examining GPA as a co-variate to control for student aptitude effects on assessment outcomes. We expect that these effects are driven by increasing student time-on-task, spreading student effort more evenly over the semester, facilitating student self-correction and engagement, and enhancing opportunities for peer-to-peer and instructor-student interactions.

**ASM Curriculum Guideline Concept(s):** Impact of microorganisms, Advancing STEM education and research  
**Pedagogical Category(ies):** Course design, Student learning, Teaching approaches, Teaching tools
A-21
Assessment of a CURE-Based Module for Protein Interactions
Stefanie H. Chen and Carlos C. Goller, NC State University

Protein-protein and protein-DNA Interactions are vital for the function of any cell. I designed an eight-week lab-based course focused on protein interaction studies. Students perform a variety of inquiry-based experiments using the E. coli SSB protein as a model system. Students are also assigned to groups and encouraged to share data between group members, allowing for more data analysis and critical thinking in their lab reports. The groups are also assigned “gamification” points to reinforce positive or discourage negative behaviors. Student learning and attitudes have been assessed using anonymous pre-/post-surveys and class grade data. We hypothesized that the data would show an increase in student confidence working with proteins, course-specific content knowledge, and ownership over the experiments. Self-reported confidence levels in laboratory skills and content knowledge increased after taking the course, from a Likert scale average of 2.8 (n = 13) to 4.2 (n = 10). This was reinforced by an increase in correctly answering content-based survey questions (38.5% correct vs. 81.8% correct). Students also performed well on the class assessments, with an average course grade of 89.9% (n = 23). However, students gave the gamification format mixed reviews, with an almost equal amount wanting to take the course without the gamification aspect (60% vs. 40%), and most reporting that it had “no effect” on their learning. Although the sample size is small, these data indicate an increase in confidence working with proteins. Students were less interested in the group gamification format, although several gave specific suggestions to modify the format for greater effectiveness. This course and its evaluation can serve as a model for other schools interested in introducing active modes of instruction for students from traditionally underrepresented backgrounds and/or with lower incoming placement scores. In fall 2017, the opportunity presented itself to test the hypothesis that team-based learning environments disproportionately benefit students from underrepresented demographic backgrounds when a large introductory course for biology majors was split into two parallel lecture sections (AL1 and AL2) at the University of Illinois. Section AL1 was offered in the largest lecture hall on campus to 530 students in a front-directed configuration. Section AL2 was offered in a 90-seat scale-up room with students sitting in “research teams” at round tables. Both sections were taught by the same instructor in a flipped format and used the same learning goals, content, pre-lecture lessons, exams, and similar lecture activities. A quasi-experiment was conducted to test the impact of the team-based instructional treatment (AL2), with the parallel lecture-hall setting serving as a control (AL1). Data collection included: 1) learning outcomes (assessed using exam scores, and paired pre- and post-assessments), 2) observations of student engagement, and 3) attitudinal data in the form of surveys (IRB 16127). Chi-squared tests reveal significantly higher attendance, higher likelihood of in-class engagement, higher self-reported satisfaction with the course, and intent to remain in a STEM major in the team-based learning environment. Math ACT scores are significant predictors of exam scores in the AL1 control (r² = 0.32, N = 361) but are a poorer predictor in the AL2 team-based treatment (r² = 0.21, N = 56). This is attributable to elevated exam residuals of 6.5% in AL2 compared with AL1 after controlling for Math ACT scores. The results suggest that providing team-based learning environments is a disproportionately effective tool to close performance gaps for at-risk students, especially when large class sizes make this approach unfeasible for an entire course.

ASM Curriculum Guideline Concept(s): Evolution, Structure and function
Pedagogical Category(ies): Teaching approaches

B-16
The Effect of Case Study and Flipped Classroom Pedagogy, in a First-Year Cell Biology Class, on Self-Assessed Learning Gains and Class Performance
Sean T. Coleman, University of the Ozarks

Active learning research has often focused on flipped classrooms or teaching science using case studies. Flipped classroom studies suggest that the method improves academic performance and participant satisfaction. Competing research indicates these gains are due to active learning itself, independent of any specific method. Another component of effective teaching is student engagement. Research suggests case studies, as a pedagogical tool, increases student engagement and critical thinking. A common concern with using case studies as a primary method is the loss of detailed content acquisition. The design of this first-year cell biology course combined the engagement and critical thinking of case studies with the active learning of a flipped classroom. The class was taught in three 50-minute periods...
per week. Before the Monday class period, students were asked to read the chapter and take a pre-quiz, then watch videos of the lecture, and take a post-quiz. Class on Monday involved answering student questions, reviewing concepts, and group work. Wednesday was devoted to a subject-related case study. Finally, the Friday period included an overall chapter review and quiz. We hypothesized that the combination of flipped classroom and case studies would increase student grades and self-reported learning gains. Pre- and post-assessment of the class used the Student Assessment of their Learning Gains instrument. Increases in the mean were identified for all areas assessed, including 16% in student understanding, 8% in skills, 5% in attitudes, and 7% in integration. Over 90% of all student comments indicated positive gains in all attributes. Analysis of course and final exam grades indicates increases of 4.5% and 5.6%, respectively. Statistical analysis of grades by student’s t-test did not indicate significance at a p < 0.05 (n = 30). While, the increase in class and final exam scores were not statistically significant, at this sample size, there is evidence to support continued investigation of this combined pedagogy. This is especially true considering student self-reported gains in understanding, skills, attitudes, and content integration.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design, Teaching approaches

B-30
ENCOUR: Establishing a Network for the Integration of Ethics/RCR Education into CUREs in the Biological Sciences
Laura Diaz-Martinez (1), Ginger R. Fisher (2), Jay M. Bhatt (1), David Esparza (1), Aimee Hernandez (1), and Jeffrey T. Olimpo (1), (1) The University of Texas at El Paso, (2) University of Northern Colorado

Course-based undergraduate research experiences (CUREs) offer an innovative platform to engage students in authentic scientific practices. One critical component of such practice is the responsible conduct of research (RCR); yet few studies exist detailing the integration of ethics/RCR within CUREs in the biological sciences. In an effort to address this concern, we performed a mixed methods study to evaluate ethics/RCR implementation efforts within discipline-based CUREs at the national level. Survey data indicated that the majority (~85%) of respondents (n = 42) have resolved ethics/RCR issues within their courses. Common issues reported included collaboration, research misconduct, and authorship. Furthermore, a significant number of respondents (57.14%) indicated that they adopted practical, context-based ethics/RCR instruction in their classroom, which included both planned activities and unplanned discussions. In this case, practical pieces revolved around general topics such as lab safety, research design, and data sampling. In contrast, components such as data management, bias and objectivity, and other, more nuanced, topics were addressed less commonly (less than 30% of responses). Additional semi-structured interview data collected from CURE instructors, designers, program directors, and stakeholders (n = 12) indicated that a large majority (~85%) of individuals agreed that ethics/RCR education should be integrated within CUREs but noted a current lack of planned and intentional integration of ethics/RCR education into such learning environments. One prominent issue identified by participants (~92%) was a lack of faculty ethics/RCR training, which results in instructors addressing only those topics that they are comfortable discussing, rather than providing comprehensive ethics/RCR education within the CURE. Through formation of the Ethics Network for Course-based Opportunities in Undergraduate Research (ENCOUR), we aim to continue to address the above concerns through national conversation and exploration of effective approaches for integration of ethics/RCR education into CUREs.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Course design

B-36
The BIOMAN Academy: A Multi-College Approach to Enlightening High School Students to the Field of Biotechnology and Careers in Bioscience
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The BIOMAN Academy is a 4-day hands-on workshop designed for high school students to explore the fields of biotechnology and biomanufacturing through experimentation and career presentations from industry scientists. The hypothesis of this initiative is that hands-on lab experiences and career path knowledge increase interest and engagement in stem disciplines at the high school level, and positively influence retention in stem fields. In this workshop a lab based, hands-on approach allows rising sophomores, juniors, and seniors to learn the science behind biologic drug development and manufacture. The students perform techniques such as bacterial transformation and growth, mammalian cell culture, microbial environmental monitoring and quality control analysis by various technologies. Interwoven into these activities is a set of career presentations from local industry scientists that connect the learning experience to real world applications. Six Academies, each with 14 to 16 students, have occurred annually since 2016 at the six hub colleges that make up the Northeast Biomanufacturing Center and Collaborative, NBC2, an NSF-funded Advanced Technology
Bridging the Gaps: an Innovative and Integrated Undergraduate Fermentation Science Course
Paul M. Duffin and Kyle Schnitzenbaumer, Transylvania University

Undergraduate science is traditionally both taught and learned through disciplinary lenses. Often, students compartmentalize knowledge in courses and have difficulty making connections between disciplines. As brewing beer encompasses biology and chemistry, we (a physical chemist and a microbiologist) developed and team-taught an innovative and integrated undergraduate course on the science of fermentation. We hypothesized that our interdisciplinary team-taught approach would develop students’ ability to connect the chemistry and biology of brewing. The course was taught during Transylvania University’s May term where students take one intensive course for 5 weeks. The course explored the scientific principles of fermentation and was structured around students brewing standard 5-gallon batches of beers from malt extract. The course also covered the major characteristics of beer, the role of brewing ingredients/processes and how they affect the final product, and involved student measurements of various chemical and microbiological aspects of beer in the laboratory (e.g., microscopy, use of hemocytometers, mass and infrared spectroscopy). Furthermore, class sessions stressed how principles and analytical methods from chemistry and biology are used in brewing science. Students were often surprised to find out that mass spectroscopy is used in commercial breweries and could identify compounds made by yeast during fermentation. Pre- and post-tests and attitudinal survey data from the students suggest that using this team-taught approach aided students to see the interconnectedness of biology and chemistry as they apply to brewing. At the end of the course, students reported greater confidence in their ability to brew beer, increased understanding of beer and brewing in scientific terms, and improved ability to identify beer styles based on taste, smell, and color as measured by pre- and post-test (average of 70% higher on post-tests, standard deviation of 12%). We can also report that the course affected two students deeply; one now works as a quality control chemist at a commercial brewery and one has become an avid home brewer.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

A-23

Learning Strategies and Problem-Solving Performance in Microbiology
Josephine Ebomoyi, Northern Illinois University

Problem-solving means answering a question that requires an answer that is not readily available through memorization but must be constructed from information provided. Various learning strategies (LS) can affect problem-solving performance among students. The objective of this study was to determine the relationship between learning strategies and performance in problem-solving skills (PSS) using IMMEX educational software. In the program, participants begin with 1,000 points. Points are deducted based on the number of valuable steps to solve the problem. We hypothesized that, there would be a positive correlation between student’s LS and PSS while using IMMEX. Since many factors besides learning strategies affect performance, alpha was set at 0.10. Participants (N = 65) solved two sets of Microbiology problems, Microquest (Mq), which focuses on cellular processes and mode of action of antibiotics and Creeping Crud (Cc) which focuses on the cause, origin, and transmission of diseases. Participants also responded to the Motivated Strategy Learning Questionnaire (MSLQ). Scores for LS were determined by averaging the item responses of participants. There were 49 (78.6%) that solved Mq while 52 (82.5%) solved Cc. Hierarchical multiple regression was used for analysis with GPA (Grade point average) as a control. Metacognitive self-regulation strategy was significantly (p < 0.001) related to ability to solve Cc. Peer learning strategy showed a positive significant (p < 0.10) relationship with scores obtained from solving Cc. More time was spent on solving Cc than Mq (p < 0.001). Incorporating metacognitive learning modules would be helpful in curriculum development to ensure better learning outcomes. It would prompt learners to participate and monitor their own learning.

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Student learning, Teaching approaches
B-10 Enhancing Introductory Biology Students’ Conceptual Understanding of and Attitudes Toward Osmosis and Diffusion through an Interactive Learning Module

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A developed understanding of osmosis and diffusion is imperative to the comprehension of advanced biological processes that are addressed in the curriculum, including neural signal transduction and cellular transport. However, current research indicates that undergraduate students often have difficulty in comprehending and applying core principles associated with osmosis and diffusion, as presented within introductory biology learning contexts. In an effort to enhance student learning of the aforementioned topics within introductory cell and molecular biology courses at our institutions, we therefore created, implemented, and evaluated an interactive, three-session module. Module activities included: a) standard lecture with Clicker questions; b) a graphic organizer exercise on osmosis/diffusion, tonicity, and transport; c) a kinesthetic activity in which students played the parts of solute/water molecules and transporters; and d) a 15-minute video review with embedded thought questions. A quasi-experimental, pre-/post-test approach was used to evaluate students’ conceptual understanding (as measured via the Osmosis and Diffusion Concept Assessment [Fisher et al., 2011]) of and affect toward both the content presented in the module and module activities themselves. Paired t-tests with Bonferroni correction revealed a statistically significant increase in student knowledge over the course of the intervention \((p < 0.010\) for all comparisons across both institutions), as well as increases in students’ self-reported confidence in understanding module content \((p < 0.001\) for all comparisons across both institutions). Frequency analyses further suggested that >75% of students found the various components of the module informative and beneficial to their own learning.

**ASM Curriculum Guideline Concept(s):** Evolution
**Pedagogical Category(ies):** Teaching tools

A-37 Making Evolution Stick: Evaluating the Use of Sticky Notes to Teach Evolution

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“Nothing in biology makes sense except in the light of evolution” (Theodosius Dobzhansky, 1973). Although this belief is maintained by many scientists and educators, the complexity and abstract nature of evolution makes evolutionary mechanisms particularly difficult to teach, which can allow student misconceptions to persist. In our experience, students in college-level introductory biology classes fall into two categories: they have not learned the fundamental principles of evolution or, despite a grasp of the basics, they have an incomplete understanding of the details. To address these challenges in teaching and learning evolution, we have developed a hands-on activity that uses the commonly available “sticky notes” to visually demonstrate how certain evolutionary mechanisms occur.

Using the sticky-note activity in a first-year college level biology course, we hypothesized that our students would achieve the following learning objectives:

1. Define evolution as the change in allele frequency in a population.
2. List the main mechanisms of evolutionary change explored in this activity (genetic drift, founder effect, gene flow, natural selection, and population bottleneck) and give an example of how each might occur.
3. Describe how each mechanism affects the phenotype and allele frequency of a population.

A comparison of pre- and post-test results revealed that students improved in their ability to articulate mechanisms of evolution. For example, following the activity 70% of students could correctly identify mechanisms of non-adaptive modes of evolution, as opposed to 50% prior to the activity. While misconceptions still exist, future modifications to the activity will tackle these misconceptions.

**ASM Curriculum Guideline Concept(s):** Evolution
**Pedagogical Category(ies):** Student learning, Teaching tools

A-33 Teaching Scientific Communication in the 21st Century: Using Website Design as a Classroom Tool

Dawn Foster-Hartnett, Patricia Goodman-Mamula, Timothy Johnson, Daniela Vidovic, and Greta Henry, University of Minnesota

The University of Minnesota launched the Grand Challenge Curriculum (GCC) in fall 2015 to address important global issues using a solution-driven, interdisciplinary approach. In spring 2018, we taught GCC 3016/5016, “Science and Society: Working Together to Avoid the Antibiotic Resistance Apocalypse.” A major focus of this class was the exploration of diverse forms of scientific communication. Student groups were tasked with finding a particular issue within the larger problem of antibiotic resistance and proposing a practical solution. These were presented orally and in written form, but the capstone project was the creation of a website. We chose the website assignment because it allows students to synthesize information from many sources. Websites are rapidly becoming the principal hub for
dissemination of information. As they would for a traditional research paper, students used a variety of scholarly sources including interviews to develop and defend their solutions. We hypothesized that designing a website would increase students’ digital literacy and their ability to collaborate effectively both in-person and online, skills highly valued in the workplace. Students first attended a lecture on website design, then proceeded to analyze “good” and “bad” sites as homework. Students and instructors evaluated the first Google sites. The final products, incorporating student and instructor feedback, were shared with the class. Student learning and perspectives were evaluated using surveys with Likert scale questions and open-ended personal reflections. For most students, this was a novel exercise (77%). Students reported that this website design project was more engaging and creative than a standard writing assignment (85%). They also felt that it helped them develop collaborative skills (80%) and increased their confidence in visual data presentation (90%). Examples of student websites will be presented.

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Teaching approaches

A-19
Survey of the Endemic Fungi of the Great Basin: Incorporating Original Research into an Undergraduate Microbiology Laboratory Experience
Ruth Gault, University of Nevada

The importance of fungal species is becoming increasingly recognized in areas of human health, bioremediation and industrial applications. To date, there has not been a comprehensive survey of the fungal species endemic to the Great Basin region of Nevada. To begin to address this deficiency, students enrolled in the Introduction to Microbiology Laboratory at the University of Nevada, Reno, are engaged in original research to identify fungal species commonly found in the area. Students collect air samples, establish pure cultures, and identify organisms utilizing morphological characteristics and DNA sequence analysis. This is a semester long project that has been continuing for eight semesters. The goal of this research project is to establish a student-generated searchable database cataloging the fungal species currently found in the Great Basin. The information included in the database will consist of macro-morphology images, micromorphology images and DNA sequences. Students present their finding to their peers in an oral presentation where their communication, analytical and critical thinking skills are evaluated. Experience gained by the students includes experimental design, aseptic technique, microscopic imaging, DNA extraction, and sequence analysis. Students complete a self-assessment (pre- and post-semester) to evaluate learning in areas such as understanding experimental design (26% increase), keeping a lab note book (38% increase), data collection (26% increase), aseptic technique (57% increase), pure culture technique (64% increase), PCR (40% increase), electrophoresis (41% increase), data presentation (22% increase), laboratory calculations (25% increase), and overall confidence in the laboratory setting (36% increase).

Information generated by the students has the potential to benefit the public in areas such as asthma and allergy, agriculture, the food industry, bioremediation, and environmental microbiology. The work presented describes the design, methodology, and assessment used to establish original research in the undergraduate microbiology laboratory experience.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Hands-on projects

B-40
Incorporating Service-Learning into STEM
Ruth Gault (1), Meghan Schiedel (2), Abbey Grimmer (1), and Stacey Muse (1), (1) University of Nevada, (2) Terry Lee Wells Nevada Discovery Museum

Service-learning is defined as “course or competency-based, credit-bearing education experience in which students 1) participate in mutually identified service activities that benefit the community; and 2) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of personal values and civic responsibility” (Bringle & Clayton, 2012, p. 105). Service-learning is shown to have a positive effect on the personal and interpersonal development of students and academic learning among other benefits (Astin & Sax, 1998; Driscoll, Holland, Gelmon, & Kerrigan, 1996; Giles & Eyler, 1994), and is considered a “high-impact” practice (Kuh, 2008). Despite the growing support for community engagement, and the long-standing history of robust STEM education, there is a noticeable gap in service-learning offerings in STEM fields. The work described reflects the incorporation of service-learning into an introductory microbiology laboratory course at the University of Nevada, Reno. Student groups developed and presented floor-programming activities to interact with museum visitors at the Terry Lee Wells Nevada Discovery Museum (The Discovery). The project was assessed on areas including the development of learning objectives for the activity, creating interactive materials (coloring sheets, mazes, etc.), team cooperation, developing training videos and instructions for the museum staff.

The collaboration established between the Discovery and students enrolled in Introduction to Microbiology Laboratory (MICR 276L) has resulted in numerous benefits for the community partner and the participating students. These include experience communicating science to the public, developing STEM activities for the public audience, management of time and resources, conflict resolution, and fostering creativity. Students reflected on their experiences and the value of
service-learning to their academic goals and future careers. A self-assessment survey (pre-/post-semester) indicated that understanding of community issues increased by 44%.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research
**Pedagogical Category(ies):** Course design

**B-22 Easing Perceived Barriers to Course-Based Research Experiences: Impact of the PARE Project**
Elizabeth Genné-Bacon, Jessica Henry, and Carol Bascom- Slack, Tufts University School of Medicine

Course-based research experiences (CREs) are an effective way to expose large numbers of students to authentic research. Despite the benefits of CREs, most laboratory courses still use traditional cookbook methods. Research has shown many barriers exist that prevent instructors from using CREs, including time, resources/cost, and training requirements. Less is known about how these challenges can be mitigated to allow CREs to reach more students. The Prevalence of Antibiotic Resistance in the Environment (PARE) project is a CRE designed to overcome these challenges using a flexible module approach. To assess the impact of PARE on lowering barriers to implementation of CREs, we undertook a qualitative study of new PARE instructors, framed in diffusion of innovations (DOI) theory. DOI theory posits that the decision to adopt an innovation is influenced by five factors: relative advantage, compatibility, complexity, observability, and trialability. We hypothesized that for instructors who are already convinced of the relative advantages of CREs but who have struggled to implement one, a module-based CRE like PARE could reduce complexity and increase compatibility and trialability, tipping the balance in favor of implementing. We conducted semi-structured interviews with 19 new PARE instructors from diverse institution types. Thematic analysis was used to code interview transcripts for DOI-related themes. We found that all instructors believed in the relative advantage of CREs, particularly their potential to enhance student learning and engagement. While CREs tended to be compatible with beliefs and values about education, PARE’s perceived compatibility was higher, particularly with respect to instructors’ course structure/content, funding/resources and past teaching experiences. Trialability was higher for PARE compared with CREs, while perceived complexity was reduced. Our data suggest that for these instructors, PARE did effectively lower barriers for implementing CREs. Designing CREs to specifically address these common barriers could increase adoption of CREs, especially at schools with limited resources.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research
**Pedagogical Category(ies):** Course design, Teaching approaches, Teaching tools

**A-9 The Implementation and Assessment of a Learning Assistant Program in a High-Enrollment Microbiology Lecture Course**
Kimberly Gomez and Miriam Martin, University of California Davis

A learning assistant (LA) is an undergraduate student who is usually trained in pedagogy and supports student learning for a course they have already taken. We recruited LAs into a high-enrollment Introductory Microbiology lecture course to facilitate peer instruction and guide students during activities. While there is ample evidence that the presence of LAs leads to improved student outcomes, we performed a pilot study to identify the positive outcomes of LAs in this lecture setting. We measured their mastery of microbiology concepts through a concept inventory and their confidence as a microbiologist and educator through a survey, administered both before and after the term. In addition, each LA was asked to keep a teaching reflection, describing what worked, did not work, and should be changed for each session. These reflections were transcribed and coded into a color-coding system. The purpose of this study was to analyze the maturation of the LAs across the term: increased knowledge in microbiology concepts, effectiveness as an educator, and whether they had identified themselves as an educator. The expanded results have yet to be determined. The pilot study showed significant variability amongst the LAs, as some focused on student perceptions, others reflected on delivery of course materials, and still others on their own efforts of their engagement with the students. Also, the LAs did not show a net gain of knowledge, and there was variability in their self-reported effectiveness and identification as an educator. The expanded results will include an extended concept inventory to try to create a better picture of what the LAs know. They will be asked to self-report their confidence in teaching microbiology and respond to a science educator efficacy survey. They will also report how much they identify as an educator and how comfortable they feel in their role as an LA. Thus, the LAs can benefit in further developing their knowledge of microbiology concepts while also understanding the role of the professor and comparing it with when they were a student in the same course.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research
**Pedagogical Category(ies):** Student learning

**A-31 Art in the Microbiology Classroom: a Useful Tool to Motivate Students and Teach Complex Processes**
Patricia Goodman-Mamula, Lisa Bofencamp, Greta Henry, and Dawn Foster-Hartnett, University of Minnesota

Art in science can both inspire and motivate students to learn. We introduced three activities into a large
undergraduate microbiology class: agar art, concept maps, and March for Science posters. For the agar art, students exposed agar plates to air, culturing a range of bacteria and yeast. Isolation streaks provided purified isolates characterized by Gram stain and identified via MALDI-TOF MS. Students also determined metabolic characteristics, intrinsic antibiotic resistance, and oxygen/temperature requirements for selected isolates. We hypothesized this activity would effectively engage students’ interest in the microbial world as well as develop their microscope and aseptic techniques. Colorful class isolates were used to create agar art, some of which were submitted with essays to the ASM Agar Art Contest. This highly popular exercise prompted us to include a colorful concept map assignment we hypothesized would help students understand complex immunological relationships, typically the most difficult segment of the course. Finally, we provided interested students with art supplies to create posters for the 2018 March for Science, in an effort to increase students’ engagement in science outside the classroom. After each activity, student perceptions (n = 196) were measured using surveys with Likert scale questions. The majority of students (>90%) agreed that the agar art project increased their knowledge of microbial diversity and ubiquity as well as their understanding of how microbes are isolated, characterized and identified. They reported that concept maps helped them understand and remember immunology (61%) as well as study for the exam (54%). Most students (65%) felt that making a poster stimulated their interest in becoming active in scientific issues affecting their community. We conclude that art activities can be effective learning tools.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research  
**Pedagogical Category(ies):** Teaching tools

**A-35**  
**Bacterial Survivor: An Interactive Game that Combats Misconceptions about Antibiotic Resistance**  
Brinda Govindan, San Francisco State University

The growing threat of antibiotic resistant infections remains a huge public health concern. While the press has drawn attention to “superbugs,” many students do not understand how antibiotic resistance arises in a population of bacteria, and how exactly overuse or misuse of antibiotics contributes to this problem. To address misconceptions related to natural selection in the context of antibiotic resistance, we developed an active learning exercise for use in a large undergraduate nonmajors microbiology lecture course. The “Bacterial Survivor” game models the random nature of genetic change and the impact of environment on survival, as well as illustrating the basic principles of evolution. We predicted that this hands-on learning activity would shift students’ thinking about the role of natural selection in the development of antibiotic-resistant bacterial populations and combat common misconceptions. Prior to the activity, 48.5% of the students (n = 101) mistakenly chose the statement “antibiotics cause mutations in bacterial DNA that create new drug-resistant strains” to explain how the overuse of antibiotics in animal feed influences the emergence of drug-resistant bacterial strains. After the activity, only 23.7% of the students chose this incorrect statement. Students were also asked to respond to the following prompt: “Explain antibiotic resistance to a fellow student.” Prior to participating in the activity, student responses fell into four main categories: “bacteria can’t be killed by antibiotics,” “antibiotics cause mutations in bacteria,” “resistance is caused by overuse of antibiotics,” and “learned adaptation.” After the activity, student responses to this question showed a shift toward explanations that included an understanding of natural selection (43%) compared with responses that included the concept of natural selection prior to the activity (14%). Our results suggest that this activity positively impacted student learning by clarifying the concept that mutations and horizontal gene transfers are random, and that antibiotics themselves do not cause mutations in individual bacteria.

**ASM Curriculum Guideline Concept(s):** Evolution, Information flow  
**Pedagogical Category(ies):** Teaching tools

**B-34**  
**Achieve Career Success in Science through Excellence (ACSScellence): Impacts of a Longitudinal, Research-Intensive Program on Students’ Development of Scientific Process Skills, Science Identity, and Attitudes in STEM**  
Aimee Hernandez, Laura Diaz-Martinez, and Jeffrey T. Olimpo, The University of Texas at El Paso

Current reform initiatives within the STEM disciplines have emphasized a need to engage students at all levels in the rigorous process of scientific research. While this is the case, the longitudinal impacts of participation in such opportunities remain unclear. In an effort to address this need, we created the NSF-funded Achieve Career Success in Science through Excellence (ACSScellence) program, which provides scholarships and research opportunities for financially-disadvantaged first-time and transfer students pursuing a science degree at our university. Scholars are immersed in the research community via faculty-mentored laboratory experiences and participation in other curricular and extracurricular activities. These activities include, for instance: (a) external mentoring and conference opportunities; (b) technical writing courses; (c) a Research2Innovation course; (d) course-based undergraduate research experiences; and (e) biweekly meetings with program directors and peers. We hypothesized that engagement in these structured, multi-tiered experiences would enhance students’ knowledge, scientific identity, and affect in the domain. Quantitative analyses of pre-/post-/delayed post-semester survey data indicate, specifically, that participation in ACSScellence...
leads to significant improvement in scholar’s (n = 15) science identity development (p < 0.04 for all comparisons), experimental design proficiency (p = 0.033), and affect in STEM (p < 0.05 for all comparisons) relative to a matched comparison group. Semi-structured interview data further suggest that ACSScellence empowers students to “think like a scientist” as well as enhancing their professional identity and sense of belonging to a professional community. Collectively, these outcomes suggest that engagement in the ACSScellence program provides scholars with the knowledge and skills necessary for career advancement and for their development as leaders, mentors, and role models for future generations of STEM students.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research  
**Pedagogical Category(ies):** Student learning

**A-15**  
**Using Repetitive Summative Assessment to Increase Learning of Basic Calculations in an Introductory Biology Lab**  
John H. Horne, Henry W. Woolley, Jerome J. Howard, and Wendy M. Schluchter, University of New Orleans

Quantitative reasoning is one of the core competencies identified as a priority for transforming the undergraduate biology curriculum. However, incoming freshmen are often weak or lack confidence in their quantitative skills. This gap is often larger for first-generation college students and students from underrepresented minorities. We hypothesized that including questions on basic calculations and conversions on every quiz and exam throughout the semester would force students to learn and master these simple quantitative approaches. We tested this hypothesis in nine sections of an introductory biology lab course (Biology I). The majority of students in this course are first-semester freshmen. We introduced problems in the first two weeks of lab on (1) unit conversions, (2) calculating molar concentrations, and (3) calculating dilutions. We then included questions for all three of the approaches on five weekly quizzes, the midterm, and the final. We assessed student learning for each approach by determining the mean percent correct for each quiz/exam. Results indicate that learning improved for each of the three quantitative approaches assessed. Performance on unit conversions started relatively high but did improve by 18% (79% quiz 1 to 98% final). Performance on calculating molar concentrations showed larger gains, increasing 26% (52% to 78%), as did calculating dilutions, with a 27% increase (56% to 83%). We conclude that repetitive assessment of these approaches did lead to significant student learning, and some degree of mastery (98%, 78%, 83%). We don’t have data specific to these quantitative questions from previous semesters, but it is a reasonable assumption that learning would not have increased further after the midterm exam, which for this semester would have been 94%, 63%, and 76%. Thus, continued summative assessment led to continued improvement for at least 2 of the 3 quantitative skills. This suggests that employing similar repetitive assessment approaches in subsequent courses, with increasingly complex quantitative problems, could lead to significant gains in quantitative reasoning skills for biology majors.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research  
**Pedagogical Category(ies):** Course design

**A-41**  
**Environmental Sampling: An Approach to Integrate Education and Research**  
Rupa Iyer, University of Houston

The interdisciplinary research-based laboratory curriculum developed at the University of Houston (UH) in collaboration with industry and academic partners uses an organophosphorus-degrading bacterium, *Brevundimonas diminuta*, as an anchor organism to integrate the requisite cross-disciplinary skills. Three sets of laboratory activity modules are used to demonstrate the lifecycle of a typical biotechnology product guiding students through the process of scientific discovery to real-world applications. Module I is an Environmental Sampling Research Module (ESRM) that engages students in ongoing collaborative research activity to populate a database of the geographic distribution of environmental contamination and improve their interdisciplinary STEM skills. Through this activity, students collect and test environmental samples to isolate pesticide degrading bacteria, their results are then plotted with the Google Maps module using color-coded pins. At the end of this activity, students submit a research paper mining their own collective research data to enhance their interdisciplinary STEM skills. We have tested the effectiveness of integrating the ESRM in terms of knowledge, skills, and overall impact. Student success is measured through evaluation of exams, presentations, and written assignments. Student satisfaction with course and program competencies is assessed through mid-term and end-of-semester surveys. Data compiled from fall 2010 to fall 2017 show that students surpassed course performance standards, which require 80% of students to score at least 70 out of a total of 100 points or better on both research presentations and papers. In addition, 90% or more of students over this time period expressed high confidence in a measurable improvement to their STEM skillsets. Supported by the National Science Foundation’s, IUSE, Institutional and Capacity Building award, the ESRM, is currently being disseminated across diverse institutions, student types, to increase opportunities for the application of effective STEM teaching methods and improve student learning.

**ASM Curriculum Guideline Concept(s):** Impact of microorganisms, Advancing STEM education and research  
**Pedagogical Category(ies):** Student learning
B-2
Study Habits that Set the Bar: Identifying Effective Study Methods of High-Performing Students
Leilani Jones, Kavi Tan, Tiffany Johnson, and Miriam Martin, University of California Davis

Many under-performing students enrolled in STEM courses do not know how to prepare effectively for exams. Often, when asked to describe their study habits, these students list behaviors that are cognitively passive or overly time-intensive. Such behaviors include low-engagement practices, such as skimming textbook readings or repeatedly listening to podcasts of recorded lectures. In this study, our goal was to identify effective study habits by correlating student performance with self-described study habits. We hypothesize that students who engage in behaviors that are cognitively active when studying will perform highly on exams and in the course. We first collected information on how students prepared for the first exam offered in a large-enrollment introductory microbiology lecture course. The following optional, extra credit prompt was added to the last page of the first midterm: “Please describe your study methods, starting with how you read the textbook to how you prepared for this exam.” Responses to this prompt were coded into five major categories and nineteen subcategories of study behaviors. The average exam and course grades from those who did or did not report using each category of study behaviors were compared. Results from the analysis indicated that the most effective study habits were indeed cognitively active behaviors. The three most effective study habits included attending office hours, forming study groups, and assessment of knowledge using sources other than those provided by the course. However, information on how intensely or frequently students engaged in such behaviors is not clear. The results from this preliminary work were used to create a more detailed survey that asks students about the intensity and frequency with which they use each study behavior. This survey will be administered after the first midterm of a subsequent offering of the course as a tool to help students to reflect on the efficacy of their study behaviors.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-32
Impacts of the NSF STEM Scholars Program on Community College Student Success and Degree Completion
Renu B. Kumar and Maire Sustacek, Minneapolis Community and Technical College

Community colleges that serve many low-income, first-generation students are an important local resource to reduce demographic disparities in science and technology through excellent, accessible STEM education. Since students face economic barriers, inclusive pedagogy alone cannot solve gaps in STEM degree attainment—there is a need for additional high-impact student support strategies. We hypothesized if students are provided with scholarships and specific STEM-enhancing support strategies, then more students will be retained in STEM disciplines, and their GPA and course completion rates will be higher than those of other students. One such support strategy at our institution is the National Science Foundation STEM Scholars Program. This program provides academically talented, financially needy students STEM scholarships, faculty mentoring, and STEM enrichment opportunities. The NSF STEM Scholars program served 110 students over a five-year period, including 49% low-income students, 19% first-generation college students, and 37% students of color, mirroring the overall demographics of our institution. We assessed the impact of the program by examining the following outcomes: 1) GPA, 2) course completion, 3) degree completion and transfer. To determine student success and course completion, we compared outcome data for program scholars, all STEM students, and the overall student population. Students supported by the STEM Scholars Program are retained at a rate of over 79% (84/106). Indeed, 75% (67/89) of scholarship recipients eligible to do so have graduated, transferred, or entered the workforce in their chosen field. This is a significant improvement compared with the overall MCTC population, which had a 41% three-year graduation and transfer rate between fall 2013 and fall 2016. Scholarship recipients also showed an improved GPA of 3.28 and course completion rate compared with GPA of 2.77 of overall MCTC population. While these initial results are promising, further work is needed to examine how much of this effect is due to the selection process for scholars and to determine which aspects of the STEM Scholars program are most high-impact.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-20
The Effects of a Molecular Modeling Seminar on Visual-Spatial Reasoning and Science Identity
Maureen Leonard, Colleen Conway, and Laurel End, Mount Mary University

Scientific researchers use visual, spatial, and temporal models to link abstract and concrete representations of concepts and their consequences (Wai, 2009; Milner-Bo-lotin, 2011). Many kinds of imagery are employed when teaching scientific information, requiring students to possess visual-spatial abilities that are not explicitly developed in preparation for or during science classes. Previous work has shown using 3D CAD modeling improved spatial reasoning in engineering students (Martin-Dorta, 2008). The development of science identities is also essential to gaining
the self-efficacy needed to persist in STEM (Trujillo and Tanner, 2014). In a one-credit seminar course repeated over one year, Jewel Scholars examined the 3D structure/ function relationship in hemoglobin using Jmol, which we hypothesized would deepen their visual-spatial ability and establish a science identity (Graham, 2013; Freeman, 2014; Stieff, 2015). They produced a poster and a 3D model of specific aspects of the hemoglobin molecule. Mental rotation tests were used in the first year (2017–2018) to assess changes in visual-spatial reasoning ability. The CLASS and SMQ surveys and interviews were used to assess changes in personal interest in science, self-efficacy, motivation, and science identity. Scholars were interviewed to assess science identity and sense of belonging. Jewel Scholars (N = 7) showed no improvement in visual-spatial reasoning over a single semester as measured by the MRT-A (paired t-test) but did show an improvement as measured by the PSVT:R over a year (repeated measures ANOVA, p < 0.001). Triangulated survey and interview data showed no significant shifts in interest or motivation (z tests), or science identity (interviews) though there were trends toward more expert-like attitudes regarding problem solving (CLASS) and more discussion of thinking like a scientist and fitting into settings where scientists work (interviews). This shows the seminar class is effective in developing visual-spatial reasoning, but did not improve science identity. More programming specifically to strengthen science identity is proposed for next year’s seminar.

**ASM Curriculum Guideline Concept(s):** Structure and function, Advancing STEM education and research

**Pedagogical Category(ies):** Course design, Student learning

**B-26**

**The Benefits of Using Iterative Practices in a Microbial Biofilm Course-Based Undergraduate Research Experience**

Caitlin Light, Megan Fegley, and Nancy Stamp, Binghamton University

The Freshman Research Immersion (FRI) program is a three-semester course-based undergraduate research experience (CURE) focusing on student understanding and application of the process of science and professional skill development. One FRI research track is focused on microbial biofilms. A key learning outcome is to help students understand the value of iteration, which has been linked to STEM retention. Iterative research tasks include development of lab, analytical, and writing skills, plus running pilot experiments. Unfortunately, students often view such repetitive tasks as boring, or evidence of failure. We hypothesized that incorporation of learning activities that illustrate and reinforce the value of iteration in research would result in improved student-reported learning gains regarding iterative practices in two surveys: Laboratory Course Assessment Survey (LCAS) (Corwin et al., 2015) and the CURE Survey (Lopatto and Tobias, 2010). Such learning activities included reliance on accuracy in lab notebook records, iterative data analysis to drive research progress, and science writing and presentation with peer, mentor, and instructor feedback to illustrate the value of precision and refinement. Results from the surveys administered to three cohorts demonstrated gains for tasks where iterative practices were implemented instructionally and framed as important to the process of research. In the LCAS, FRI cohort #3 exhibited an iteration score of 86% compared with published results for a traditional biology lab course (72%) and a reference CURE (80%). The CURE Survey identified strong, student-reported learning gains in areas where iterative strategies were used, including learning laboratory techniques, ability to analyze data and other information, understanding of the research process, tolerance for obstacles faced in the research process, and skill in science writing and presentation. These results demonstrate that teaching strategies in CURE courses addressing students’ misunderstandings about the value of iterative tasks in research can enhance student learning gains and perceptions about research.

**ASM Curriculum Guideline Concept(s):** Impact of microorganisms, Advancing STEM education and research

**Pedagogical Category(ies):** Teaching approaches

**B-38**

**Health Sciences Microbiology Case Studies to Develop 21st Century Skills**

Lisa Loeffelholz, San Jacinto College

As educators, we participate in many forums about skill areas and critical thinking. We agree that certain skills are necessary for success, specifically being able to analyze and logically reason. A case-based teaching strategy was implemented in response to poor student performance. Since few exist for lower-division courses, case studies were developed to encourage critical thinking. This approach is novel because it considers the practice of clinical microbiology and use of virtual lab data. The aim of this project was to assess the effectiveness of case-based teaching versus traditional lecture when evaluating student learning. Methods included a survey-based assessment, formative assessments to evaluate comprehension and a summative assessment at the end of instruction. Case study elements included: patient history; disease differential and justification; specimen collection and lab testing workflow; analysis and interpretation of lab results to determine etiology; review of antimicrobial susceptibility data to determine treatment options. The survey was a self-assessment tool. Students reported increased engagement and improved skills such as effective use of resources and problem solving. Formative assessments involved completion of case studies to determine etiology. Students completed forms describing relevant characteristics of an organism. Forms were
examined for accuracy and completion and used to complete the case studies. The course included five case studies, which progressed in level of difficulty. Average scores on the first and final case studies were 62% and 85%, respectively. Summative assessments revealed an increase in student success when comparing pre- and post-case study groups as indicated by average exam scores of 67.76% and 76.90%, respectively. Exam questions to assess student learning in the traditional lecture format were not changed when using the case-based method. Lower exam scores were most likely due to memorization of content without comprehension.

In conclusion, the case-based teaching strategy improved independent student learning and helped to develop critical thinking skills.

**ASM Curriculum Guideline Concept(s):** Structure and function, Systems

**Pedagogical Category(ies):** Teaching approaches

**A-27**

**The Student-Centered Classroom: Probiotics and the Human Microbiome**

Jennifer K. Lyles (1) and Monika Oli (2), (1) Francis Marion University, (2) University of Florida

An innovative student-centered, interactive learning experience was implemented in an undergraduate pre-professional microbiology laboratory course. Students selected and prepared their own fermented products and used common microbiological and molecular techniques to analyze the probiotic content over a six-week time period. This student-centered learning experience emphasizes relevant scientific background information, as well as hands-on fermentation and laboratory techniques. Relating the topics of probiotics and fermented foods to the human microbiome and disease motivates students to master challenging concepts by contextualizing them in clinical, real-world scenarios, while learning basic microbiological skills. It was hypothesized that this experience would enrich student learning and engagement regarding the topics of probiotics and the human microbiome. To test the hypothesis, pre- and post-study surveys were administered using Qualtrics. To understand the students’ background and to incorporate their interests into the activities, demographic information was obtained, as well as medical history pertaining to gastrointestinal (GI) health, food habits, and background knowledge regarding probiotics and fermented foods. A total of 66% of student participants \( (n = 182) \) reported that they consume fermented products, but 86% have never prepared fermented foods or beverages. Despite their exposure to probiotics, the majority of students (79%) reported that they are unaware of the gut-brain axis. Most participants (91%) were curious about the topic and wanted to learn more. Based on post-study survey results, 85% of student participants report that they will apply what they have learned from this experience in their daily lives, 90% feel that the information learned will be useful in their future careers, and 100% report that they are likely to suggest consuming probiotics or fermented foods to a friend or patient experiencing GI issues. This innovative approach to student learning in a laboratory setting has encouraged students to make a real-life connection between microbiology, medicine, and their own health.

**ASM Curriculum Guideline Concept(s):** Impact of microorganisms

**Pedagogical Category(ies):** Hands-on projects

**B-6**

**Student Perspectives on the Efficacy of Anticipatory Activities and a New Bioinformatics App**

Tina Marcroft, Scott Kelley, and Chris Rasmussen, San Diego State University

Computing has increasingly become an integral part of the biological sciences. The substantial increase in the amount of data available to analyze as a result of next-generation sequencing and other high-throughput methods necessitates the use of more sophisticated bioinformatics software. Accordingly, undergraduate students require additional training in the operation and construction of this software’s algorithms. In a series of focus groups with undergraduate and graduate students, we explored the breadth of reactions to and use of a bioinformatics app and its associated anticipatory learning activities. The former is a new smartphone-, tablet-, or computer-based program that scaffolds students’ understanding of several foundational bioinformatics algorithms, while also providing unlimited randomized practice questions. The latter was administered before each relevant portion of the app and consisted of short, open-ended problem-solving activities designed to help students informally reinvent algorithms. We conjectured that students would make positive remarks about the utility of the app and perceive it as having helped them learn. We conducted three focus groups near the end of a bioinformatics course that used the app. They included seven participants, most of whom were graduate students. Students’ remarks were recorded and transcribed. Transcriptions were open-coded for different perspectives on the app and activities. Preliminary results suggest that 100% of the students found both useful and were motivated to use them. For example, one undergraduate suggested the app let her “see one step at a time” so if “you made a mistake, you could find exactly where the mistake was.” Another student stated, “I think doing it on the apps, and doing it actively and understanding it, really is gonna help me remember it a lot better.” Students’ perceived usage of the app ranged from 5 to 30 minutes per visit, and students’ usage patterns varied throughout the semester. Interestingly, 50% of graduate students did not fully recognize the intended purpose of the anticipatory activities, while 100% of the undergraduates we spoke to did.
Microbiome research is an attractive direction for new course-based undergraduate research experiences (CURES), as sample collection is relatively straightforward and the resulting large datasets give students an opportunity to ask a variety of questions. Current research in microbiology requires scientists to synthesize a background of experimental design with computational and statistical analysis. Despite the need for collaborations between computer science and biology, current academic programs at the undergraduate level often do not provide sufficient practice in bioinformatics, biostatistics, and other intersections between the two fields. To address this situation we developed the Pipeline for Undergraduate Microbiome Analysis (PUMA), which combines previously published processes and tools for microbiome research with a set of custom ‘plug and play’ python scripts for processing 16S sequencing data from a variety of sources. We also developed accompanying instructional modules and video tutorials to teach students both the theory behind the analysis tools and the skills for needed for visualizing and interpreting biostatistical data. We hypothesized that students using PUMA would be able to formulate and statistically test hypotheses linking environmental parameters (metadata) to diversity metrics, community composition, and inferred functional profiles. PUMA was assessed using entry/exit surveys and reflection questions designed to gauge the students’ comfort with integrating computational analysis with microbiology, and the Statistical Reasoning in Biology Concept Inventory (SRBCI). Preliminary qualitative analysis of surveys and reflection questions saw an increase in students’ self-reported confidence levels in using the analysis tools. Students assessed also improved their competencies with biostatistics, as demonstrated by the 10.5% improvement in the average score on the SRBCI. PUMA 16S sequencing data seamlessly transition to a suite of programs for microbiome data visualization and analysis, all of which are easily accessible to undergraduates without command line experience.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research
**Pedagogical Category(ies):** Teaching tools

**A-25**
**PUMA: Pipeline for Undergraduate Microbiome Analysis**
Jordan Moberg Parker, Keith Mitchell, Christopher Dao, Jiem Ronas, and Amanda Freise, University of California, Los Angeles

Empirical evidence within the bioeducation literature indicates that students’ development of quantitative reasoning skills is imperative for their success in both personal and professional arenas. Research furthermore demonstrates that engaging students in constructivist exercises that emphasize connections between the discipline and mathematical literacy have the potential to positively impact their attitudes toward quantitative tasks while decreasing their perceptions of themselves as poor quantitative reasoners and scientists. While this is the case, the majority of active-learning approaches described to date in this area focus on single implementations (e.g., one lesson or module) within the classroom, and more recent exercises appear targeted exclusively at introductory learning contexts. In an effort to address these concerns, we developed, implemented, and evaluated a horizontal curriculum that incorporated arctic/polar science research into an upper-division Quantitative Methods in Ecology course at our institution. Framing the course in this manner allowed us to retain one, common theme throughout the duration of the term (rather than multiple themes per method, as is traditional) as students applied their knowledge to address real-world questions and issues influencing the arctic/polar science community. The impact of the curriculum on students’ (n = 20) statistical reasoning abilities, statistics attitudes, and scientific process skills was assessed using the Statistical Reasoning in Biology Concept Inventory (SRBCI; Deane et al., 2017), Student Attitudes Toward Statistics survey (Schau, 1992), and Scientific Process Flowchart Assessment (SPFA; Wilson and Rigakos, 2016), respectively. Quantitative analyses of pre-/post-semester data revealed a statistically significant increase in SRBCI scores (p < 0.001) as well as a general increase in student affect (p ≤ 0.008 for all comparisons). Significant increases in students’ understanding of the nature of science, experimental design knowledge, and reasons for doing science were likewise observed on the SPFA (p ≤ 0.010 for all comparisons).

**ASM Curriculum Guideline Concept(s):** Systems, Advancing STEM education and research
**Pedagogical Category(ies):** Course design

**B-28**
**Metacognition and Critical Thinking Emerge as Key Goals in a Microbial Ecology CURE Lab**
Samantha T. Parks, Georgia State University

During the establishment of a microbial ecology CURE, several unexpected deficiencies in critical thinking and student confidence were observed. Students lacked the ability...
to construct a testable hypothesis and struggled to analyze research articles or their own data to adjust research goals throughout the semester. While obtaining meaningful data was always a goal of the CURE, such deficiencies prompted a second set of goals designed to further student reasoning and self-confidence.

In the CURE, students construct Winogradsky columns in order to test the impact of essential oils, herbs and spices upon microbial activity, including antibiotic resistance. Assessments include a research proposal, lab notebooks and reports, weekly journal club and research presentations.

It was hypothesized that through participation in the CURE lab, students would gain confidence in the lab and their ability to identify, read and understand pertinent scientific literature. At the conclusion of the CURE lab, students were informally surveyed to gain insight into the impact that participation in the CURE had had upon their confidence and scientific literacy. Students responded with their impressions of the lab, perceived outcomes, and ratings regarding their confidence with scientific literature, literature searches, experimentation, and their role as scientists. Students reported a range of beneficial outcomes including “working together as a lab helping each other,” “learning to write a research proposal,” and “learning how to do each of the experiments as a whole because I never understood the importance of these procedures until now.” The largest self-reported gains were observed when students were asked how much they “felt like a scientist” (30.9% increase) and about their “understanding of scientific literature” (27.3% increase). Such gains are particularly notable in that all student participants were upperclassmen and had already taken at least one upper level lab course. Such preliminary data lends support to further investigation of the impact of the CURE lab using structured surveys to measure self-confidence, scientific literacy, and metacognition.

ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Student learning

B-18
Impact of a Semester with Three Design-and-Improve Lab Modules on Introductory Students’ Statistical Reasoning and Experimental Design Skills and Sense of Autonomy
Iglika Pavlova, The University of North Carolina at Greensboro

To attract and retain STEM majors from diverse groups, institutions should provide students with the opportunity to engage in scientific investigation with significant authenticity and iteration, and to start early in required courses (Rodenbusch et al., 2016; Shaffer et al., 2014). Thus, three modules to study the effects of plant compounds on caterpillars, Daphnia, and bacteria were incorporated in two intervention sections of an introductory biology course. In each module, students worked in teams to design, implement, analyze, improve, write, and present their experiments; students applied any conceptual issues in experimental design and statistics directly to their own projects.

We hypothesized that only students in the intervention groups would improve their statistical reasoning and experimental design ability over the course of the semester. Students showed start-to-end of semester improvement in the intervention, but not in the traditional instruction, sections ($p < 0.001$) on the difficult Statistical Reasoning in Biology Concept Inventory test (SRBCI; Deane et al., 2016).

In contrast, there was no significant difference in either group on the Expanded Experimental Design Ability Tool (E-EDAT; Brownell et al., 2013), and both groups started with higher scores than published work (Marsan et al., 2016). To test the hypothesis that intervention students would report a sense of autonomy, we open-coded for themes in their end-of-semester reflections. The majority of students noted a feeling of being actively involved in experimental choices (61.5%), as well as understanding the scientific process better through their personal experience in experimentation (84.6%). These data indicate that engaging students in their own iterative experimentation may be an effective method to use in introductory science labs to teach statistical reasoning. A study with more students is examining rarely measured longer-term outcomes that will ultimately contribute to the budding scholarship on the elements and formats for the success of integrating undergraduate research in large-enrollment introductory courses at large, diverse, public institutions such as UNCG.

ASM Curriculum Guideline Concept(s): Systems, Advancing STEM education and research
Pedagogical Category(ies): Course design, Student learning, Teaching approaches

A-39
Analyzing the Impact of Service Learning on Civic Engagement and Sustainable Practices in a Large-Enrollment Nonmajors Biology Class
Samiksha Raut, Daniel Mendoza, Sarah Adkins, and J. Jeffrey Morris, The University of Alabama at Birmingham

National efforts to reform undergraduate education have highlighted the need to relate abstract concepts in biology to real-world examples on a regular basis. This is especially important for nonmajors, who may not otherwise realize the value of scientific processes in their day-to-day lives. Among the suggested interventions to help address this need, involving undergraduates in service-learning projects has been regarded as one of the most effective ways to increase the relevance of biology to their lives. We therefore decided to explore the impact of service learning on civic engagement and sustainable practices by introducing a new learning module on global climate change in a large-enrollment nonmajors biology class. To assess student learning gains ($n = 96$), an adapted
version of the instrument from Dauer and Forbes (2016) was administered in pre- and post-intervention format. The pre-/post- survey was designed in the form of an open-ended questionnaire to observe a shift in student knowledge about sustainable living and global climate change and how both of them affect human health. Based on our survey and focus group results, 30% of students showed an increased understanding of what global warming is and how it affects human health. Specifically, they were increasingly concerned about how plastic pollution could influence human health and how changing their personal habits could have a large environmental impact. This suggests that service-based learning could serve as a robust active learning activity to enhance student learning about global warming and environmental pollution within the context of an introductory biology course for nonmajors.

**ASM Curriculum Guideline Concept(s):** Information flow, Advancing STEM education and research

**Pedagogical Category(ies):** Course design, Student learning, Teaching approaches

**B-4 Managing Cognitive Load to Improve Student Performance**

Tracy Ruscetti, Erika Sweet, David McMillan, and Christelle Sabatier, Santa Clara University

Cognitive load theory posits that if working memory capacity is exceeded, all cognitive tasks suffer decline. Writing is a cognitive task, and, as such, writing quality depends on the volume of concurrent cognitive activities. Our research focuses on how quantitative writing about data is impacted by cognitive load. We developed a method to measure quantitative writing and scored quantitative writing samples from lab reports, exam questions, and classroom activities. For example, we administered a pretest in which students interrogated a simple 3 x 2 data table (3 conditions, 2 measures) and then wrote a quantitative statement in response to two prompts. One prompt narrowed students’ focus to consider only two values (low complexity = 2). The second prompt allowed students to choose which values to compare (high complexity = 6). Student writing scores in response to the low complexity prompt were twice as high as writing scores in response to the high complexity prompt (ANOVA, p = 0.011). These data suggest that decreasing the number of values a student must consider improves writing. We observed the same correlation when we asked students to write lab reports with complex data sets—students’ writing scores were lower when confronted with higher complexity data sets, but improved when we provided more explicit prompts. More explicit prompts helped students focus on the appropriate values that are relevant to the comparison and ignore irrelevant values. In addition to improved writing scores with more explicit prompts, we see improvement in critical thinking and reasoning scores. Our data suggest that helping students manage their cognitive load may give students the critical volume of cognitive space required for more in depth critical thinking.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research

**Pedagogical Category(ies):** Student learning, Teaching approaches, Teaching tools

**A-11 Ready for Biology? Predicting Achievement in an Introductory College Biology Course**

Anupama Shanmuganathan, Washington & Jefferson College

An important determinant of undergraduate retention in biology is achievement in introductory courses. Consequently, this study focused on achievement in an introductory college-level biology course and how it is impacted by various demographic and educational factors. Based on previous studies, it was hypothesized that one or more of six factors—gender, race, academic aptitude, prior knowledge of biology, first-generation college status, and number of semesters in college—would predict achievement in biology. Students enrolled in nine sections of BIO 121: Foundations in Cell and Molecular Biology (n = 395) at Washington & Jefferson College from four semesters (fall, 2014–2017) were included in the study. Achievement was measured by final course grade (%) and failure rates (grades D-F-W). Academic aptitude was measured with combined SAT (verbal + math) scores while prior knowledge was measured by the score on introductory cell and molecular biology concept inventory (CI) administered on the first day of classes. The results showed that mean course grade was significantly affected by race (lower by 5% for STEM minorities, p < 0.05), number of semesters at college (higher for freshmen by 7%, p = 4.4E-12), academic aptitude (lower by 7.7% for students with SAT scores of 1,150 or below, p = 1.11E-11), and prior knowledge of biology (lower by 6% for those with low CI scores, p = 3.8E-05). Over four iterations of the course, failure rates were 17% higher among STEM minorities, 30% higher among students with lower prior knowledge and 32% lower among students with lower academic aptitude. Contrary to previous studies, first-generation college status and gender did not significantly affect mean course grade or failure rate. Multiple linear regression analysis with course grade as the independent variable and the aforementioned six factors as dependent variables showed that academic aptitude and prior knowledge of biology were most predictive of achievement. The results of this study reveal factors that affect achievement in biology, help identify at-risk students and show that predictive educational factors may be leveraged to improve retention in biology.

**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research

**Pedagogical Category(ies):** Student learning
Thiru Vanniasinkam, John Harper, George John, and Andrea Campton, Charles Sturt University

In the classic science fiction book Dune, the Guild Navigators fold space to travel without moving. In our first-year General Microbiology class we have about 500 students, half of whom are studying by Distance Education (DE). We hypothesized that strategies to give DE students an ‘on-campus’ experience online (analogous to ‘folding space’) and emphasizing the relevance of microbiology to their programs would lead to better engagement and performance in the course. We teach this Microbiology course in 16 undergraduate programs ranging from the Bachelor of Agricultural Sciences to the Bachelor of Biomedical Sciences. Strategies to “fold space” included personal recording of lectures specifically developed for our Distance students, rather than recordings of lectures given to on-campus students. Online meetings to provide synchronous contact with on-campus students and discussion forums that were managed to provide rapid responses to questions were some strategies implemented to provide a supportive learning environment. To show relevance of the course to various programs, the first lecture linked the importance of microbiology to the different programs and future careers with discipline-specific examples throughout the course. Students were also assessed on the relevance of microbiology to their program. The success of these strategies is reflected in formal confidential student evaluations over the last 10 years. Student satisfaction in the course went from 4.7 to 6.3 (on a scale of 1 to 7) and retention of students doubled over this period. Overall, the average subject satisfaction rate for the distance cohort was 79.2 ± 3.3%. The overall average percentile ranking of all core questions asked in the survey was 45.6 ± 9.3. One of the key features of our approach was our engagement with students in a way that was supportive and relaxed, where humor was used in a positive way to help students learn and to see the fun in learning. The data suggest that strategies implemented in this course were effective in enhancing overall course engagement and performance in this student cohort.

ASM Curriculum Guideline Concept(s): Information flow, Impact of microorganisms
Pedagogical Category(ies): Course design, Student learning, Teaching approaches

Handwashing is one of the most effective methods to deter the transmission of potential pathogens. Although the didactic material is presented and assessed on exams, it is uncertain whether student handwashing behavior is altered. We hypothesize that an observational study of handwashing in restrooms will improve student awareness of personal handwashing behavior.

The assignment instructed students to unobtrusively observe thirty individuals in a publicly-accessible restroom. Students recorded whether individuals attempt to wash their hands with soap and/or water and the duration of the process. Students also collected data about other behavior until the individual departs the restroom. After completion of the study, students wrote a report about their findings, which is assessed on a rubric.

At least four undergraduate Clinical Microbiology courses are included in the study over a six year period. Students in the course were predominantly nursing students. Pre- and post-assignment surveys were administered that included five-point Likert questions addressing student perception of public and self-handwashing technique and behavior, as well as student perceptions of the assignment.

The Mann-Whitney test of Likert results indicated student awareness of washing for the prescribed 20 seconds was greater after the assignment (mean = 3.63 ± 0.13) than before the assignment (mean = 4.32 ± 0.10), p < 0.001. Separate analysis of student awareness of recontamination after handwashing was not significant after the assignment, p = 0.854. These preliminary results support the continued use of the assignment in future semesters as a means to increase student awareness of handwashing behavior.

ASM Curriculum Guideline Concept(s): Advancing STEM education and research
Pedagogical Category(ies): Student learning, Teaching approaches