24th Annual ASM Conference for Undergraduate Educators (ASMCUE)

Sheraton Denver Downtown Hotel
Denver, Colorado
July 27–30, 2017

ANNUAL CONFERENCE ABSTRACTS
Poster Presentations – Saturday, July 29, 2017

Session A
Author Presentations: 9:15 AM – 10:15 AM

Session B
Author Presentations: 1:30 PM – 2:30 PM

ALIGNING ASMCUE ABSTRACTS TO BIOLOGICAL CONCEPTS

The 2017 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 (www.asm.org/index.php/guidelines/curriculum-guidelines). The guidelines identify six overarching concepts, which provide a framework for 22 key microbiological topics, and two key skills and are based on concepts put forth in the 2011 national report, Vision and Change in Undergraduate Biology: A Call to Action. The ASM concepts and topics were selected to promote deep understanding of core concepts that are deemed to be of lasting importance beyond the classroom. Likewise, students’ development of competency in the selected skills will have enduring and lasting value beyond both the classroom and laboratories.

In May 2012, a Perspectives article published in the Journal of Microbiology & Biology Education (JMBE) entitled, “The Development of Curricular Guidelines for Introductory Microbiology that Focus on Understanding,” described the consensus-building process around the new, concept-based curriculum for Introductory Microbiology courses.

For the purposes of ASMCUE, a seventh concept, advancing STEM education and research, has been added to the abstracts in order to identify authors working in this broader-scoped area. The seven concepts are therefore: evolution, structure and function, pathways, information flow, systems, the impact of microorganisms, and advancing STEM education and research.

The pedagogy themes are organized into five categories: course design, hands-on projects, student learning, teaching approaches, and teaching tools.

Each abstract is assigned to both content and pedagogy themes. These assignments, designated by the submitting author, are indicated for each abstract. A quick reference index listing abstracts by content and pedagogy is available on p. 17, and by author on p. 18.

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Does a Discovery-Based Activity about Herd Immunity Change Student Attitudes about Vaccination?
Rebecca Rashid Achterman, Bastyr University

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

2-B
Student Attitudes toward Biology in an Introductory Biology Course at a Two-Year, Open-Access College
Amy Beumer, University of Cincinnati, Blue Ash College

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

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3-A
Concept Inventory Development Reveals Common Student Misconceptions about Microbiology
Amy Briggs, Beloit College

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

4-B
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Christopher Burtner, Harvard Medical School

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

5-A
Monitoring Student Learning Outcomes in a Course-Based Undergraduate Research Experience Focused on Next Generation 16S Sequencing
Amanda Cottone, University of Pennsylvania

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

6-B
Preliminary Assessment of a Microbial Ecology Research Capstone for Gains in STEM Skills and Attitudes
Pratima Darr, Georgia Gwinnett College

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

7-A
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Sagarika Dash, Glendale Community College

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

8-B
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ASM Curriculum Guideline Concept(s): Impact of microorganisms, Advancing STEM education and research
Pedagogical Category(ies): Hands-on projects

9-A
Implementation of a Biology Concept Assessment Tool (BCAT) for Nonmajors Biology
Melissa Eslinger, US Military Academy, West Point

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

10-B
Mix of the Old and the New: Identification of Bacteria
Jeanetta Floyd, Georgia State University

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

11-A
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Marsha Gaston, University of Cincinnati Blue Ash College

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

12-B
Student-Driven Independent Research Investigations in an Introductory Majors Microbiology Laboratory Course
Brinda Govindan, San Francisco State University

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

13-A
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Julie Grainy, University of Georgia

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

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John E. Gustafson, Oklahoma State University
ASM Curriculum Guideline Concept(s): Structure and function, Advancing STEM education and research
Pedagogical Category(ies): Course design, Hands-on projects, Teaching approaches

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

16-B
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Adam Kleinschmit, Adams State University

ASM Curriculum Guideline Concept(s): Structure and function, Information flow
Pedagogical Category(ies): Teaching tools

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Alice Lee, North Carolina State University

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

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Mustafa Mujtaba, Florida Gulf Coast University

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

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Jennifer O'Connor, Rose-Hulman Institute of Technology

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

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Adeolu O luremi, Ladoke Akintola University of Technology

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

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Christopher Parker, Texas Wesleyan University

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

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Analyzing the Effects of Formative Assessment in Promoting Transfer of Learning in an Undergraduate General Microbiology Course
Andrea Rediske, University of Central Florida

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

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Andrea Rediske, University of Central Florida

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

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Tracy Ruscetti, Santa Clara University

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

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

26-B
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Johanna Schwingel, St. Bonaventure University

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

27-A
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Emily Smith, Middle Tennessee State University

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

28-B
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Jason Tor, Hampshire College

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

29-A
Interdisciplinary Service Learning Project for Water Quality and Supply Assessment in Low-Income Homes of Barrio San Agustín, San Francisco Solano, Buenos Aires Metropolitan Area–Argentina
Diana Vullo, Universidad Nacional General Sarmiento

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

I-A
Does a Discovery-Based Activity about Herd Immunity Change Student Attitudes about Vaccination?
Rebecca Rashid Achterman, Bastyr University

Vaccine-hesitant individuals are a heterogenous group who hold varying degrees of indecision about specific vaccines or vaccination in general. We hypothesize that students at a Natural Health Science University will have attitudes about vaccines consistent with vaccine hesitancy and will become more supportive of vaccination after exposure to a discovery-based activity about herd immunity.

Two undergraduate-level microbiology courses are included in the study over a three-year period. The activity involves modeling disease spread in a population and is conducted in one course, taken by students enrolled in Nutrition or Acupuncture and Oriental Medicine programs. A second course, taken by Human Biology majors, does not conduct the activity.

The first year of this study has been completed. For both courses, a pre-/posttest survey was administered that included Likert questions addressing vaccine hesitancy, as well as an open-ended question to probe student attitudes. Summative assessment from Exam 2 and an anonymous open-ended question were also included. We found that five of the six survey questions hold together as an overall measure of vaccine hesitancy (Cronbach’s $\alpha = 0.732$ at pretest; $\alpha = 0.725$ at post-test). One concern had been that students in the control course would have more favorable initial attitudes toward vaccination; however, the mean of the initial measure of vaccine hesitancy between the courses at pretest was not significantly different.

Results of paired t-test analyses indicate that students in both courses exhibited more favorable attitudes toward vaccination at the end of the course, as evidenced by increased scores on the overall measure from pre- to posttest that approached statistical significance ($n = 16$; $t = -1.724, p = 0.053$). Separate paired t-test analyses on individual items demonstrated similar trends with the greatest changes from pre- to posttest for questions addressing herd immunity ($t = -3.576, p = 0.002$) and likelihood to recommend vaccination ($t = -2.611, p = 0.01$). These preliminary results justify continuing the project in future years to determine whether the discovery-based activity has a specific effect.

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

2-B
Student Attitudes toward Biology in an Introductory Biology Course at a Two-Year, Open-Access College
Amy Beumer, University of Cincinnati, Blue Ash College
One of the goals of educating future biologists is to work with students to move them toward thinking like a biologist. This can include attitudes toward intellectual skills such as problem solving abilities, reasoning, and an understanding of biology beyond memorization. It also means focusing on other attitudes toward science such as enjoyment and the connection of biology to the real world. The purpose of this research was to determine whether student attitudes in a first-year Biology majors course at a two-year, open-access college with relatively small classes matched those at four-year schools, both initially and in changes over a one-semester introductory biology course. Due to different student populations, the hypothesis was that attitudes both initially and after one semester would differ from those in a student population of a four-year school. The validated CLASS-Bio survey was administered in the first and last weeks of the semester to assess student attitudes (Semsar et al. 2011). Data were collected using the Qualtrics platform and analyzed using the Microsoft Excel spreadsheet provided by Semsar et al. (2011). Differences in survey results were assumed to be statistically significant if they exceeded two standard errors of the mean (SEM), which is greater than a 95% confidence interval (1.96 × SEM) (Altman and Bland 2005). Seventy students were validated for the pre-semester survey, but only 30 students responded to both the pre- and post-semester surveys. On the pre-semester survey, 65% (±4.0 SEM) of the paired student sample (n = 30) and 68% (±3.0 SEM) of the unpaired (n = 70) answered in a manner more similar to experts than novices. This is significantly higher (>2 SEM) than the 57% reported for majors biology by Semsar et al. (2011) in their validation study, but only slightly higher than the 65% reported by Hansen and Birol (2014). On the post-semester survey, 67% (±3.8 SEM) of students (n = 30) answered favorably for no gain or loss in expert views (<2 SEM). This differs from other studies, where Biology majors’ views shifted to more novice over the course, but mirrors the patterns for nonmajors biology students (Semsar et al. 2011, Ding and Mollohan 2015). Factors that might explain the discrepancy to some extent include this study’s small sample size (n = 30 vs. 370) and the duration between pre- and post-semester survey. Second, this study was performed at a two-year open-access college, where students’ backgrounds are quite diverse. Further research is necessary to tease apart factors. I plan to run this survey again in the fall of 2017 with a larger sample size to also allow me to investigate the role of student background and class format on initial and changing attitudes.

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

**Pedagogical Category(ies):** Student learning

### 3-A

**Concept Inventory Development Reveals Common Student Misconceptions about Microbiology**

Amy Briggs, Beloit College

Misconceptions, or alternative conceptions, are incorrect understandings that students have incorporated into their prior knowledge. The goal of this study was the identification of misconceptions in microbiology held by undergraduate students upon entry into an introductory, general microbiology course. This work was the first step in developing a microbiology concept inventory based on the American Society for Microbiology’s Recommended Curriculum Guidelines for Undergraduate Microbiology. Responses to true/false questions accompanied by written explanations by undergraduate students at a diverse set of institutions were used to reveal misconceptions around fundamental microbiology concepts. These data were analyzed to identify the most difficult core concepts, misalignment between explanations and answer choices, and the most common misconceptions for each core concept. From across the core concepts, nineteen misconception themes found in at least 5% of the coded answers for a given question were identified. The top five misconceptions, with coded responses ranging from 19% to 43% of the explanations, are described, along with suggested classroom interventions. Identification of student misconceptions in microbiology provides a foundation upon which to understand students’ prior knowledge and to design appropriate tools for improving instruction in microbiology.

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

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

### 4-B

**A Discovery-Based Summer Research Laboratory for High School Students in the Genetics of Aging**

Christopher Burtner, Harvard Medical School

The Summer Learning Laboratory in the Molecular Genetics of Aging is a three-week boot-camp style, discovery-based research experience for under-represented minority (URM) high school students. The hypothesis of this educational intervention is that authentic research experiences contribute positively to the retention of URM students in STEM fields by 1) training them as practitioners in the field and 2) developing their sense of identity as a scientist in a research community. In lab, students investigate the link between genetics and longevity by measuring the lifespan of baker’s yeast *Saccharomyces cerevisiae* harboring gene deletions. In the process, they develop skills in pipetting, serial dilutions, spectrophotometry, CFU plating, and data analysis and visualization, with a focus on quantitative methods and data reproducibility. We administer the Survey of Undergraduate Research Experience (Grinnell College) to measure learning gains in areas such as “Learning laboratory techniques,” “Understanding how scientists work on real problems,” “Tolerance for obstacles faced in the research process,” and “Readiness for more demanding research.” Data from the survey indicate that
laboratory participants had outstanding learning gains in these categories, matching and, in most cases, exceeding the learning gains of undergraduate university students in summer research experiences. A second survey instrument that is unique to our program asks students to report the degree to which they feel the program made clear how scientists train for their work, how research is accomplished in a team, and how scientists collaborate on large projects. The program-specific survey indicates students received clarification on the process of training in research and the kinds of challenges scientists face during training. To track long-term outcomes, we are developing an alumni database to determine the degree to which lab participants seek other research opportunities and persist in STEM education.

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

6-A  
**Monitoring Student Learning Outcomes in a Course-Based Undergraduate Research Experience Focused on Next-Generation 16S Sequencing**  
Amanda Cottone, University of Pennsylvania

The AAAS called for undergraduate biology educators to design innovative research curricula that introduce students to the scientific process and more closely model the practices of scientists. We designed a research unit that engaged 943 students in next-generation 16S sequencing in their introductory biology lab course and hypothesized that the new curriculum would enhance student learning outcomes compared with students enrolled in a “verification” lab course. In pre- and post-course surveys, we measured the following outcomes: students’ content knowledge gains, their attitudes toward learning science, and their understanding of the scientific process. We also implemented curricular changes after the pilot year to improve learning outcomes (e.g., we moved the research unit from the first to the second semester of the introductory series to allow more time for students to strengthen their understanding of the scientific process and genomics). We used linear mixed effects modeling to assess students’ changes in attitudes and their understanding of the scientific process, and we compared these outcomes among five cohorts who participated in the research unit and a control group (n = 115) that did not engage in authentic research. Results show that the post-pilot year changes resulted in an increase in content knowledge gains (e.g., a post-pilot year cohort showed a 54% increase in correct responses on designing appropriate hypotheses, whereas pilot year cohorts showed no change or a decrease in correct responses). Linear mixed effects modeling showed that students’ attitudes and their understanding of the scientific process did not differ significantly when compared with the control group; however, a slight trend showing improved student attitudes exists in non-pilot year cohorts. These data show positive attitudes and increased understanding of the scientific process are not automatic byproducts of conducting scientific research in undergraduate biology courses. Our future research will look at following these results longitudinally, and collecting qualitative data to understand why students are exhibiting such trends.

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

6-B  
**Preliminary Assessment of a Microbial Ecology Research Capstone for Gains in STEM Skills and Attitudes**  
Pratima Darr, Georgia Gwinnett College

Research-based capstone courses are a powerful vehicle for increasing inclusivity. A theme focused on microbial ecology was implemented in a preexisting undergraduate capstone course to enable Biology majors to choose their own research focus and then use current techniques to engage with it. Briefly, students investigate a microbial community using both culture-dependent and culture-independent methods and then communicate their findings in oral and written formats. Specifically, students are exposed to FISH (fluorescent in situ hybridization) as a high-impact culture-independent technique for microbial community analysis. We report the use of a newly developed quiz to assess gains in research skills. A survey in use for all STEM courses under assessment for successful integration of investigative principles, at our institution, gauged attitudinal changes that may relate to persistence in STEM, as did instructor-prompted feedback. We hypothesized that the quiz would reveal improvement in content knowledge and research skills and that the survey and guided feedback would reveal increased interest and confidence in students’ ability to conduct research. The quiz revealed that over 90% of students remain deficient in quantitative reasoning. On the positive side, over 50% made significant gains in their understanding of microbial culture practices and nucleic acid hybridization applications. N for our assessments is only 14. The survey indicates that over 50% of students felt that they became better at overcoming obstacles and understanding scientific writing standards. Guided feedback reveals students’ empowerment from being able to select their research focus and a sense of functioning more like “real” scientists. Though these data are preliminary, they have led to the development of new exercises to promote higher levels of quantitative reasoning and understanding of sophisticated techniques like FISH. Better practices for improving the quality of scientific communication have also been adopted as a result. We seek to share these and our assessment data with the greater community of biological educators.
**ASM Curriculum Guideline Concept(s):** Advancing STEM education and research  
**Pedagogical Category(ies):** Course design, Student learning

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### 7-A

**Impact of Formative Assessments on Student Learning in Bioinformatics**  
Sagarika Dash, Glendale Community College

Despite the rise in bioinformatics course offerings at the undergraduate level, academic institutions face many challenges in implementing effective learning assessments for students. Several studies show that formative assessments play an important role in improving student engagement and learning. Given these findings, I hypothesize that implementation of a three-step formative assessment method will have a positive impact on student learning in undergraduate bioinformatics courses. For this study, a three-step assessment method consisting of 1) pre-lesson assessment, 2) completion of tutorials and homework assignments, and 3) post-lesson assessment was developed and implemented to measure student learning in an undergraduate bioinformatics course. Due to the interdisciplinary nature of the bioinformatics course, information regarding students’ background and experience in molecular biology, bioinformatics algorithms, and computer science (programming languages) was collected using an online survey on the first day of the semester. Analysis of the survey clearly indicated varied levels of academic preparedness among the students. Multiple-choice pre-assessment quizzes were created and administered at the beginning of every module using Canvas Learning Management System (LMS). After teaching the bioinformatics concepts, online tutorials and inquiry-based homework were assigned to evaluate students’ learning and their ability to apply the bioinformatics concepts and tools to real-world problems. At the end of each module, a post-assessment quiz was administered. A paired t-tests analysis using R program was used to compare the pre- and post-assessment scores. This analysis clearly indicated a statistically significant increase in student performance in the post-assessment scores ($t = 11.761, p < 0.05$) in all modules. Although these results support my hypothesis, further research would be necessary to determine the impact of these learning gains on students’ higher-order cognitive skills in bioinformatics.

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### 9-A

**Implementation of a Biology Concept Assessment Tool (BCAT) for Nonmajors Biology**  
Melissa Eslinger, US Military Academy, West Point

Introduction to Biology is a novel one-semester course offered to non-STEM majors at the United States Military Academy. A biology concept assessment tool (BCAT) was designed to assess conceptual understanding in cell biology, genetics, evolution, and human physiology. While concept inventories exist for several sub-disciplines, our knowledge, there is not a composite inventory tool for a survey biology course. We present the BCAT, a 30-question multiple-choice tool that spans an undergraduate introductory biology course, paralleling course outcomes. The BCAT was administered to 138 cadets during the initial offering of
the course. Comparing pre- and post-course performance demonstrated that cadets averaged a 41% normalized gain following instruction. Further, performance was analyzed by predictors of success such as SAT/ACT scores, performance in previous science courses, and college entrance examination rank (CEER) scores. These predictors facilitated the categorization of the enrolled students into at-risk, average, and scholar populations. This categorization correlated with observed patterns in measurable gains on the BCAT, whereas student gender, faculty experience, and faculty training had no effect on performance. Test validity was benchmarked by the performance of 80 cadets majoring in life science who had completed a one-semester advanced biology course. The nonscience majors performed as well as—if not better than, in particular areas—STEM majors upon completion of the one-semester introductory biology course. BCAT pre- and post-course question discrimination and difficulty analysis, once compared, showed an overall shift in difficulty from “hard” to “medium/easy,” indicating a gained understanding of previously unfamiliar concepts. Together, these data serve to validate the BCAT as a valid assessment of student learning in a one-semester introductory biology course. This tool proved useful in assessing comparative gains between populations and in identifying common misconceptions to provide quantitative evidence for deliberate biology curriculum adjustments.

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

10-B
Mix of the Old and the New: Identification of Bacteria
Jeanetta Floyd, Georgia State University

Molecular techniques are used in a vast number of academic, industry, and clinical laboratories to identify and study bacteria. To prepare undergraduate students for research careers, it is important to expose them to these techniques and provide opportunities to apply them. In the clinical setting, molecular assays have become widely available for diagnostic microbiology, spurred by technological developments and therapeutic demands. Biochemical and culture-based techniques are practical; however, these methods can take up to 16 hours or longer to diagnose agents of infection. Furthermore, not all microorganisms are able to be cultured in a laboratory setting. Traditionally, in our labs, we have identified bacteria using only biochemical techniques. In an effort to prepare current microbiology students, our majors microbiology course has implemented a three-week-long exercise in which students used both biochemical test and molecular techniques to identify two bacteria. The molecular techniques used included DNA extraction, PCR, gel electrophoresis, PCR purification, DNA quantification, sequence analysis, and phylogenetic analysis. We hypothesize that the use of molecular techniques in this exercise will enhance student comprehension of these techniques and their confidence in using the techniques as a skill on a resumé.

Student learning was assessed via Likert scale-based surveys (n = 26). Survey data show an increase in student comprehension, with 58% of students agreeing, and 15% strongly agreeing with having more knowledge regarding molecular techniques and their application after completing this exercise. The data also show a slight increase in confidence in using and listing molecular techniques as a resume skill. In particular, 35% of students agreed and 27% strongly agreed with being content in using their skills on a resumé. These results suggest that the use of molecular techniques to identify bacteria in a majors microbiology course increases student comprehension of molecular methods and also increases student confidence in listing these skills on a resumé.

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

11-A
Analysis of Student Performance in Allied Health Microbiology Versus Performance in Three Different Prerequisite Courses
Marsha Gaston, University of Cincinnati Blue Ash College

Identifying barriers to student success in allied health programs is important to increase retention of these students and program completion. Potolsky et al. (2003) reported a positive correlation between performance in prerequisite science courses and success in the first two years of baccalaureate nursing programs, while Ward et al. (2010) found no similar correlation in a baccalaureate dental hygiene program. Despite ultimate successful completion of a program, needing to repeat a required course due to an earned D/F/W adds financial and time barriers to student success, especially at an open-access, two-year institution such as University of Cincinnati (UC) Blue Ash College. One semester of an allied health microbiology course with lab is required for students either before acceptance into the nursing, dental hygiene, veterinary technology, and pre-pharmacy programs at UC or early on in the chosen program. Allied health microbiology has a prerequisite of at least a C- in allied health biology, major-level biology, or anatomy and physiology. Twenty-two percent of students enrolled in microbiology between 2013 and 2016 earned a D/F/W at UC Blue Ash despite this requirement. As three different courses may be used as a prerequisite, it was hypothesized that differences in success in microbiology would be observed based on the type of prerequisite course. Only those who completed a
prerequisite course at UC and enrolled in microbiology at UC Blue Ash were included in the data pool. Grades for students enrolled in microbiology, each student’s corresponding prerequisite course, and their grade in that course were compiled and de-identified (n = 770). Data for grades earned in microbiology were compared with the identity and grade in each prerequisite course. This study focused on students who needed or will need to repeat microbiology to complete their program after earning a D/F/W (n = 172). Of the students who earned a B in allied health biology and enrolled in microbiology (n = 85), 37.6% earned a D/F/W in microbiology. This is significantly higher, calculated using a z-test, than those who earned a B in majors biology (11.7% of 60 students, p = 0.00054) and those who earned a B in anatomy and physiology (9.3% of 150 students, p = 0). Similarly, a higher percentage of students who earned a C in allied health biology (62.3% of 53 students) earned a D/F/W in microbiology compared with students who earned a C in majors biology (37.9% of 29 students, p = 0.034) and anatomy and physiology (23.7% of 93 students, p = 0). No statistical differences were calculated when comparing grades in majors biology and grades in anatomy and physiology within this population of students. As many student learning outcomes overlap between these courses, future studies will need to identify potential reasons for these discrepancies. These findings may be used to provide data-driven advising or targeted support resources to students based on their grade in certain prerequisite courses early in their academic careers.

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

12-B
Student-Driven Independent Research Investigations in an Introductory Majors Microbiology Laboratory Course
Brinda Govindan, San Francisco State University

In a large urban university setting, where the majority of students are commuters, opportunities are limited for providing all Biology majors with authentic laboratory research experiences. We addressed this challenge by redesigning the curriculum of a majors introductory microbiology laboratory course to focus on student-driven, inquiry-based research projects. We predicted that this intervention would have a positive impact on 1) student engagement, 2) experimental design skills, and 3) understanding of the process of science. Students (n = 41) chose their own research questions on a wide variety of microbiology topics, conducted background research, and developed and wrote proposals describing their hypothesis, proposed experimental design, and expected outcomes. All proposals were subjected to both peer review and instructor/GA feedback using the EDAT rubric (Sirum and Humberg 2011) before the experimental phase of the project began. Students collaborated in pairs over a six-week period, employing techniques of their choice ranging from enumeration and antimicrobial susceptibility testing to 16S rDNA PCR/DNA sequencing. Projects represented diverse topic areas from food microbiology to environmental microbiology. All groups reported their findings to peers and faculty in both oral and written presentations. To assess student engagement, we used open-ended reflective surveys and found that 88% of students reported that, if time and resources were not an issue, they would want to continue their projects. We assessed students’ experimental design skills pre- and post-project implementation using the EDAT rubric. Finally, we assessed student understanding of the process of science using open-ended reflective surveys. We found that students (n = 41) changed their ideas about the nature of scientific research (39%) and reported development of their troubleshooting (29%), experimental design (29%), and organizational skills (34%) as a result of this curricular redesign. This study provides further evidence for beneficial outcomes of open-ended, authentic research experiences in undergraduate laboratory courses.

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

13-A
Assessment of Misconceptions and Prior Knowledge in a Microbiology Course Using a Concept Inventory
Julie Grainy, University of Georgia

Microbiology courses are often taught by diverse faculty with varying teaching styles. Our objective was to create an assessment tool to evaluate student understanding of important concepts across all introductory microbiology courses at a doctoral university. Concept inventories are tools to identify misconceptions at the start of a course and measure learning gains at the end of a course. Several inventories have been developed for STEM subjects, but there is a need for a microbiology concept inventory. In this study, a microbiology concept inventory was developed, refined, and validated. The ASM Curriculum Guidelines were utilized to develop a list of fundamental concepts students should learn in an introductory microbiology course. A multiple-choice inventory was developed and tested with a novice group of students at the beginning of a course, as well as with a group of microbiology experts for comparison. It was predicted that concept inventory scores for the novice group would indicate a lack of knowledge in the majority of the concepts and reveal any misconceptions. Students were prompted to explain why they chose a certain answer, and common incorrect responses were recorded. As expected, the results of the inventory identified incomplete understanding of certain concepts. Furthermore, the expert
groups scored significantly higher, supporting the inventory’s validity. These preliminary results provide evidence for this inventory as a valuable assessment tool.

The data from the first version of the concept inventory, including information from experts, influenced the improvement of a refined version to be implemented this summer. Once fully refined and validated, the concept inventory can be used to identify gaps in understanding at the start of a course, which can be addressed with targeted active-learning strategies. The effectiveness of interventions can be assessed with a concept inventory at the end of the course. This study provides the foundation for further development of the concept inventory into a useful tool for faculty as they improve their curriculum to enhance student learning.

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

14-B  
**Trials and Tribulations: Implementation of Effective and Productive Course-Embedded Research Projects in Undergraduate Laboratories**  
John E. Gustafson, Oklahoma State University

We embedded authentic research projects into introductory biochemistry and microbiology courses. In freshman biochemistry (annual enrollment = 85), we conducted 3 projects: 1) connecting Arhodomonas draft genome contigs; 2) cloning Elizabethkingia antibiotic resistance genes; and 3) analyzing RNAseq data from Elizabethkingia challenged with antibiotics. During these activities students: closed 8/14 predicted genomic gaps; cloned 23 antibiotic resistance genes; and were guided through the process of RNAseq data analysis and gene/operon characterization. During poster presentations, students described well what they accomplished in projects 1 and 2, but less so for project 3. The microbiology laboratory (annual enrollment = 600) produced novel bacterial isolates that were speciated. Subsequently, students in an upper division undergraduate/graduate hybrid genomics course analyzed draft genomes of select isolates. Student writing assignments summarizing genome analysis were assembled into manuscripts, polished by instructors, and submitted to peer-reviewed journals. To date, these courses have yielded 80 draft genomes and 8 publications (16 undergraduate and 5 graduate authors). All course research conducted advanced knowledge or provided data for further research. We hypothesized that these course modifications would increase students’ perceptions of their work as scientifically authentic and increase research skills. To test these hypotheses, we administered three surveys: Classroom Undergraduate Research Experience (CURE), Laboratory Course Assessment Survey, and a course-specific one, for which exploratory factor analysis produced three factors (research authenticity, scientific skills assessment, and skill element attainment), all of which exceeded the threshold for positive effect. ANOVA showed no differences between semesters, indicating consistent responses in perceived quality of experiences, despite differences in research projects. Comparisons across semesters and to national averages on the CURE survey indicated increases in the contributions of scientific practices to learning gains.

**ASM Curriculum Guideline Concept(s):** Structure and function, Advancing STEM education and research  
**Pedagogical Category(ies):** Course design, Hands-on projects, Teaching approaches

15-A  
**A Teaching Strategy to Relate Christian Faith and Scientific Explanations of Origins: Its Impact and Effectiveness**  
Joanna Klein, University of Northwestern–St. Paul

Christian students often question how to integrate their faith with the scientific information they are learning in the classroom. One issue at the forefront is how to relate scientific and biblical explanations of origins. While Christians hold a variety of positions regarding evolution, many perceive that evolution and Christian faith are in conflict. To address this perceived conflict in an upper-level genetics course at a Christian university, we embedded a unit centered around the book Language of God by Francis S. Collins. Additional instruction elaborated on points addressed in the book, and students participated in an online discussion forum concluding with a final written reflection. We hypothesized that this curriculum would help students reduce their perceived conflict between their religious beliefs and evolution and result in a higher acceptance of evolution. To test the effect of this curriculum on student perception of the conflict between evolution and religious faith, we administered a survey before and after students read the book and conducted semi-structured interviews with a subset of students. Students were asked whether they perceived a conflict, why or why not, and how their classroom experiences influenced their perceptions of evolution. From this information, we could determine where they fell along a spectrum of positions regarding the relationship of religion and evolution before and after instruction. We also recorded factors that influenced their position. We found that while 11/33 students did change their positions or became more uncertain about their special creationist beliefs in response to in-class instruction, many students did not change their thinking over the course of the unit. Interviews indicate that students’ first instructional exposure to evolution content in college seemed to be an important factor for whether a student would change from a special creationist position to accepting evolution in the genetics course. Our findings contribute to a growing body of research that explores the effectiveness of teaching methods and materials for evolution education and will inform future instruction.
Assessment of a Large Course Redesign in a General Microbiology Lecture
Alice Lee, North Carolina State University

A large course redesign in a general microbiology lecture was implemented to improve student engagement and learning outcomes. The redesigned course is offered in three platforms: online sections utilizing interactive videos, student-centered classroom sections with emphasis on active learning, and traditional lecture sections enhanced with online resources and in-class activities. We hypothesized that this redesign would improve student learning outcomes and engagement, regardless of the platform. To test this hypothesis, we conducted a multi-methods assessment. The assessment included a pre-/post-direct measure of student learning using a difficult concept. Student performance on a set of multiple-choice questions related to the difficult concept were embedded in regularly scheduled exams. Paired t-tests were used to compare pre-/post-student performance on the difficult concept questions and with their overall exam grade. Across all three sections, the difference in learning gains between the pre- and post-questions was ~30%, indicating that students learned the difficult concept. Prior research in the field shows that students' perception of the learning environment is an important indicator of retention and continued motivation and persistence. We developed and administered, in Qualtrics, a pre-/post-learning environment questionnaire (LEQ). The LEQ is composed of a dual-response, online survey containing four subscales (academic environment, affective dimension, self-determination, and perceived value of course material) examining different dimensions of the classroom environment. The LEQ data were imported into STATA for analysis. We used split-sample t-tests in our cross-section analyses and chi-squared tests to compare data within sections. On the pre-LEQ, there were no significant differences among the three sections. On the post-LEQ, significant negative differences emerged between the online section and the in-class sections in three of the four subscales. Our assessment also included student focus groups and instructor interviews, which substantiate and extend the findings from the LEQ. This multi-methods approach to assessment illuminated the impact of a large course redesign on the dynamics of the learning environment and its impact on student learning.

Assessment of a Model-Based Riboswitch Activity for Instruction on Microbial Gene Regulation
Adam Kleinschmit, Adams State University

Genetic regulatory mechanisms are a major content area under ASM Curriculum Guidelines. However, research demonstrates that students struggle with application of the central dogma, making comprehension of advanced regulatory concepts challenging. We designed an active learning activity for general through upper level microbiology classrooms that involves interaction with physical models of bacterial riboswitches. It was hypothesized that the models would increase perceived student confidence in their understanding of gene regulation and allow students to accurately predict the outcome of regulatory mechanisms in the cell. In the activity, students worked in groups with an inexpensive bag of supplies (beads, pipe cleaners) to model riboswitch conformations in a bacterial RNA transcript, with integrated group discussion questions. To assess effectiveness, we implemented the activity in upper-level classrooms at three universities (one research-intensive and two primarily undergraduate institutions). We used a pre-/post-activity, 5-point Likert-type survey instrument to assess student perceptions of confidence in understanding of riboswitches and application of the central dogma to riboswitches. Pre- and post-activity survey responses (n=31) were compared using the Wilcoxon signed-ranks test. For all cases, median post-activity test ranks were statistically significantly higher than median pre-activity test ranks (p < 0.0001). Additionally, from post-activity knowledge assessment questions, we determined that > 80% of students could correctly describe and diagram examples of riboswitches, and we utilized data from our initial implementation to improve student performance on central dogma-related questions in two subsequent implementations. We conclude that this activity leads to self-reported student increases in confidence in the ASM curriculum dimension of gene regulation, including understanding of central dogma concepts, in addition to demonstrated ability to diagram and predict, and connect riboswitches to evolutionary roles.

Interactive Teaching Strategies for a Combined Lecture and Lab Microbiology Course
Mustafa Mujtaba, Florida Gulf Coast University

Various teaching methods are increasingly being utilized in colleges and universities to enhance students’ retention of concepts taught in the classroom. At Florida Gulf Coast University, a combined lecture and laboratory microbiology
Weekly Reflective Writing Regarding an In-Course Research Project Led to More Understanding of the Process of Science and the Development of Skills and Attributes of a Scientist
Jennifer O’Connor, Rose-Hulman Institute of Technology

Reflection is a process in which an individual critically examines and evaluates his or her own experiences or learning. For professional degrees, reflective writing is commonly incorporated in the practicum, as students evaluate their experiences and form connections important for professional growth. The Small World Initiative is a course-based research project, and it was hypothesized that regular reflective writing would assist students in making connections between the research experience and the process of science and in developing the skills and attributes of a scientist. Students wrote a day 1 essay on science and scientific process and then critiqued this essay in a final reflection. Also, students wrote weekly reflective essays in response to a prompt regarding the research. Reflections and essays were coded for themes including those related to attributes of a scientist (Nature’s survey of scientists) and skills of a scientist (Harsh 2016). In the first essay, most students (93.8%) provided a basic/textbook definition of the scientific process; by the final reflection, student critiques indicated an increased understanding of the scientific process (90.9%). Regarding attributes of scientists, only 31.3% of students reflected any scientist attributes in the day 1 essay. Over the course of the term, the percentage of students displaying scientist attributes increased to 50% (week 3), 83% (week 5), 92% (week 7), and 100% by the final week. The average attributes per student moved from 0.44 on day 1 to 1.91 at the final reflection (p = 0.0002). Regarding skills of science, throughout the term, students regularly displayed use of skills (91%–100% each week) in the reflections. Per the reflections, the average number of science skills used per student moved from 1.6 in week 1 to 2.3 in the final week (p = 0.02). These results indicate that weekly reflections on the research experience led to increased scientist attributes, understanding of the scientific process, and scientific skills. This activity may be applicable to independent student research in addition to course-based research.

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

Excellent Result Achieved among Biomedical Students when Projected Slides and Videos Were Supplemented with a Traditional Method of Teaching Practical
Adeolu Oluremi, Ladoke Akintola University of Technology

Background: Demonstrating competence in clinical sample processing and reliable result reporting are keys to proficiency in medical laboratory practice. Two professional examinations which are almost purely practical are two of the main prerequisites to graduation in the Department of Biomedical Sciences, LAUTECH, Nigeria. Performance in laboratory exams was worsening every year, so we aimed to determine the impact of projected slides and videos in addition to a traditional practical class on students’ performance on practical examinations in Microbiology, Chemical Pathology, Histopathology, and Hematology.

Methods: Traditionally, practical classes usually involve three steps: pre-practical (oral teaching), practical (real experiment), and post-practical (correction of practical experiment done). In 2013, we added videos of microbiology techniques (gram stain and biochemical tests), blood grouping and cross-matching, hematoxylin and eosin, glucose estimation, etc. to the existing traditional methods. The same procedures were applied during the revision class in preparation for the semester, mock, and professional practical examination among 300, 400, and 500 level students. We compared their individual and overall performance in semester, mock, and professional examination three years before and after the projection was introduced. Statistical analysis of data was performed using SPSS software, and a p value ≤ 0.05 was considered significant.
Results: Individual ($p = 0.044$) and overall ($p = 0.039$) performances significantly improved when traditional methods were supplemented with projected videos. There were no student scores below 48% when projection was used. No female students failed after projection was introduced. We recorded average scores of 84.5%, 79.1%, and 95.3% for 2014, 2015, and 2016, respectively, when projection was added to the traditional method for 300, 400, and 500 level courses compared with 69.2% , 71.4%, and 75.9% for traditional method alone in years 2010, 2011, and 2012, respectively. It was discovered that projection aided their understanding and performances in practical examination. There was a significant association between performance and students’ level ($p = 0.01$), gender ($p = 0.05$), and year ($p = 0.045$).

Conclusion: Exposure to high-quality slides and projected videos in addition to a traditional method of teaching yielded high performance in all levels. This implies that the students will be efficient on the bench and sound in their practice after high performance in all levels. This implies that the students will be efficient on the bench and sound in their practice after graduation. Demonstrating laboratory skills with aided materials significantly improved medical students’ performances.

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

21-A
The Effect of Concept Surveys on Test Scores in a Nonmajors Biology Course
Christopher Parker, Texas Wesleyan University

Reflective assignments are a common method used in the classroom to increase the students’ awareness of their progress toward learning goals and to identify possible gaps in learning. They are often used sparingly as activities or assignments to address a specific learning goal in a class. It might be possible, however, to use reflective practices on a broader scale to assist students as they prepare for exams. A concept survey is a periodic survey given to students that asks them to rate how well they could complete their current learning objectives if tested at that moment. This study proposes that students who use the information gained through the concept surveys will perform better on the exams. To test this hypothesis, students in three sections of nonmajors biology, 34 students in total, were asked to complete concept surveys on a chapter-by-chapter basis in which they were asked to rate on a scale of 1 to 10 how well they could complete each chapter’s learning objectives at that time. The students’ responses were returned to them so that they could use the concept surveys as a study guide if they chose. Students completed four exams throughout the semester. They were asked to self-report whether they had used their concept surveys to study for each exam. Grades from 136 exams (four exams for each of the 34 students) were grouped based on whether they used the concept surveys, and the effect of the concept surveys on test scores was determined by comparing the means of the two groups using an unpaired Student’s t-test.

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

22-B
Analyzing the Effects of Formative Assessment in Promoting Transfer of Learning in an Undergraduate General Microbiology Course
Andrea Rediske, University of Central Florida

Undergraduate introductory or general microbiology is a vital prerequisite for allied health degree programs, including pre-medical, pre-physician’s assistant, and pre-nursing programs. Given the high rates of healthcare-associated infections in the United States and the inconsistent training of pre-allied health students in aseptic technique and infection control measures, there is a clear need for the study of effective learning transfer of these practices from the undergraduate microbiology lab to clinical settings. This study aims to address some of these inconsistencies and lack of learning transfer by answering the question: What is the effect of weekly pre-lab formative assessments in students’ transfer of learning of microbiology laboratory techniques and knowledge? Students in a general microbiology laboratory at a large research institution in the southeastern US had previously only been evaluated through high-stakes summative midterm and final lab practical exams and not using low-stakes formative assessments that could facilitate learning transfer. Researchers hypothesized that the implementation of weekly pre-lab formative assessments would have a positive effect on learning transfer of microbiology knowledge and skills as measured by a significant increase in post-intervention summative assessments. A quasi-experimental design was utilized in this study because a strict experimental design with a large lecture section divided into individual lab sections was impossible. Analysis of variance (ANOVA) was utilized to determine differences in mean lab practical midterm and lab practical final scores between a historical control group semester (fall 2015) and the semester in which the intervention was implemented (fall
Preliminary results indicate that the implementation of formative assessments in the study population may have a significantly positive effect on final lab practical exams ($F = 175.03, p < 0.001$) but not midterm lab practical exams. Further study is needed to determine the influence of gender, ethnicity, age, and degree program covariates in this study.

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

### 23-A  
**Qualitative Analysis of Perceived Difficulties with and Future Applications of General Microbiology Laboratory Knowledge and Skills**  
Andrea Rediske, University of Central Florida

Boud and Walker (1990) theorized that learning through experience is comprised of three essential elements: preparation, experience, and reflective processes. Based on this conceptual framework, open-ended reflection questions were implemented as post-lab formative assessments designed to encourage the reflective process in an undergraduate general microbiology course at a large research university in the southeastern United States. This study aims to answer the following research questions: 1) Do student responses to open-ended post-lab questions show meaningful evidence of learning transfer over the course of the semester? 2) How do microbiology students perceive the role of lab in helping them to prepare for their future careers in allied health, academic research, or other professional fields? 3) What difficulties do students encounter when performing laboratory experiments in general microbiology? Evidence from qualitative thematic content analysis indicated evolution of low-road transfer of automaticity in student habits and practices. Lateral transfer of complexity in transfer of skills and techniques was also noted among student responses. The greatest evidence of evolution of transfer was from near transfer of context to far transfer of context, as students demonstrated application of knowledge gained in microbiology to contexts outside of the lab. Responses indicated that predominantly students in pre-allied health career tracks and pre-research tracks were able to perceive the role of the microbiology lab in helping them prepare for their future careers. Finally, evidence from student responses suggested that students primarily had the greatest difficulties with laboratory procedures, interpretation of results, and manual dexterity with using lab equipment, and to a lesser degree, difficulties with microscope use and time constraints. The research described in this study may provide insights into the degree of learning transfer that occurs in the microbiology lab, which may assist instructors in making curricular adjustments to facilitate learning transfer that could potentially improve student outcomes.

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

### 24-B  
**Helping Students Write about Data: A Simple Teaching Intervention to Support Quantitative Writing**  
Tracy Ruscetti, Santa Clara University

In laboratory courses, instructors often assess students based on effective interpretation and communication of data through written lab reports. However, when students struggle to write effectively, instructors cannot easily distinguish poor reasoning from poor writing. We hypothesized that if we supported quantitative writing, we would be better able to objectively assess student reasoning about data. We focused on quantitative comparative (QC) statements, e.g., “the rate of x is 3 times faster than the rate of y” (Polito 2014). We identified four key characteristics of a QC statement: calculation, context, comparison, and clarity. We developed an annotation scheme (4C annotation) to highlight these elements and easily identify incomplete or unclear statements. In our laboratory-intensive, lower-division molecular biology course, we implemented 4C annotation as a classroom intervention to support students’ writing about data. Students quickly mastered 4C annotation and improved their writing. We also observed a 17% increase in lab report scores in students who received the 4C annotation intervention compared with students who did not ($t_{343} = -7.64, p < 0.0001$). This intervention allowed students to communicate their reasoning more clearly and provided a common framework for students and instructors to discuss data as evidence across multiple experiments. Instructors benefitted from the intervention through 1) better rubric design to assess writing separately from reasoning, 2) improved grading consistency among instructors and between different writing assignments, and 3) improved scaffolding of written assignments across multiple unrelated laboratory experiments. The 4C annotation scheme helped us achieve our goal of improving student writing so we can focus on students’ higher-order reasoning skills to build compelling conclusions from their data.

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

### 25-A  
**Student Metacognitive Skills and Exam Performance Increase when Metacognition Instruction is Embedded in an Introductory Biology Course**  
Jessica Santangelo, Hofstra University

Students quickly mastered 4C annotation and improved their writing. We also observed a 17% increase in lab report scores in students who received the 4C annotation intervention compared with students who did not ($t_{343} = -7.64, p < 0.0001$). This intervention allowed students to communicate their reasoning more clearly and provided a common framework for students and instructors to discuss data as evidence across multiple experiments. Instructors benefitted from the intervention through 1) better rubric design to assess writing separately from reasoning, 2) improved grading consistency among instructors and between different writing assignments, and 3) improved scaffolding of written assignments across multiple unrelated laboratory experiments. The 4C annotation scheme helped us achieve our goal of improving student writing so we can focus on students’ higher-order reasoning skills to build compelling conclusions from their data.
Students in introductory STEM courses can struggle—even students who performed well in high school. In particular, students with less developed metacognitive skills may struggle to assess and adjust their learning strategies to match the demands of college-level courses focused on applying and evaluating information. Students enter introductory biology courses with a range of metacognitive abilities that can be assigned to one of four categories: Not Engaged, Struggling, Emerging, or Developing (Stanton et al. 2015). I tested two hypotheses: 1) that metacognitive category and course performance are correlated, and 2) that both can be influenced by inclusion of metacognitive instruction and practice within a course. I collected quantitative (responses to the Metacognitive Awareness Inventory) and qualitative (responses to open-ended reflective prompts about learning strategies used in the course) data from 292 students in eight sections of an introductory biology course. Here I report data from three cohorts of students enrolled in different sections of the course: an Honors section (n = 25), a Regular section (n = 32), and an Enhanced section (n = 37). The Enhanced section included an extra hour of class each week and incorporated metacognitive instruction and practice. Metacognition was not discussed in the other sections. No patterns emerged from the quantitative data. However, the qualitative data revealed that by the end of the semester, the Enhanced section had more students in the Developed and Emerging categories than the other sections ($X^2 = 23.368$, df = 6, $p = 0.001$), and no students in the Enhanced section were “Not Engaged.” In addition, more students in the Enhanced section who scored a C, D, or F on the first exam increased subsequent exam scores relative to the other sections ($X^2 = 10.177$, df = 2, $p = 0.006$). Embedding metacognitive instruction within a course both supported students’ metacognitive development and increased their performance in the course.

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

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

**26-B**

**A Science and Journalism Collaboration to Enhance Scientific Communication**

Johanna Schwingel, St. Bonaventure University

Effective communication of scientific concepts can be difficult for science majors, as they explain concepts in the same technical jargon it was taught. Jargon provides a challenge to communication with unfamiliar audiences.

Biology majors’ perceptions of communication ease with a nonscientific audience was examined. Students in a microbiology course selected discrete primary research papers, treating the research as their own, while journalism peers interviewed them. Biology students needed to comprehend the primary article to facilitate explanation to nonscientists. Journalists needed to ask probing questions to develop their own understanding as they wrote an article detailing an unfamiliar subject. The paired student interaction provided immediate and delayed feedback on how effectively the concepts were explained and understood. Resulting articles were published in a campus-run, online newspaper serving the local community.

We hypothesized biology students’ assumptions on the ease of communicating science would change. In a pre-activity, Likert-scale questionnaire, 38% of biology students disagreed or strongly disagreed that: “Discussing biology related material with peers not in biology related majors is easy.” While not statistically significant (Wilcoxon signed-rank test, $p > 0.05$), after interacting with the journalists, 80% of Biology students disagreed or strongly disagreed with the same statement. In addition to qualitative student comments, 80% of biologists agreed that: “This project made me think differently in how I need to approach communicating science.” This activity provided a unique opportunity for biology students to convey scientific information to nonscientists, as students received immediate feedback from nonscience peers when concepts were not clearly explained.

Successful communication of scientific findings is important. For healthcare-intent students, word selection and use of analogies or pictures is key to effective communication with patients. For students entering the communication field, author understanding is essential when presenting technically challenging information.

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

**Pedagogical Category(ies):** Hands-on projects, Student learning

**27-A**

**Classroom Module Versus Apprenticeship: Learning Gains and Confidence Differences of Cloning Classroom Module Versus Apprenticeship: Learning Gains and Confidence Differences of Cloning**

Emily Smith, Middle Tennessee State University

According to *Vision and Change* from AAAS, there has been a call to reevaluate science communication methods. One suggested change was for a more widespread integration of research experiences into the biology classroom instead of disjointed labs. Middle Tennessee State University’s (MTSU’s) Biotechnology class already has this type of experience in place through a bacterial cloning project spanning several weeks. While studies have been conducted looking at aspects of multi-week labs, such as career aspirations and intellectual development, there is a limited number of studies that compare student learning between a class research experience (CRE) and a traditional research apprenticeship (RA) and none on the topic of cloning. We hypothesized that students would have significantly higher learning gains from
an RA than a CRE, due to the individualized attention in the RA. Thus, we compared learning gains of skills involved in the cloning process, as well as confidence in using those skills, between CRE and RA students involved in a bacterial cloning project. Students enrolled in both the RA (n = 3) and CRE completed a 15-question pre-/posttest, multiple-choice concept inventory centering around five techniques: pipetting, restriction digest, gel electrophoresis, PCR, and transformation. They also filled out a Likert-scale confidence assessment pertaining to skills utilized in the project. Results indicated no differences in learning gains between students enrolled in the two tracks, but there was a significant difference in pretest (n = 22) and posttest (n = 15) learning gains for CRE students (p = 0.005). Significant differences were also seen when comparing knowledge about pipetting versus restriction digest (p = 0.0002) and pipetting versus PCR (p = 0.0003). Confidence differences were seen for all students on pre-/posttests (p < 0.0001), between skills (p < 0.0001), and based on times the skill had been practiced (p < 0.0001). In conclusion, while differences between the two tracks were not seen, which may be due to the small sample size of RA students due to the time commitment to an RA student, differences were seen in learning gains of different skills as well as confidence for all students.

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

28-B
Students’ Knowledge and Perceptions of Learning in a Co-Taught Astrobiology Course
Jason Tor, Hampshire College

Astrobiology is an interdisciplinary field drawing on expertise in a range of scientific disciplines and the humanities (e.g., ethics, history). Effective teaching in this area means going beyond traditional disciplinary learning to support students’ boundary-crossing skills. It is challenging for individual faculty rooted in their disciplines to provide the breadth of expertise needed to support student learning across these broad disciplines. We hypothesized that an astrobiology course co-taught by faculty in disparate fields (in our case, microbiology, planetary science, and history of science) would improve students’ understanding of core concepts in multiple areas relevant to astrobiology. Thus we examined the undergraduate learning experience by assessing both knowledge gains and students’ perception of their learning. The surveys were given pre- and post-course over two successive years. Survey data were pooled from both years and analyzed by examining the shifts in the means of the Likert-scale responses compared via Student’s t-test. To assess astrobiology knowledge, students were asked to answer multiple-choice questions from various disciplines of astrobiology and the percent-ages of correct answers were compared via Fisher’s exact test. Although we do not have a non-co-taught course for comparison, analyses of responses indicated statistically significant increases in both measured content knowledge and self-reported perceptions of knowledge in our courses. Results from pre-tests indicate that students had limited prior knowledge of key astrobiology concepts; however, post-course testing demonstrated statistically significant improvements in the students’ comprehension in 9 of 11 areas examined. Students’ perceptions of their learning also increased in four key areas of the course (each p < 0.0001), in addition to their ability to read the astrobiology primary research literature (p = 0.005). Overall, student knowledge of astrobiology increased during the course, highlighting the benefits of co-teaching courses like astrobiology to broaden students’ learning in interdisciplinary areas of science.

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

29-A
Interdisciplinary Service Learning Project for Water Quality and Supply Assessment in Low-Income Homes of Barrio San Agustín, San Francisco Solano, Buenos Aires Metropolitan Area–Argentina
Diana Vullo, Universidad Nacional General Sarmiento

UBANEX is a program focused on the development of service-learning projects for students of Buenos Aires University involving social, environmental, and public health concerns. One of these projects was presented by the Engineering Faculty together with Architecture and Universidad Nacional General Sarmiento. The aim of the project was to implement an interdisciplinary project for water quality and supply assessment in low-income homes belonging to a southern district of Buenos Aires Metropolitan Area. This area was selected from a special request of the Barrio San Agustín Public Kindergarten authorities. As there are severe health problems related to both water contact and ingestion, the main study was focused on the evaluation of water quality, distribution, and access in the influence area of the kindergarten. Based on the hypothesis that voluntary involvement of students in social concerns improves attitudes toward self and learning, 18 Chemical and Civil Engineering students were recruited as volunteers from August to December 2016. The students had 20% to 80% of their studies completed, from Analytical Chemistry and Microbiology passed to no lab course taken. Each student collaborated according to their own interests: surveys, sampling, chemical or microbiological analysis, infrastructure checking, etc., and attended meetings to be informed about key topics plus a final brainstorming instance. The assessment consisted in
personally following each student performance in aspects such as social involvement, development of chemistry and microbiology lab skills, data compilation, and analysis in a final report and a survey. In all, 72% of the students stated that their participation updated them on the water quality problem, 60% acquired new lab techniques and analyzed results, 89% supported the university involvement in social concerns, and 56% agreed that the project contributed to enlarge their own view on the professional field. One hundred percent of the students confirmed their interest in participating in the next UBAEX project: development and implementation of water treatments for microbiological quality improvement and arsenic and nitrate removal.

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

**Pedagogical Category(ies):** Hands-on projects, Teaching approaches

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