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ARTICLES

Collaborative Teaching Practices in Undergraduate Active Learning Classrooms: A Report of Faculty Team Teaching Models and Student Reflections from Two Biology Courses

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Abstract: Effectively managing active learning classrooms (ALCs), particularly large ALCs, can present a variety of challenges for instructors. There is a rapidly growing body of research literature addressing the impact of ALCs on student engagement and learning, but fewer studies have focused on investigating instructional practices and instructors in ALCs. Moreover, little to no information on best practices for multiple instructors in these learning spaces has been reported, although the presence of multiple instructors or facilitators simultaneously seems to be frequently implemented in these spaces. Many unanswered questions remain regarding optimizing the opportunities afforded by ALCs and collaborative teaching models while minimizing difficulties that may arise when multiple instructors facilitate student learning concurrently. In an effort to begin reporting faculty experiences and student perspectives of team teaching models at the college or university level, this paper provides an overview of collaborative teaching models described in the literature, describes collaborative teaching models in two undergraduate biology courses, and reports student responses to questions addressing their experience with collaborative teaching in those courses. Finally, from our experiences, we provide recommendations of helpful practices for courses with multiple facilitators acting simultaneously in ALCs.

Key words: Biology, Classroom Management, Cooperative Groups, Instructional Strategies, Teaching Strategies

INTRODUCTION

Models of co-teaching (i.e. the use of multiple instructors simultaneously engaged in instruction in one classroom) have been studied and written about mostly in the context of K-12 education (Pancsofar & Petroff, 2013; Takala & Uusitalo-Malmivaara, 2012; Conderman, 2011), particularly regarding students with special needs or disabilities (Hang & Rabren, 2009; Friend et al., 2010). Reforms in higher education have fueled the construction of active learning environments and adoption of student-centered instructional approaches, making co-teaching more common at the collegiate level. Compared to traditional lecture-based instruction in large auditorium-style rooms, instruction in ALC-style learning spaces¹ engages students in a reduced-lecture pedagogical model focused on cooperative, active learning strategies guided by facilitators

(Beichner, 2008; Walker, Brooks, & Baepler, 2011). Research has been published addressing ALC design (Brown & Long, 2006; Chism, 2006; Muthyala & Wei, 2013), the impact of instruction in ALCs on students' social, affective, and cognitive domains (Prince, 2004; Dori & Belcher, 2005; Beichner et al., 2007; Dori et al., 2007; Beichner, 2008; Gaffney, Housley Gaffney, & Beichner, 2010; Walker, Brooks, and Baepler, 2011; Cotner et al., 2013) and revising curricula for instruction in ALCs (Brown & Lippincott, 2003; Nogaj, 2013). In contrast, although ALC environments and active learning strategies lend themselves well to facilitation by multiple instructors (Bradley et al., 2002; Beichner et al., 2007; Beichner, 2008; Gaffney et al., 2008), there are few reports that discuss best ways to deploy teaching teams in ALCs for college and university courses.

A review of co-teaching literature found although most educators who participate in co-teaching report increased satisfaction and positive attitudinal changes, "practitioners and researchers have not made, or cannot make, empirically based claims that their teaming efforts have been effective" (Welch, Brownell, & Sheridan, 1999, p. 46). More recent research demonstrated higher levels of teacher-

¹ Active Learning Classrooms (ALCs) are also known as "Student Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP) (North Carolina State University; Biechner et al., 2007) and Technology Enabled Active Learning (TEAL) (Massachusetts Institute of Technology; Dori et al., 2007).

to-teacher interactions - “teacher social capital” – can increase student math and reading achievement in K-5th grade settings (Leana & Pil, 2006). While other authors have reported on student perceptions of team teaching, these investigations addressed teaching teams comprised of classroom teachers and special education teachers in K-12 settings (Pugach & Wesson, 1995; Gerber & Papp, 1999). Research reporting student perceptions in ALCs have not specifically addressed the perceived impact of multiple instructors (Gaffney, Housley Gaffney, & Beichner, 2010).

Collaborative Teaching Models Described in the Literature

Collaborative teaching, or co-teaching, “involves two or more educators working collaboratively to deliver instruction in a heterogeneous group of students in a shared instructional space” (Conderman, 2011, p. 24) and involves three collaborative phases: co-planning, co-instructing, and co-assessing (Conderman, 2011, p. 26). Co-teaching approaches are described as six models, which differ in the extent to which each instructor contributes in the delivery of content and/or engages with students (Friend & Cook, 2010, p. 168-175). Each model is described briefly below.

(1) One lead, one observe. One instructor is the sole deliverer of content, while the other instructor observes; useful when a less experienced instructor seeks to gain familiarity with particular content or instructional approach or if an incoming co-instructor simply wishes to observe the classroom dynamics prior to participating (Friend & Cook, 2010, p.168-169).

(2) One lead, one assist. This model is also known in some literature as “one lead, one drift” (Forbes & Billet, 2012, p.61). In this model, one instructor is the primary deliverer of content, while the other instructor(s) move between individual students or student groups to answer questions, direct activities, and provide support to the lead instructor (Friend & Cook, 2010, p. 175).

(3) Station teaching. Students migrate to stations to participate in different learning activities; useful in laboratory settings, particularly when specific pieces of equipment are being used at each station. Each instructor serves as an expert guide for a different station or stations, and students rotate among all stations (Friend & Cook, 2010, p. 170-171).

(4) Parallel teaching. Instructors facilitate instruction of the same material and activities through engagement with subgroups of students within the larger teaching space or in separate classrooms (Friend & Cook, 2010, p. 171-172).

(5) Alternative teaching. Allows co-instructors to address needs of different student groups: one

instructor may be working with the majority of students while a co-instructor is engaged with a smaller group of students who have a particular instructional need such as remediation (Friend & Cook, 2010, p. 172-173).

(6) Team teaching. Each instructor contributes equally, with instructors engaging in trading off or “tag-teaming” at specified signals or content breaks (Friend & Cook, 2010, p. 173-174). Team teaching is sometimes viewed as the ‘goal’ of co-teaching endeavors (Conderman, 2011, p. 27).

Collaborative Teaching Models Used at the University of Minnesota Rochester in Two Undergraduate Biology Classes

At the University of Minnesota Rochester, a Bachelor of Science in Health Sciences (BSHS) undergraduate degree program is delivered through the Center for Learning Innovation (CLI), a multi-disciplinary department in which faculty utilize strategies of integration (Davis, 1997; Harden, 2000) and co-teaching to deliver a health sciences-focused curriculum across humanities, quantitative, physical, life, and social sciences. Students who enter the BSHS are mostly traditional-aged college students coming from within 50 miles of campus, located in the upper Midwest. Approximately 72% identify as female and 20% identify as underrepresented minorities.

Undergraduate introductory biology courses are team-taught in technology-enhanced ALCs designed for 80 students; upper-level courses are also team taught, but generally taught in ALCs designed for 42 students.

Both BIOL2311: Integrative Biology (a first-year 5-credit course with lab) and BIOL3311: Molecular Genetics (a 3-credit upper-level elective) implement a flipped classroom model: students are expected to complete pre-class readings and respond to 4-5 targeted questions about the material provided by the instructors. Class time is devoted to a variety of teaching and learning activities including low-stakes quizzes, mini-lectures, jig-saw activities, audience response (“clicker”) questions, case studies, online simulations, student drawing and writing on whiteboards, concept mapping, student investigations using online resources, and other Classroom Assessment Techniques (for examples of CATs, see Angelo & Cross, 1993).

During a single class meeting generally more than one co-teaching model is used: a 60-minute session might begin with a 10-minute mini-lecture in which one instructor presents materials facilitated through the use of lecture slides or “chalk-talk” while the other instructor(s) observe (Approach 1), followed by 30 minutes of small group activity during which students work to solve practice

problems, etc. while instructors facilitate student groups in a similar way at different locations in the learning space (Approach 4). Group work could be followed by 20 minutes of large-group discussion and debrief in which students may present details of their group discussion or activity, and instructors offer explanations, clarifications and examples (Approach 2 or 6). When using Approach 2, the role of “lead instructor” was rotated among three faculty on a daily basis, although rotating “lead instructor” on a weekly or by-unit basis is also possible. During the co-planning phase, instructors must determine the model(s) that are most appropriately suited to their teaching team, facility, course content, and student population.

Data Collection: Rationale

At the University of Minnesota Rochester, team teaching and high-contact faculty approaches were embraced with the rationale that these strategies would be beneficial for student learning and for the student learning experience in general. Thus, assigning multiple instructors to a course is a regular practice. We wanted to collect data that would help elucidate the impact of team teaching at our institution and qualitative analysis provides a starting point to describe the perceived impact of co-teaching in ALCs on affective domains of student learning.

METHODS

Responses included in this analysis were provided by students who consented to participation in research approved by University of Minnesota IRB (study #1008E87333 and 098S71602).

Students in a first-year biology course (BIOL2311: Integrative Biology, Spring 2013, enrollment 144) and an upper-level elective genetics course (BIOL3311: Molecular Genetics, Fall 2013, enrollment 38) were asked to provide voluntary feedback related to the collaborative teaching models they experienced in those courses at the conclusion of the course. Data were collected using an online curriculum-management platform.

Quantitative Data: Students were asked to rate their agreement with the following statement on a Likert scale of 1 (strongly agree) to 5 (strongly disagree): “Having multiple instructors in the classroom at the same time helped me learn.”

Qualitative data: Students were asked the open-ended response question: “How did having multiple instructors in the classroom at the same time contribute to your learning?”

Questions were presented to students following a quiz or exam. Students were made aware through text that prefaced each question that responses were voluntary and would have no impact on their performance in the course. The voluntary nature of

data collection, as well as the ability of students to opt out of participation in the research, results in a number of responses included in analysis that is less than the total enrollment in the course, although response rates for both classes were consistent (90.9% of those enrolled for BIOL2311 and 89.4% of those enrolled for BIOL3311). Data were collated, de-identified, and analyzed after the end of the semester. Qualitative analysis approaches aligned with grounded theory (Corbin & Strauss, 1990; LeCompte, 2000; Patton, 2002, p. 133), relying on descriptive themes that emerged from students’ written responses: responses were iteratively read and assigned a theoretical category code (Maxwell, 2008, p. 236-238). Some responses included reference to more than one theme and were included in more than one reported category for qualitative analysis results.

RESULTS AND DISCUSSION

Overall, students reported very strong agreement with the statement “Having multiple instructors in the

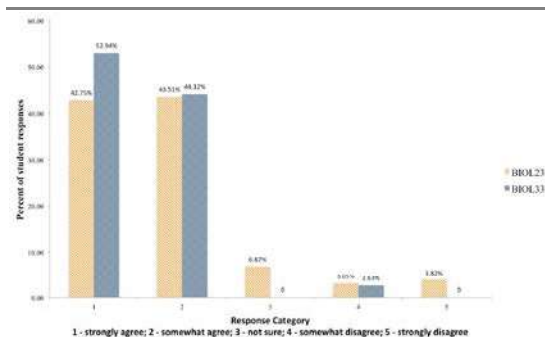


Fig. 1. Results of student responses regarding helpfulness of having multiple instructors in the learning space. Students were asked to rate their agreement with the statement “Q. Having multiple instructors in the classroom at the same time helped me learn.”

classroom at the same time helped me learn.” (Figure 1): the average response for students in the introductory course was 1.82 (N=131) and the average response for students in the upper-level course was 1.53 (N=34).

Qualitative analysis of open-ended text responses to the prompt “How did having multiple instructors in the classroom at the same time contribute to your learning?” revealed four themes, summarized in Table 1 and discussed below. Themes 1, 2, and 3 are very complementary and often student responses included elements of each, yet they highlight different implications resulting from a co-teaching environment.

1. Having questions answered/getting assistance with group activities

Qualitative analysis revealed that 65% (85 of 131) of student responses from BIOL2311 and 61% (19 of

Table 1. Themes in student responses to prompt: “How did having multiple instructors in the classroom at the same time contribute to your learning?”

Theme	Example Student Responses
1. Having questions answered/getting assistance with group activities	“It was easier to ask for help and also the student feels more comfortable asking questions since one does not necessarily have to interrupt the class”
2. Access to and relationship building with instructors	“I was able to get more one-on-one support and help when I was having difficulty”
3. Efficiency of managing an ALC with multiple instructors.	“They can all help different tables with different questions so it's a better use of our time”
4. Multiple perspectives in the classroom	“Sometimes an instructor's explanation did not make sense to me. Another instructor explained it differently... My “light bulb” lit more quickly after a different explanation”

34) of responses in BIOL3311 included commentary on having questions answered more readily with multiple instructors or being able to obtain assistance for collaborative, active group learning activities. Several students reported that it was easier to ask a question of an instructor who was in the role of observer or assistant rather than the instructor leading to avoid having to halt the large class to have a question answered.

2. Access to and relationship building with instructors

Approximately a third (31%; 41 of 131) of responses provided in BIOL2311 and close to two thirds (61%; 19 of 34) of responses provided in BIOL3311 reported a positive impact specifically with regard to perceived access to instructors. With multiple instructors present, students felt supported in their learning to a greater extent than they felt a single instructor could have provided. Some students commented on being able to establish one-on-one relationships with instructors to a greater extent.

3. Efficiency of managing an ALC with multiple instructors.

A small percent, 11% (15 of 131) of responses in BIOL2311 and 12% (4 of 34) of responses in BIOL3311, commented on the positive impact of having multiple instructors for efficiency of delivering an active, collaborative, student-centered curriculum.

4. Multiple perspectives in the classroom, alternative examples or approaches with different teaching styles

Lastly, 27% (36 of 131) of responses in BIOL2311 and 41% (13 of 34) of responses in BIOL3311 addressed the benefit of multiple perspectives or explanations that come from multiple instructors in the learning space. Students also commented that if a particular instructor’s teaching style or personality was not amenable to their learning, they could seek out help from other facilitators. Such “personalized learning” would not

be possible (or would be much more difficult) in a course with only one instructor.

Students in both courses clearly have embraced, and perceive benefits from, collaborative teaching models at our institution. While both populations of students report a greater ability to have their questions answered when there are multiple instructors present, responses from the upper level smaller-enrollment course emphasized access to instructors to a greater extent. It is worth noting that the student:facilitator ratio for the first-year large-enrollment course was approximately 20:1 whereas in the upper-level smaller-enrollment course the student:facilitator ratio was closer to 10:1, which likely also impacted the student experience and could be a contributing factor in differences in student responses between the two classes.

Difficulties

Although very few responses (9 in BIOL2311; 1 in BIOL3311) included concerns or negative perceptions of having multiple instructors simultaneously participate in instruction, such responses provide valuable insight into challenges that may arise with co-teaching models. Three themes emerge regarding difficulties, summarized in Table 2 and discussed below.

Difficulty 1. Management of the learning space

The first theme of difficulty regarding collaborative teaching practices refers to the physical presence of multiple instructors, which students can perceive as distracting. To ameliorate this difficulty, we recommend approaching the physical learning space as several “Zones of Engagement” that are divided among the facilitators present (Figure 2). Each instructor or teaching assistant is anchored in one of the zones, and works with students in that area to minimize facilitator movement. Further, to avoid the perception that instructors are hovering over students, instructors sit at the table with students, take part in the discussion of the group, answer questions, direct students’ activities (i.e. keep students on task), or just observe. Our recommendation is contrary to the behavior described in Gaffney et al. (2008, p.19)

Table 2: Difficulties expressed in student responses to prompt: “How did having multiple instructors in the classroom at the same time contribute to your learning?”

Difficulty Expressed	Example Student Comment
1. Management of the learning space	“I thought having multiple instructors and TA's in the class at the same time was really distracting. I find it easiest to learn from one person at a time, so having like five people walking around made things a little bit difficult”
2. Consistent messaging/content delivery/learning objectives	“Having multiple instructors was sometimes confusing because they contradicted themselves sometimes” “Sometimes I found it to be annoying and sometimes I liked that we could have different viewpoints and explanations.”
3. Class “housekeeping”: who’s in charge here?	“It was helpful during class discussions, but I never emailed a professor because I was confused as to which one to answer to. I would rather answer to one professor rather than many professors”

in which it is stated that “Instructors rarely sit, as they are continually interacting with students: answering and asking questions, distributing resources, and listening to what students are saying.” We suggest that, although it is the case that instructors should move between groups to facilitate instruction and

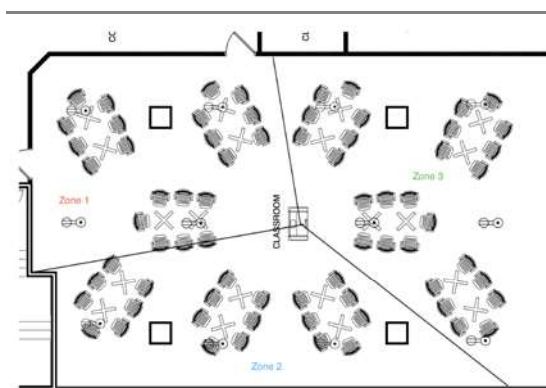


Fig. 2. “Zones of engagement” intended to help effectively manage active learning classrooms with multiple instructors. Each instructor or teaching assistant is based in one of the zones, and works with students in that area.

guidance of multiple groups, instructors should act to minimize the extent to which they engage in disruptive movement or hovering behavior when observing or interacting with groups.

Difficulty 2. Consistent messaging/content delivery/learning objectives

Agreement among instructors regarding the learning objectives and instructor expectations of students can and should be addressed by co-teaching partners and teams throughout the co-teaching endeavor, but especially prior to classroom instruction during the co-planning phases. Co-teachers should work to develop clear and specific learning objectives for each classroom meeting time and activity to ensure that all instructors can provide a consistent message with regard to the important learning goals.

Difficulty 3. Class Housekeeping

Consistent messaging between instructors is also of critical importance for the third identified difficulty, class housekeeping, especially with regard to classroom policies (e.g. attendance, excused absences, make-up work, attending different sections of the class, how assignments should be submitted, etc.) to ensure students do not receive different answers depending on whom they ask. Co-instructors should also determine what methods of communication with students are preferred (i.e. should a student email all instructors of a course in advance of an absence, or should the student contact one lead instructor who will disseminate the information as necessary?) and should clearly communicate this preference to students at the outset of the class. Co-instructors should also be clear to whom students should come with questions about the course content, which may depend on the co-teaching approach used in the course.

Conclusions: Implications for Course Design and Implementation Utilizing Multiple Instructors and Recommendations from Our Experiences

Our reflection on the collaborative teaching models used in introductory and upper level university biology courses at our institution, in conjunction with analysis of student perceptions of those collaborative teaching models, has led to three overall recommendations for successfully implementing collaborative teaching models in ALCs for college courses.

First, to successfully implement collaborative team teaching models, it is crucial to have a high level of organization and effective communication among all instructors involved in the course. Many college faculty members are not experienced in teaching collaboratively and simultaneously so team teaching endeavors implementing these approaches necessarily require thought and careful planning to be successful (Conderman, 2011). Further, employing student-centered teaching techniques requires flexibility to adapt instruction day-to-day as well as

across a term as student-student and student-instructor interactions impact delivery, as others have noted (Bradley et al., 2002). Individual instructors and teams of instructors should engage in regular reflection to evaluate the effectiveness of the implementation strategies used.

Second, clear communication to students is essential. With multiple instructors for a course, students can be confused about to which instructor they should ask questions regarding assignments, grades, or attendance. If communication between students and instructors and between instructors is not managed carefully, students may adopt an “ask mom, if mom says no, ask dad” approach.

Third, gathering and reviewing feedback from students can inform revisions of course design, implementation, and assessment strategies. For us, the results of this investigation have influenced how we physically move through the ALCs and have divided the space among instructors.

Collaborative teaching can provide a valuable classroom experience for faculty and students, and potentially increase student satisfaction as a result of a perception of increased support. Being able to address more student questions in the learning space may increase positive feelings associated with the course and subject matter experience, and ultimately improve student learning. While many institutions may not employ multiple faculty members in one learning space, graduate or undergraduate teaching assistants and peer-instructors can be incorporated to achieve some of the same benefits accomplished by having multiple faculty members present in the learning space. Our experiences suggest that, in fact, having undergraduate teaching assistants in the learning space may provide additional benefits in the form of formal and informal tutoring and peer-mentoring interactions that continue outside the learning space.

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An Inquiry-Infused Introductory Biology Laboratory That Integrates Mendel's Pea Phenotypes with Molecular Mechanisms

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Abstract: We developed a multi-week laboratory in which college-level introductory biology students investigate Mendel's stem length phenotype in peas. Students collect, analyze and interpret convergent evidence from molecular and physiological techniques. In weeks 1 and 2, students treat control and experimental plants with Gibberellic Acid (GA) to determine whether uncharacterized short mutant lines are GA responsive. These data allow students to place the mutation in the GA signal transduction pathway. During weeks 2 and 3, plants are genotyped for Mendel's *le* mutation using a derived cleaved polymorphic sequences (dCAPS) PCR assay. This laboratory allows students to make a direct connection between modern molecular genetics and the easily scored phenotypes Mendel used as the basis of his fundamental discoveries. We administered surveys to assess student gains in accord with four learning goals: understanding the lab, basic science literacy, scientific practices, and working collaboratively. Student confidence increased significantly in the first three, but not in working collaboratively, although students reported greater confidence working in groups than alone.

Key words: Laboratory, Genetics, Inquiry-Based Instruction

INTRODUCTION

The official position of the National Science Teachers Association is that an undergraduate laboratory experience "should not be a rote exercise in which students are merely following directions, as though they were reading a cookbook" (NSTA, 2006). Despite this, many undergraduate introductory biology laboratory exercises (including several currently taught at Swarthmore College) are self-contained 3-hour affairs in which students follow prescribed protocols to reproduce known results. One pragmatic rationale for adherence to this traditional paradigm is the ease with which instructors can guide and evaluate the work of a large group of students. Another is interest in exposing students to a broad range of concepts and methods (Anderson, 2002). Student success in these labs is usually defined as the degree to which results conform to predetermined outcomes. Even when successful, such "cookbook" experiences can be discouraging for students as they lack prospects for personal discovery or authentic contributions to science. Traditional labs can present the nature of science as confirmatory rather than exploratory and relegate students to the role of passive audience members rather than active participants (Munby & Roberts, 1998). Pedagogical methods such as these have been described as disengaging and disempowering (Roth & Lee, 2004).

In response to the traditional paradigm, progressive educators have widely advocated inquiry-based science education since at least the early 20th century (Dewey, 1938). Inquiry is marked by exploration of true unknowns, participation in experimental design, time for reflection and revision,

and a capstone such as a written or oral presentation (NRC, 2000) and is most fully realized in mentored student research experiences (Katkin, 2003). Benefits of these experiences include procedural troubleshooting skills and a better understanding of the role of convergent evidence in establishing claims (Bleicher, 1996; Kardash, 2000; Richie & Rigano, 1996; Ryder, et al., 1999). Such gains in concert with positive collaborative relationships with mentors or other group members have the potential to facilitate formation of scientific identities and to stimulate further participation and deeper membership in the scientific community (Hunter et al., 2006; Seymour, et al., 2004; Templin & Doran, 1999) and membership in related communities such as Western medicine (Kudish, 2009). Although independent student research experiences are an effective mode of inquiry-based learning, such experiences are not widely available to introductory biology students due to their high cost in time and attention of faculty mentors or other laboratory members (Merkel, 2003). As a practical compromise, recent curricular innovations have infused inquiry elements into weekly biology labs resulting in improved student edification and satisfaction (Rissing & Cogan, 2009; Lord & Orkwiszewski, 2006).

We set out to design an inquiry-based laboratory appropriate for a college level introductory biology course that would allow students to work directly with one of Mendel's pea mutants and allow them to integrate their understanding of a visible phenotype with their knowledge about the underlying molecular mechanisms that regulate the phenotype. Mendel's classic work describing how traits are transmitted

between generations laid the groundwork for our current understanding of genetics. His description of transmission genetics preceded modern conceptions of the molecular basis of these phenomena by decades and beautifully illustrates the awesome power of genetics to provide biological insights without the need to know anything about molecular mechanisms. Mendel used seven visible phenotypes, each controlled by a single gene, in his seminal work: plant height (*Le*), seed shape (*R*), seed and flower color (*A*), cotyledon color (*I*), fruit shape (*V*), fruit color (*Gp*), and inflorescence architecture (*Fa*) (Lester et al., 1997; Mendel, 1865). Several of the genes responsible for these phenotypes including *R*, *I*, and *Le* have since been cloned and characterized (Armstead et al., 2007; Bhattacharyya et al., 1990; Bhattacharyya et al., 1993; Lester et al., 1997; Martin et al., 1997; Sato et al., 2007).

Although Mendel's work and molecular genetics are often taught together in introductory biology courses, the mode of action of the genes that underlie Mendel's phenotypes is not always addressed in an integrated manner that explicitly links Mendel's work with modern molecular genetics. Mendel's pea phenotypes provide a great opportunity to connect genotypes to phenotypes because the causal genes have been identified and can be used to illuminate fundamental concepts in biology. Consider the *Rugosus* (*R*) gene, which is responsible for the "difference in the form of the ripe seeds" (Mendel, 1865) and results in wrinkled seeds when mutated (Bhattacharyya et al., 1990; Bhattacharyya et al., 1993). During seed maturation, peas accumulate large amounts of polymerized sugars in the form of amylopectin, a branched form of starch. This starch functions as a food reserve used to drive the rapid initial growth of germinating seedlings. *R* encodes a starch-branching enzyme which, when mutated, results in decreased levels of amylopectin and increased amylose (unbranched starch) and sucrose levels. Increased sugar levels lead to higher osmotic pressure in the cells causing the developing seeds to swell. When they dry at maturity, *r* seeds shrink more than *R* seeds resulting in a wrinkled as opposed to a smooth morphology (Bhattacharyya et al., 1990; Bhattacharyya et al., 1993). This mechanistic understanding of seed shape phenotypes can be used to link discussions of Mendelian genetics to fundamental biological concepts including osmosis, turgor pressure, the structure and properties of biological polymers, and the activity of starch-modifying enzymes. Similarly, the *I* gene, which is responsible for cotyledon color (green vs. yellow) encodes an enzyme required for chlorophyll catabolism (Armstead et al., 2007; Hortensteiner, 2009). The connection between the degradation of a photosynthetic pigment and a change in tissue color clearly illustrates the light absorbing property of pigments. It can also be used as a starting point for

discussing the molecular basis of leaf senescence and nutrient remobilization of agriculturally important stay-green traits, and of the conservation of genes and phenotypes between species.

The laboratory exercise we designed requires students to collect, analyze and interpret multiple lines of convergent evidence using a combination of molecular and physiological techniques. We chose to base the experiment on *Le*, a gibberellic acid (GA) biosynthetic enzyme that controls stem length (Lester et al., 1997), for several reasons. First, because pea seedlings grow robustly and reliably, mutant *le* (dwarf) phenotypes are clearly visible a week after seed germination. This allows the experiment to be incorporated into courses with a minimal amount of preparation and plant care. Second, the mutant dwarf phenotype can be rescued to full length by a simple foliar application of GA. Similarities exist between this experiment and Beadle and Tatum's (1941) classic experiments which are often discussed in introductory biology courses. Both reveal the relationship between genes and enzymes by using the products of enzymatic reactions to rescue mutant phenotypes. Finally, a large number of molecularly uncharacterized *le* alleles are available from the USDA pea germplasm stock center (<http://www.ars.usda.gov/Main/docs.htm?docid=15144>).

We designed the exercise to be performed over a 3-week interval in a 3-hour laboratory period each week. In the first week, we introduce students to the concept that pea growth depends on the biosynthesis of GA, encoded by the *Le* gene. We distribute seedling controls including wild type (*Le*) and Mendel's mutant peas, in which the dwarf phenotype is caused by a mutation in the biosynthetic pathway (*le*). We also distribute seedlings in which the dwarf phenotype is caused by an unknown mutation. This serves as the experimental condition. Groups of students measure the height and count the number of leaves of each seedling. They then treat these plants with a GA spray. GA treatment during development is known to rescue *le* mutants to full wild-type height. Thus, students are able to conclude whether or not their unknown mutation is in the biosynthetic portion of the GA signaling pathway or is a mutation in a gene required for GA perception or signaling (e.g. the gene that encodes the GA receptor). During the second week the effects of the GA treatment on plant height are measured. Also during the second week, students prepare DNA from each line and set up PCR-based dCAPS genotyping reactions (Neff, et al., 1998) for each of the three lines (wild type, known dwarf and unknown dwarf) to determine if the unknown plants share the same mutation as Mendel's mutants. The PCR products are digested using restriction enzymes between weeks two and three and then analyzed using agarose gel electrophoresis during the third week. There is time built into the

Table 1. Descriptions of Four Learning Goals.

Learning Goal	Description
Understanding the Lab	Understanding principles and methods of PCR, restriction enzyme digestion and gel electrophoresis and how these techniques can be used in tandem to genotype unknowns
Basic Science Literacy	Understanding how molecular methods can be used to address scientific and social issues including those described in the popular media
Scientific Practice	Performing laboratory protocols to characterize unknowns, written argumentation in laboratory reports, revising reports following peer-review, and searching and understanding published scientific research literature
Working Collaboratively	Undertaking distributed responsibilities in small groups

third laboratory period to discuss the results of both the phenotypic and genotypic analyses. Finally we ask our students to write up these experiments as a laboratory report in the style of a scientific research paper.

Hallmarks of authentic scientific inquiry include *understanding the lab* in terms of principles & methods, *basic science literacy* such as how molecular methods can be used to address scientific and social issues, *scientific practices* including searching and understanding scientific literature, and *working collaboratively* i.e. undertaking distributed responsibilities in small groups (Table 1; NRC, 2000).

Opportunities for authentic practice can engender a sense of contribution and belonging in a community and inspire students to further participation beyond the classroom (Lave and Wenger, 1991). Inquiry-based science education has been shown to improve students' confidence in their understanding of and capacity to use scientific concepts, including students who do not envision themselves as future scientists (Kudish, 2009; Roth & Lee, 2004). In this paper we present several lines of data to evince the success of the lab. These include student self-reported "pain vs. gain" to compare the laboratory exercise to others in the course and to an earlier incarnation of this exercise that did not include unknowns or genotyping. We also assessed changes in students' confidence in four proficiencies students acquire through participation in inquiry-based laboratories, as described in the literature (Table 1.)

MATERIALS & METHODS

Course and Institutional Context

This research was performed at Swarthmore College as part of a semester-long team-taught introductory cellular and molecular biology course (Bio1). The course is designed for both biology pre-majors and non-majors and every year 70-80% of the ~120 students enrolled in the course are freshmen. Students attend lecture *en masse* and are divided into five or six laboratory sections of up to 24 students each. Four faculty members lecture in the course on topics including both Mendelian and molecular genetics. A faculty member and a professional laboratory instructor or a pair of laboratory instructors teach each laboratory section and are

assisted by an undergraduate student teaching assistant.

Description of the Lab: Mendel's Mutant Peas

The laboratory handout that we provide to our students and detailed instructors notes are provided as online supplemental materials at the following URL: <http://www.swarthmore.edu/biology/mendels-mutant-peas-i-iii>

Assessments

We collected three lines of evidence to evaluate the success of the laboratory in improving students' motivation and confidence in their learning: self-reported "pain vs. gain," degree of motivation associated with characterizing a previously unknown mutation (as opposed to recapitulating an expected result) and changes in confidence based on four learning goals described in Table 1. Data collection methods included pre- and post-laboratory surveys (2009) and end-of-term surveys (2007 and 2009). We used the following methods to generate these data.

Pain vs. gain: We calculated student ratings of the "pain" versus the "gain" associated with the laboratory in end-of-term surveys (Aronson & Silveira, 2009). To differentiate between the outcomes of teaching with (2009) and without (2007) the genotyping component we considered differences between absolute pain and gain scores within and between semesters. We also rank-ordered all of the exercises in each semester based on gain/pain ratios to compare the pea laboratory with the other laboratories taught in each semester. We assumed that higher grades might lead to more positive self-reports regardless of the incorporation of the new inquiry-based elements. Thus, to eliminate grades as a possible confounding variable for positive student response, we compared mean writing assignment scores associated with this laboratory across both semesters.

Motivational effects of characterizing true unknowns: We administered pre- and post-laboratory surveys before the start of the first week and at the end of the last week of semester in 2009. In the post-laboratory survey, we asked students to rate the motivational effects of characterizing true unknowns vs. pre-determined outcomes.

Changes in confidence based on four learning goals: Using pre-laboratory and post-laboratory

Table 2. Mean Pain and Gain ratings (0-4 scale) for all Fall 2007 Bio 1 labs (n=109).

Laboratory Project	Gain	Pain	Difference
Antibiotics	2.66	1.10	1.55
Mendel's Mutant Peas (traditional)	2.72	1.25	1.48
Structure and Function of Plasmid DNA	2.76	1.34	1.42
DNA/PCR	2.76	1.40	1.36
Biotechnology & Society Presentations	2.62	1.46	1.16
Cell Diversity	1.84	0.70	1.13
Earthworm Action Potentials	2.42	2.22	0.20

surveys we calculated differences in student responses to 15 matched questions to assess effects on student confidence in understanding the lab, basic science literacy, scientific practices and working collaboratively (Table 1). We used 2-tailed paired t-tests to test for significance.

RESULTS:

Before 2009, this laboratory consisted solely of the phenotypic analysis of the effects of GA treatment (weeks 1 and 2 of the current lab) using previously characterized *le* mutants. In order to integrate molecular and phenotypic analyses into a single laboratory exercise we developed a dCAPS-based genotyping protocol that was included for the first time in 2009. We also wanted to infuse the laboratory with elements of inquiry so we expanded the laboratory to include the characterization of 'unknowns,' lines of short plants that are presumptive *le* mutants.

In post-laboratory surveys, students rated the pea laboratory as having the highest absolute gain and the greatest gain to pain difference of any of the eight labs taught in the course in the fall of 2009.

Compared with ratings of the traditional fall 2007 lab (Table 2), the inquiry-infused 2009 laboratory had a higher gain score, greater gain-pain differences, and rose from second to first in same-semester rankings against other labs (Table 3).

Mean laboratory report scores were similar between fall 2007 (Mean=85.82, SD=7.81, n=109) and fall 2009 (Mean=85.30, SD=6.77, n=114), suggesting that higher grades are unlikely to be a confounding variable for increased ratings in the end of the semester survey. Students rated the

characterization of true unknowns as somewhat to very motivating with very motivating being the highest on a 4-point scale, possibly implicating the inclusion of unknowns as a factor in the high gain ratings for this laboratory (Table 4).

Our assessment revealed significant increases in student confidence following participation in the inquiry-based laboratory (Figure 1). Of the four learning goals, students reported the greatest increases in confidence in understanding the lab, followed by basic science literacy. Student confidence in their ability to participate in certain scientific practices also improved. These included formulating a testable hypothesis, designing a laboratory experiment, performing experiments independently and forming and supporting arguments in the discussion section of a laboratory report. By contrast, their confidence in other scientific practices, specifically those involving primary literature, did not significantly improve. Additionally, students were more confident working collaboratively than independently.

DISCUSSION

We endeavored to create an introductory laboratory that connects phenotypes and genotypes and ties together Mendel's traits with an understanding of the molecular mechanisms that regulate them. One of our goals was maintaining the practical features of traditional labs in a large course while at the same time incorporating those features of inquiry-based labs that enhance student learning and motivation. Three convergent lines of evidence suggest that this laboratory creates the positive outcomes associated with inquiry-based experiences.

Table 3. Mean Pain and Gain ratings (0-4 scale) for all fall 2009 Bio 1 labs (n=114).

Laboratory Project	Gain	Pain	Difference
Mendel's Mutant Peas I, II & III (inquiry based lab)	3.22	0.94	2.28
Regulation of Gene Expression I & II	2.84	0.94	1.90
An Experiment in <i>Drosophila</i>	3.02	1.15	1.87
A Virtual Introduction to Mendelian Genetics	2.22	0.50	1.73
Neurobiology I & II	2.65	1.35	1.30
Human Genetics	2.18	0.97	1.20
Cell Diversity & Life and Death in Bio	1.72	0.74	0.98
Bioinformatics	1.74	0.89	0.85

Table 4. Post-lab survey responses indicating motivation derived from characterizing true unknowns as wild-type vs. mutant (n=89).

Number of Students	Description	Rating
1	Not motivating	0
6	A little motivating	1
50	Somewhat motivating	2
32	Very motivating	3
89	Mean rating	2.27

Firstly, students reported more gain and less pain than in a previous semester, prior to inclusion of true unknowns and genotyping. Secondly, they reported more gain and less pain compared with ratings of non-inquiry labs taught in the same semester. Thirdly, these students were motivated by the opportunity to characterize true unknowns and gained confidence in their capacities to understand and participate in certain scientific practices. These included formulating a testable hypothesis, designing a laboratory experiment, performing experiments

undergraduates' confidence in navigating primary scientific literature (Kozeracki, et al., 2006).

Students were more confident working collaboratively than independently. However, their confidence in working collaboratively did not significantly change after participation in the laboratory. We speculate this indicates that our students were already accustomed to working with partners or other small groups in previous courses or contexts e.g. during primary and secondary schooling or in traditional labs earlier in the semester.

Overall, our findings support the conclusion that infusion of inquiry elements into an otherwise traditional introductory biology laboratory for a mix of biology pre-majors and non-majors results in increased student motivation and confidence in understanding scientific concepts and undertaking scientific practices. These outcomes support recent quasi-experimental studies showing gains in comprehension, enjoyment, skills and attitudes toward science for biology majors (Rissing & Cogan, 2009) and non-biology majors (Lord & Orkwisezewski, 2006.)

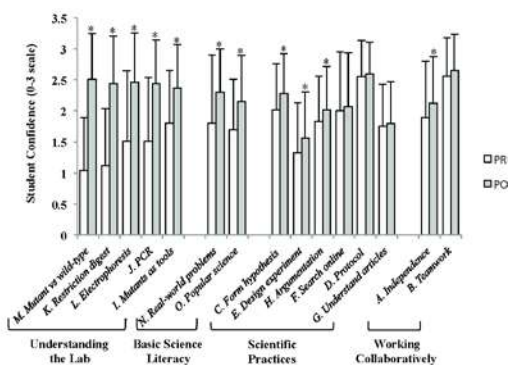


Fig. 1. Mean pre-laboratory and post-laboratory student confidence on a scale from 0-3 (0=not at all, 1=a little, 2=somewhat, 3=very motivating) in 15 items (A-O) representing four learning goals (n=89). *p < 0.01 (2-tailed paired t-test)

independently and forming and supporting arguments in the discussion section of a laboratory report.

Students' confidence in other scientific practices, specifically those involving primary literature, did not significantly improve. These included the ability to search online for scientific research articles and understand scientific research articles. During the laboratory, instructors modeled an online primary literature search for the introductory students on a projection screen and we required primary literature citations to support arguments in students' laboratory reports. However, we did not guide students through their own literature searches. Our results suggest that a demonstration is insufficient to increase student confidence in this practice. This finding is consistent with pedagogical literature describing the need for and efficacy of intensive scaffolding to increase

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ACUBE 58TH MEETING ABSTRACT SUPPLEMENT

Association of College and University Educators 58th Annual Meeting

October 16-17, 2014

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KEYNOTE ADDRESS

Plagiarism in a Digital Age

Christopher Price, *The College at Brockport, State University of New York*

Christopher Price is the Director of the Center for Excellence in Learning and Teaching (CELT) at The College at Brockport, State University of New York. He has been at Brockport since receiving his PhD in Political Science from the University at Albany in 2004. In addition to his work at CELT, Chris teaches an undergraduate hybrid course in political thought and a graduate online course on democratic philosophies of education. Some of the teaching and learning workshops he has conducted include discussion-based teaching, communicating effectively with students, collaborative learning, academic integrity, and using critical reflection to improve teaching and learning. Chris established and directs the faculty learning community program at Brockport. He lives in Rochester, New York with his wife Jessica and his children Lucy and Henry.



Guest Presentation

The Biology and Natural History of the Lewis & Clark Expedition

Richard Prestholdt and Roger Wendlick

Lewis and Clark experts Dick and Roger will speak on the flora and fauna discovered and described by The Corps of Discovery between 1802 and 1806. Lewis and Clark's infamous journey west led to a wealth of knowledge about the plants and animals of the Rocky Mountains and Pacific Northwest. Dick and Roger participated in the Lewis & Clark Bicentennial Event - an adventure that took them from Philadelphia to Oregon from 2002-2006 and included traveling by foot, boat, and horseback. Both gentlemen are published Lewis and



Clark experts. They will be dressed in period clothing and their show-and-tell items include furs, books, weapons, medicinal plants, and a variety of the equipment Lewis & Clark had on the trail.

TALKS, WORKSHOPS, AND ROUND-TABLE DISCUSSIONS

Biology, Moral Behavior and Policy, A Unique Course with different Perspective on Biomedical Ethics

Khadijah Makky, Susan Giaimo, and Robert A. Wheeler, *Marquette University*

What makes people behave the way they behave? What affects our decision-making and how this can impact public policy? The presented course is a novel upper division class that was designed to go beyond the teaching of the basic philosophical theory of biomedical ethics. This discussion-based multidisciplinary class covers the neuro-anatomy and the molecular biology of moral behavior and decision-making. The class was divided into three connected yet distinctive blocks, each block looking at human moral behavior from a different angle. After exploring the brain anatomy and biological mechanisms in each block, students explore specific public policies relevant to the biomedical sciences and the positions held by advocacy groups that influence those policies. The class was designed to develop students' critical thinking and writing skills and apply them to express insights into the biological and environmental forces that influence public policies. Periodically, students are presented with dilemma questions to lead group discussions allowing them to express their views and at the same time respectfully accept the views of others. Students are assessed using a series of exams and written assignments. In each paper students were allowed to expand on their personal views on different moral dilemmas such as stem cell research and end of life decision. Students' evaluation of the course and feedback was extremely positive with high approval of the in-class discussions and paper assignments.

STEM-Sense: Students building and using sensors for data collection in biology laboratories

Denise Piechnik and Matthew Kropf, *University of Pittsburgh*

Our workshop will demonstrate the approach of our interdisciplinary pilot-study that introduces biology students to microcontroller sensor systems that they build and then use to collect their own data. By supplementing existing lab exercises, we will show how we use these sensors in two introductory laboratories; respiration in a Cell and Molecular Biology course, and soil moisture in an Ecology and Evolution course. Biology students are instructed on basic electronics, followed by directions for the assembly and the use of the programmable microcontroller system by Arduino. Students perform the classic biology experiment, make observations, formulate their hypotheses, and then use the microcontroller and sensor to collect real-time data. By modifying existing lab exercises, the inexpensive and easy-to-learn Arduino sensor systems provide a

tractable approach for exposing biology students to STEM-based skills in the context of research-based lab exercises.

Improving Lab Report Writing and Student Confidence Using a Classroom Partner Program and Scaffolding Assignments

Marlee B. Marsh, *Columbia College*

Students generally need to work to strengthen their writing skills when they enter college, and writing in science is no different. Science writing is a technical skill and freshmen tend to struggle when composing first lab reports. Originally, a thorough and complete "How to Write a Lab Report for Biology" guide was composed and reviewed with students in small groups in the hopes of turning out polished lab reports at the end of the semester. However, many student products were below average ($n=36$, Avg = 74) as students failed to follow guidelines in document. In search of a novel way to enhance student writing and reduce faculty-grading time, scaffolding methodology was employed in order to allow students to focus on how to write one section of the lab report at a time. Additionally, Biology faculty partnered with the college English faculty to assign a classroom partner to the class (CP). The CP was a science student skilled in writing who met with Biology faculty and each member of the class for every writing assignment to provide peer review and guidance. After meeting with the CP and having at least one round of revisions, students turned in scaffolding assignments to professors for another round of feedback. At the end of the semester, student averages on the lab report were high ($n=31$, Avg = 91) and student feedback about the classroom partner were excellent.

Regional Communities of Practice for implementing Vision and Change Recommendations

Karen Klyczek, *University of Wisconsin-River Falls*, Gary Reiness, *Lewis and Clark College*

To inspire, encourage, and sustain evidence-based teaching, we also need to effect changes in our departments, programs, and institutions. The Report "Vision and Change in Undergraduate Biology Education: A call to action" (AAAS 2011) recommends organizing undergraduate life sciences education around five core concepts and six core competencies, using student-centered best pedagogical practices. As we seek solutions at our own institutions, networks of like-minded individuals can be powerful allies. The Partnership for Undergraduate Life Science Education (PULSE) was established to develop strategies for department-level transformation and implementation of Vision and Change recommendations. One of the approaches to achieve these goals is the development of regional

networks of faculty and institutions dedicated to the formation of local communities of practice that can exchange knowledge, ideas, and resources. PULSE Leadership Fellows representing networks in the Pacific Northwest and the Midwest/Great Plains regions will describe the ongoing activities in these networks, as well as plans for expanding their outreach and impact. Participants will interact with PULSE resources and learn how they can connect to network activities.

Enhanced Undergraduate STEM Education Through a University/Community College Collaboration to Provide High Quality Research Experiences to First and Second Year Students

Presley Martin, PhD, *Hamline University*, Lori Thrun, PhD, *Century College*

Hamline University is collaborating with Century College and North Hennepin Community College in an HHMI funded project to provide first and second year students with research opportunities, both in their introductory courses and as 10 week summer research internships. The goal of the grant is to increase the number of student who major in a STEM field, and increase the diversity of students pursuing a STEM degree. The summer research program pairs students from Hamline with a community college student who work together on a research project with a Hamline faculty member in the Biology, Chemistry, or Physics Department. All students in this program have finished one or two years of college coursework. The grant provides stipends and funds for research supplies for 22 research students each summer. We are also developing a series of 'Distributed Research Projects' (DRPs) which will be incorporated into the curriculum of all three collaborating institutions. The DRPs are ongoing research projects that are designed in a way that allows students in introductory courses to engage in a portion of the research and contribute data to the project. In this presentation we will provide an overview of the first DRP to be implemented, which is focused on analysis of the distribution and identification of antibiotic resistance genes found in the environment. We have just completed the first year of this DRP and will discuss preliminary assessment results and our experience with collaborating across institutions on a complex pedagogical project.

Assessment of Factors Affecting Learning and Retention in a Two-Semester General Biology Course Sequence

Elizabeth Evans, Lisa Felzien, and Christina Wills, *Rockhurst University*

Successful introductory biology courses are essential for providing foundational knowledge, exposure to scientific thinking, opportunities to challenge high-performing students, and opportunities to cultivate learners with inadequate preparation. Assessing both

learning and retention is critical for determining student success and persistence in science. At Rockhurst University, freshmen students considering a major in biology or related discipline are typically enrolled in a 2 semester course sequence, General Biology I and II. Since 2009, we have used a pre-test/post-test strategy to assess learning in general content areas and track whether students retain material learned in General Biology I through General Biology II. For this presentation, we have examined several implications of our assessment: 1) long-term trends between final grades and overall scores on pre and post-tests in General Biology I and II; 2) effects of minor changes in instruction on learning in General Biology I and retention through General Biology II; and 3) whether our assessment may be used to predict student success and determine new ways to support underprepared students.

DIY Animation

Conrad Toepfer, *Brescia University*

You spent all morning on YouTube looking for just the right animation for your class. Well ok, part of that was watching dogs scared of cats, but still. Just when you thought you found the perfect video, the narrator tosses in a horrible misconception. Argh, what will you do? Make your own! In this workshop, I will give you an introduction to storyboarding animations and using apps to create your own animations. Come with one or more ideas of concepts you would like to animate and a tablet. If you do not own a tablet, bring a friend who has one. We should have time to do short animations, and hopefully look at some options for post-processing. Fine art skills are not necessary. If you are convinced that you are not artistic enough, come anyway. Your students might like to do this for an assignment.

Case It update: Computer simulations for case-based learning in molecular biology

Mark Bergland and Karen Klyczek, *UW-River Falls*

Case It! is an NSF-sponsored project to provide molecular biology computer simulations and associated cases to the educational community. Case It v6.07 is a computer simulation that will perform a variety of laboratory procedures on any DNA or protein sequence. It is used by students to analyze cases based primarily on infectious and genetic diseases, via role-playing and other means, but can also be used as a tool to study original research questions. Both PC and Mac versions of Case It v6.07 can be downloaded from www.caseitproject.org, free of charge for educational use. Case It supports the Vision and Change initiative of NSF by providing a low-cost method for educators to incorporate inquiry-based activities in the classroom. It is also useful as a tool for open-ended undergraduate research. We will demonstrate freshmen research applications involving the HHMI SEA-PHAGES project and also a project based on

the study of colony decline in honeybees, both of which are part of our freshmen curriculum at the University of Wisconsin - River Falls. We will also demonstrate a new qPCR module that accurately displays results of actual qPCR analyses, such as those conducted by freshmen students in the BEE project at UW-River Falls.

Case It! won an AAAS Science Prize for Inquiry-based Instruction, and an essay appeared in the July 27, 2012 issue of Science magazine (“Engaging Students in Molecular Biology via Case-Based Learning”). The project has proven to be effective at a variety of educational levels, from high school through advanced undergraduate classes.

Flippin' the A&P Classroom: Why Didn't I Do It Earlier?

Tom Davis, *Loras College*

The author used his own version of flipping the A&P classroom in an attempt to get 1) more students talking to each other in lecture, 2) more students better prepared for class before class, 3) less “telling” of info by the instructor and 4) more student engagement and active learning during lecture. Daily quizzes were appreciated by most students and helped them prepare for class each day. Student teams in lecture were used regularly to answer questions, ask questions to other groups and present their versions of drawings of structure and function. Each day each group had a different spokesperson who spoke for the group when answering questions. Groups often presented drawings or answers simultaneously on the blackboard and then the class evaluated each answer from each group. Examples of student lecture activities and extensive discussion with session attendees will be the main components of this session.

Using a case study of Viagra and nitroglycerin causing an MI in the first physiology lab of the semester-what issues to consider?

Mark Milanick, *University of Missouri*

Consider this real case, published in the New England Journal of Medicine. Henry gave George (70 y/o) some of his Viagra™. Soon George began to feel chest pain. Instead of going to the hospital, he told his mother. Mom gave George some of her nitroglycerin. Eight hours later he went to see his physician and was diagnosed as having a heart attack. This is the opening scenario for the first laboratory in a course aimed at pre-health professional students. In this discussion, I will briefly present the lab exercises that I use to answer the questions:

- Why might the combination of Viagra™ and nitroglycerin lead to a heart attack?
- Why should one exhale when lifting weights? Could this relate to why some people think strokes are more common when straining to poop?
- When they use a stethoscope to measure blood pressure, how do they get the blood pressure?

Then I will lead a discussion on the following issues as I would like suggestions about this approach and how to improve it.

- What are the trade-offs of using how-easy-it-is-to-flow for conductance and how-hard-it-is-to-flow for resistance? In general, it is better to use easy to understand terms (high blood pressure) or to stress mastery of the clinical terms (hypertension)?
- How important is it, for these types of students, to have open inquiry labs vs. labs that connect physiology to potential clinical applications?
- Is the fact that flow requires a pressure difference and a pathway a general concept for most facets of physiology?

The Pros and Cons of Using Human Models and Examples in General Biology Courses

Christina Wills, *Rockhurst University*

This roundtable discussion will focus on the pros and cons of using human models and examples in freshmen general biology courses. Many universities and colleges require a two semester sequence of general biology courses. This sequence often includes sections on genetics, molecular structures and processes, mitosis and meiosis, evolution, ecology, and a brief tour and animal, plant and fungal phyla. There are numerous references that can be made to humans in most if not all of these sections. Are these references beneficial or detrimental to freshmen? Do they encourage students to view humans as a part of ecosystem or do they foster an egocentric view of biology? Should instructors use a large number of human examples to increase student interest in the subject? Should instructors exclude human models to increase students' understanding of the biology? Does the use of human models and examples improve or impede student performance in upper level biology courses? Is it important for students interested in human health care careers to focus on other species? I will pose these questions and provide anecdotal evidence from the Rockhurst general biology sequence.

Assessing the Impact of Integrated Research in a Molecular Biology Course

Lisa K. Felzien, *Rockhurst University*

Engaging undergraduates in research is essential for teaching them to think like scientists. Mentoring large numbers of students, however, is a challenge for faculty and has resulted in the use of inquiry based laboratories in courses to achieve research goals. While these labs have been successful, many instructors wish to expose students to a greater variety of concepts and techniques, necessitating the integration of larger research projects that are relevant for both. Projects that require both conceptual and technical learning allow students to use experiments to learn molecular principles, understand why specific techniques are applicable for certain biological questions, critically analyze varied

data, and examine how techniques relate to acquiring new information. To provide an authentic research experience for undergraduates, a semester long research project was developed in the course, Molecular Biology. The goals for the project were: 1) to support the content goals of this integrated lecture/laboratory course, 2) to provide opportunities for students to develop critical thinking skills required for conducting research, and 3) to instill an appreciation for molecular biology research in students. To examine whether these goals were met, student performance on related pre-test and post-test questions were compared, surveys to determine student perceptions about the project were administered, and student comments about the project on final exams were summarized.

Skull detective: Teaching students to observe

Lynn Gillie, *Elmira College*

The first step in the scientific method is observation. Many students will look at an object, but not truly observe it. This is true of observations using a microscope, examining lab specimens, and ecological observations in the field. Skulls are an inexpensive resource used to examine biological variation qualitatively and quantitatively and create hypotheses. We will examine skulls and discuss ways to use data to get students thinking. This exercise has been used successfully with students at all levels.

Hunger U at Syracuse University: Impacts of an Informal Education Experience on Student Attitudes Toward the Science of Food Sourcing

B. Elijah Carter and Jason R. Wiles, *Syracuse University*

The HungerU Tour is dedicated to connecting with college students and sharing the story of the role of modern agriculture in tackling world hunger. A mobile, interactive display, HungerU is an informal education exhibit that shows how hunger affects people around the world. Along with the mobile exhibit, a "Food Forum" was organized, which involved a panel of faculty experts in food security and related science and technology in dialogue with students about the challenges of feeding a growing human population. In this study, we sought to evaluate the impacts the HungerU mobile exhibit and Food Forum on our students at Syracuse University who attended one or both of the events. The population within which we can measure impacts of the program are the students in our General Biology course. For this population, we were able to employ a quasi-experimental, controlled, pre/post approach along with qualitative exit surveys to ascertain student awareness about hunger issues, whether students engage in hunger-prevention efforts following HungerU, and whether they perceive the display to have influenced their decision to do so. We found that students became more aware of hunger as

the primary source of human mortality, more accepting of the use of genetically modified organisms and other advanced agricultural techniques in dealing with the challenges of hunger, and more interested in small-scale farming in developing countries. Students report that they are more likely to get involved with hunger-related activities than they did prior to HungerU and the Food Forum.

Online and Hybrid Biology Courses: Five Years In

James W. Clack, *Indiana University - Purdue University*

I have now been teaching and administering online courses for five years. My resulting experience has allowed me to gain certain insights on the development and administration of online courses empirically and as they compare with face-to-face instruction. I will provide an expanded analysis of the state of online course development tools and an appraisal of different approaches to online instruction. I will also review several different course management environments such as Canvas, Blackboard, Angel, and Oncourse. I will include a brief discussion about how each of these interacts with online modules created with different online development software packages. I will also include a brief discussion of my personal experiences relating to student success and/or issues in online versus face-to-face instruction. Finally, I will discuss effectiveness and security of online assessment tools, specifically, how best to minimize cheating during exams and quizzes that are not taken on-site or proctored.

An approach to STEM education in the biology classroom and lab

Matthew Kropf, and Denise Piechnik, *University of Pittsburgh Bradford*

The integration of Science Technology Engineering and Mathematics (STEM) learning across disciplines in higher education is a major focus of educators, funding agencies, and academic institutions such as the National Academy of Sciences and the National Science Foundation. However, teaching tools and curriculum to implement the multi-disciplinary approach needed are not well established; particularly in Biology. Building on the success of a few Biology students who transferred skills from an elective course in Sensors and Automation to a Biology research experiment, faculty collaborators in Biology and Engineering applied for and were awarded a grant to develop a strategy to integrate learning about microcontroller sensor systems into the biology classroom and lab. This presentation outlines the process of developing and implementing technology teaching tools for introductory biology classes at the University of Pittsburgh Bradford.

Undergraduate research collaboration mapping lethal mutations in *Drosophila*

Jamie Dyer and Laura Salem: *Rockhurst University*,
Danny Miller and Scott Hawley, *Stowers Institute for Medical Research*

Students at Rockhurst University have begun an ongoing research project mapping unknown lethal mutations stored in the Bloomington *Drosophila* Stock Center. The experiments involve analyzing whole genome sequences, selecting candidate genes, and performing a series of crosses. We will discuss the benefits of establishing a collaboration with a neighboring institution as well as the long term goals for the project.

Using Cystic Fibrosis to illustrate heterozygote advantage

Janice Bonner, *Notre Dame of Maryland University*
The relationship between malaria and sickle cell disease (SCD) is frequently used as a model of heterozygote advantage. Students often tend to absorb this connection as a biological fait accompli, however, and don't contemplate the thinking that led to a recognition of the connection. In this session, participants will be introduced to another possible example of heterozygote advantage, cystic fibrosis (CF). CF, like sickle cell disease, is a genetic disease that persists in a particular portion of the human population; 2% of people of European descent are carriers. Like the connection between SCD and malaria, a plausible selective agent for CF must provide evidence along three lines: a molecular explanation of how heterozygosity protects from the disease, a clinical connection between heterozygosity and morbidity and mortality, and a match between CF and the historical and geographical distribution of the selective agent. Three infectious diseases have been proposed as selective agents: cholera, typhoid fever, and tuberculosis. In this session, participants will be shown how students can be led to use the available literature to explore the CF heterozygote advantage.

Question by question analysis of student performance on a general biology assessment instrument

Chad Scholes, Jamie Dyer, and Ryan Elsenpeter,
Rockhurst University

The Rockhurst University Biology Department began an assessment of learning and retention of knowledge through our General Biology sequence in Fall 2009. Nine questions considered to be fundamental to the cellular and molecular content of General Biology I were answered by students on the first day of class (pre-test) and at the final exam (post-test). Students continuing on in General Biology II the next semester were given the same pre- and post-tests. This 9 question assessment was administered each semester until Spring 2013, during which our instrument was expanded to 20 questions, allowing for the inclusion

of some General Biology II content. Analysis of student performance for each question allowed us to determine concepts where large increases in knowledge and retention were observed, as well as certain areas that need more emphasis or a change in teaching strategies to improve student understanding and retention. In-depth analysis of individual questions in our instrument led to possible explanations for some of the variability in student performance. Finally, in an attempt to further understand student retention of biological information, the same test was administered in Genetics, a course populated with sophomores and juniors. Results were compared to students' previous performance on this test in General Biology I and II to determine trends suggesting retention, or lack thereof, for students progressing through the biology program at Rockhurst University.

Survey of Biology Capstone Courses in American and Canadian Higher Education: Requirement, Content, and Skills

Neil Haave, *University of Alberta, Augustana Campus*

Capstone courses and experiences have been shown to have high educational impact (AAC&U 2013 Peer Review 15(4); Kuh 2008 High-impact educational practices) with various approaches available for biology majors (Davis 2011 Bioscene 37(1)). However, no information exists regarding the degree to which capstone courses are offered in biology degree programs. This paper presents surveyed data, which determined both the prevalence and character of biology capstone courses in the USA and Canada. The survey sampled approximately 450 institutions with a 36% response rate. The sample included a vast majority of public institutions (94-96%) in the USA and Canada (88%). The vast majority (>88%) were either 4-year degree or research institutions. More than 2/3 of American biology degree programs required a capstone course. This increased to >80% for schools associated with the liberal arts or a biology association. In contrast, only 25-50% of Canadian schools required capstones. Most American (>53%) capstones were seminars, whereas 1/3 of Canadian institutions were seminars. 36-44% of American biology capstone courses included a research experience. This increased to >62% for Canadian institutions, and those associated with ACUBE. Most respondents indicated their course provided some review of the conceptual foundations of biology, though this was not a focus of the course. Most biology capstones do not devote a significant amount of time toward a consideration of the history or philosophy of biology. Most schools included the development of writing (> 75%), speaking (>80%), critical thinking (>80%), and research (>60%) skills as learning objectives.

Incorporating human subjects research ethics into a biology majors course

Kristen L.W. Walton, *Missouri Western State University*

Students in the biology department at Missouri Western State University are exposed to bioethics issues informally, but are not required to take a separate bioethics course. "The Immortal Life of Henrietta Lacks" by Rebecca Skloot is the story of the woman whose cervical cancer biopsy gave rise to the HeLa cell line, as well as the historical context for relevant medical, social, and ethical issues. This book is assigned reading in an upper division Molecular Basis of Disease course with the aim of using the Lacks family story as a springboard for learning about the guidelines for ethical treatment of human research subjects and human tissues. Students had weekly reading assignments with questions about the relevant science and/or ethical issues. After finishing the book, students were assigned to write a brief paper on the events that led to the current federal regulations for human subjects research. Students were also surveyed about their knowledge of these guidelines and for their qualitative feedback to the usefulness of including this book as part of the course. Overall, this book has been a successful platform for increasing student knowledge of human subjects research ethics and empathy for the humans who have contributed tissues to medical research.

Linking undergraduate lab experiences to local campus research

Lori Kayes and Krissi Hewitt, *Oregon State University*

Many of our undergraduate's students lack an understanding of the mission of the university. Students do not understand that faculty have multiple facets to their jobs or they do not appreciate the caliber of the research being done by their instructors. We have created several new laboratory modules to modernize our introductory biology curriculum. In doing so, we have made a concerted effort to tie modules to research being done by our faculty on campus. This gives us the opportunity to increase our students scientific literacy, introduce them to local issues, and provide an avenue for exploring potential research opportunities of interest. By explicitly linking our laboratory activities to the research activities on campus we have also forged connections with the research faculty that have improved the quality of our laboratory modules. I will discuss several examples of these links in my talk. For example, we have a lab on invasive plant species removal efforts. This is linked to research being done by one of my graduate teaching assistant on control of invasive plant species. The pre-lab introduces the students to the species and the issue of invasive species control. We use a video of the

researcher to discuss her questions and methods. For the actual laboratory activity students go out to the field, actively remove the invasive species, and collect data on the plant community. As their summative assessment, they write a scientific paper on their data collection and develop an invasive species removal protocol for the plant species.

Traxoline Requaselled: The Montillation of Online Homework

Jason R. Wiles and Christina Giovinazzo, *Syracuse University*

Attributed to Judy Lanier, the story of Traxoline has been used to illustrate how teaching can go wrong even when we think it is going just fine. The traxoline example is fairly famous with regard to lecture-style "teaching". Herein, we report on an experiment whereby we explored the classic traxoline example in the context of an online homework assignment. Results reveal some interesting and enlightening insights into student interactions with the internet while completing online homework. Implications for critical thinking and plagiarism are considered.

Systems Physiology, Active learning in an inquiry based laboratory course.

Adam Rich, *The College at Brockport*

The ability to solve new problems is a desirable skill but many undergraduate courses do not present opportunities for students to practice and develop these skills. An inquiry-based course was designed to address this problem. The course, called Systems Physiology, mimics basic medical research as much as is reasonably possible. The primary goal was for students to develop an understanding of the research process while focusing on physiological control mechanisms. Success was defined as acquiring technical skills with the hands and developing the intellectual skills with the head to formulate a good research question, plan and execute experiments, interpret data, and to think critically. The course focuses on the research process while participating in an authentic research project. Students work in teams and present weekly progress reports. Research challenges are discussed and solutions are developed in collaboration with the entire class. A final presentation and summary report are required. In this way students learn the challenges and rewards of scientific research. Developing an active inquiry based laboratory course mimicking authentic research is difficult, particularly with assessment of student learning, and also in motivating students that are most familiar with cookbook labs and unambiguous solutions, or with multiple choice format exams. The approach to teaching important problem solving skills and to assessing student learning outcomes developed in Systems Physiology will be described, as well as student perceptions of this course.

Dive Right In: Starting Undergraduate Research as a First Year Visiting Faculty Member.

Ryan Elsenpeter, *Rockhurst University*

Starting a position as a visiting faculty member with a focus primarily on teaching brings excitement and challenge. As a new instructor at a smaller teaching-centric university, I decided it was as good a time as any to undertake an ongoing research project with undergraduate students. Experiences I have had with starting undergraduate research will hopefully spur discussion for the benefit of all attendees. Beyond ubiquitous issues like limited funding and lab space, my presentation will also focus on both the good and bad of starting research at the beginning of a visiting faculty position, challenges faced when entering into such a task, and a summary of my overall experience thus far.

Community engagement in undergraduate biology: opportunities and challenges

Amy E. Boyd, *Warren Wilson College*

Community engagement comes naturally to social scientists, but the benefits of engaging students in work that enhances community while strengthening course learning can be reaped in biology courses as well. I will discuss challenges of using service learning in biology courses and present examples of fruitful opportunities for addressing these challenges and harnessing the power of community engagement at all levels.

Bridge to The Next Generation: Building Research Interest and Developing Global Engagement With Undergraduates

Kimberly Gwinn, *University of Tennessee*

The Bridge To The Next Generation program profiles a plan for developing a research experience for undergraduate students majoring in biology, agricultural sciences or natural resources-related fields of study. The purpose of this program is to generate increased student interest and engagement in biological sciences and natural resources-related careers. Over the next decade, the numbers of graduates from agricultural and life sciences, food and natural resources (ASFNR) programs is expected to decline by more than 10%. An additional factor contributing to the declining numbers of ASFNR graduates is the high attrition rate (more than 50%) of all science, technology, engineering and mathematics (STEM) majors from U.S. universities. Employment opportunities exist now and will continue to grow for ASFNR graduates with advanced degrees as the world meets new challenges for ensuring global food supply and sustainable water supplies.

The goals of the program include: increased student interest in ASFNR disciplines, increased student persistence, enhanced career preparation, provide information, clarification and exposure to career paths in ASFNR including graduate school programs, increased undergraduate student skills in field and lab

research techniques, promote an increased understanding of the research process in terms of how scientists think and how they work on real problems, and to promote increased self-confidence in ability to do research.

FACULTY DEVELOPMENT WORKSHOPS

Session I: Teaching like a Pro in Your First Few Years

Becky Burton, Janice Bonner, and Conrad Toepfer
How can you maximize the cooperation of students, peers, and administrators as you implement the best in innovative pedagogy? Where can you find excellent “turn-key” activities? Master teachers will guide you through:

- Educational Outcomes and Criteria
- Effective Assessments
- Flipping your Class
- Resources

Experienced educators will share their most effective and efficient strategies so that you can focus your time and attention on what matters most.

- Syllabi that work
- Efficient Feedback
- Managing your time

Session II: Pre-Health Care Advising

Gigi Makky and Debbie Meuler

Do most of the undergraduates at your institution want to be doctors, dentists, or other related health professionals? This workshop will provide attendees with up-to-date information on

- Statistics on who IS getting accepted into medical school
- How to best prepare students for medical school
- How to guide students that may not be ready for the health professions

Session III: Getting an Academic Job

Aggy Vanderpool, James Clack, and Tara Maginnis
Teaching-intensive institutions (TIIs) have hiring criteria that are probably very different from those of the institution where you received (or will receive) your PhD. This workshop will be led by faculty who serve on hiring committees for TIIs. Topics will include:

- What sets successful TII candidates apart
- How to get the experience that TIIs expect
- How to market yourself effectively to TII search committees
- Pitfalls to avoid

Session IV: Promotion and Tenure

Laura Salem, Greg Smith, and Paul Pickhardt
Members and past members of T&P committees share their expertise on navigating the process successfully from your first day on campus until you order those new business cards. Topics include:

- Identifying the written and unwritten expectations
- Optimizing service commitments
- Documentation and presentation
- Letters of support

POSTERS

Gender Bias in Lesson Models for Biology Education

Amy Buxton and Jamie Jensen, *Brigham Young University*

While extensive research has been conducted examining gender stereotypes and the gender gap within education, past research has not focused on how to improve student interest and learning within biology by the specific lesson models teachers employ ("models" being the specific lesson content used to teach a broader biology concept, e.g. bird plumage is a model to teach sexual selection). We have developed an instrument to measure if, when, and what lesson models exhibit gender bias in biology. We selected eight broad topics within biology, and created three sets of flashcards within each topic. Within each set, one flashcard depicts a stereotypically male model (e.g. a shark) that could be used to teach the topic, while the other depicts a stereotypically female model (e.g. a dolphin). We gave this survey to 25 male and 25 female students in each grade, k-6, as a way of collecting preliminary data. We found several models that display significant gender bias. Our long-term goal is to create curricular materials based upon these biased models to test if they affect male and female interest and learning in biology.

Encouraging Students to Pursue Careers and Graduate School in Biology and Biochemistry through Administration of an NSF S-STEM Scholarship Program

Jennifer Maki, Daniel Westholm, Jennifer Rosato, and Luther Qson, *The College of St. Scholastica*
Historically, most entering biology and biochemistry majors at The College of St. Scholastica (CSS) have intended to pursue a career in medicine, due to the prominence of medical professions and a general lack of awareness of other scientific career options. CSS is located in a small city (with a population of 86,000) and serves a large proportion of low-income (30% are Pell recipients) and first-generation (40%) college students. In an attempt to increase awareness of careers in the basic sciences, CSS has sought and received S-STEM grants from the National Science Foundation for more than ten years. This presentation will focus on the effects that this funding has had on our biology and biochemistry students' education and outcomes.

The S-STEM program offers scholarships and provides a variety of extracurricular offerings, including: mentoring, field trips, career and graduate school preparation as well as research and presentation opportunities for scholars who major in STEM fields. In the current grant cycle, biology and biochemistry majors on average annually comprise

43% of all majors represented among the S-STEM scholars.

During the last decade at CSS, there has been a steady increase in the number of students participating in undergraduate STEM research, the biology curriculum is being updated to include more active learning strategies, and laboratories have been renovated. S-STEM funds have played a crucial role in this transformation, enhancing our ability to attract and retain qualified students in biology and biochemistry, and supporting these students as they explore diverse career paths."

Continuing a Case Study: Biology Research as a Capstone Experience

Stephen S. Daggett, *Avila University*

The Department of Biology at Avila University continues to require a minimum of two semesters of research as part of students' senior capstone experiences as noted in a presentation at ACUBE at the annual 2013 meeting. Challenges discussed included time blocks for laboratory and field work, faculty compensation, and student motivation. Since then, the program has undergone several significant changes to address these challenges and more changes are anticipated. This poster presentation will review the basic structure of these courses, list major challenges, and present the department's approach to dealing with these challenges."

Genomics Education Partnership (GEP): Teaching Biology Using a Bioinformatics Research Project

Nighat P Kokan, *Cardinal Stritch University*,
Christopher Shaffer, Wilson Leung, and Sarah C R Elgin, *Washington University*, David Lopatto, *Grinnell College*

The Genomics Education Partnership (GEP, <http://gep.wustl.edu>), a growing consortium of undergraduate institutions across the US, provides students at primarily undergraduate institutions (PUI) with a genomics research experience. The flexible GEP curriculum can be implemented in a variety of ways: from a two-week module, to a larger fraction of an existing course, to a full semester course or independent study devoted to genome annotation and sequence improvement. The consortium has steadily grown from its inception in 2006 with seventeen institutions to over a hundred affiliates; in 2013-2014, 62 schools and over 1100 students participated. The research question under investigation uses comparative genomics in *Drosophila* species: how do the sequence organization and gene characteristics differ between heterochromatic and euchromatic domains? What are the unique properties of the transcription start sites of Muller F element genes that enable them to be expressed in a heterochromatic

environment? Utilizing survey and quiz results, we demonstrate that undergraduate students benefit by taking part in a national level genomics research project. Benefits are possible at a wide variety of institutions using a variety of course formats. However, faculty must devote a substantial amount of instructional time (avg. 45 hrs.) to this research project in order for students to show knowledge gains similar to those gained from a summer research experience.

The *Drosophila* ovary as a laboratory model for introducing the genetic and cellular basis of cell migration

Melissa A. F. Daggett, *Missouri Western State University*, Leonard L. Dobens, *University of Missouri – Kansas City*

Drosophila has been widely used in many teaching laboratories to introduce students to the practical uses of a model organism in scientific research, in particular to present and observe the outcomes of simple Mendelian inheritance. Here we present the details of a laboratory module that uses *Drosophila* to demonstrate the importance of gene expression in the process of cell migration. Cell migration in the *Drosophila* ovary is critically important for the proper morphological development of the egg chamber during oogenesis, a process that interestingly shares many of the signaling components required for cell migration observed throughout normal animal development and during tumor invasion in human cancers. This laboratory provides an opportunity to discuss the genetic and cellular basis of cell migration and to demonstrate techniques used in a modern *Drosophila* research laboratory including the basics of sorting males from females and identification of cuticle markers, but also the development and use of enhancer traps, balancer chromosomes, microdissection, histochemistry and microscopic analysis. Components of this laboratory module have been found to be appropriate for presentation and completion by students ranging from advanced high school laboratories through graduate level cell and developmental biology laboratory courses.

Utilizing a needs assessment analysis to inform the development of a cell/molecular biology laboratory course

Jenean H. O'Brien, *University of Colorado Denver*, Fordyce G. Lux, III, *Metropolitan State University of Denver*

When given the opportunity to develop a new upper division laboratory course, there are several potential topics and curriculum design options. Therefore, a two-tiered needs assessment analysis involving student surveys, faculty interviews, and literature review was performed. The purpose of the initial analysis was to determine which topics and techniques within the field of cellular and molecular

biology were both of interest to students and considered important by faculty for inclusion in this laboratory class. Specifically, students and faculty were asked to indicate which subject areas already covered in the associated lecture course could be enhanced, which would aid in preparing students for future careers and which may increase interest in the field. The results of these surveys and interviews led to the development of a research-focused cell/molecular biology laboratory course. The second tier of needs assessment focused on determining an appropriate course design. Based on publicly-available course syllabi and published curriculum evaluations, a multi-modal approach was developed. The beginning of the course focuses on how to perform specific cell/molecular biology research techniques and why. The laboratory course then culminates with a project to design-your-own experiment based on these techniques, which will then be performed. This combination is designed to allow for building a factual foundation from which students can expand into inquiry-based learning.

Surveys of self-identified knowledge of biology prior to formal undergraduate instruction

Joel Carlin, *Gustavus Adolphus College*

Effective teaching can benefit from assessment of students' pre-existing knowledge. However, records of past exposure to biological concepts (such as high school curricular standards) may be quite different from the individual's actual familiarity with any topic. I present a rapid assessment of self-identified knowledge used in an introductory survey course which provides context for nonparametric comparisons. First, students self-identified their confidence to define an array of biological and statistical terminology. Second, students listed previous exposure to science, technology, engineering and mathematics (STEM) coursework and hobbies before and during college. These data were collected across three years at a U.S. rural liberal arts college and in one semester at an intensive English liberal arts college in China. Preliminary comparisons indicate the potential utility of a revised instrument in providing greater understanding of baseline knowledge in college undergraduates.

New York State Parks' FORCES: A Model for Engaging Students and the Community for Stewardship and Education

Caitlin C. Conn, *New York Office of Parks, Recreation & Historic Preservation*

"Through FORCES (Friends of Recreation, Conservation, & Environmental Stewardship), New York State Park staff are working to establish relationships with academic institutions through which students participate in a variety of projects within State Parks. Student involvement ranges from one-day events, semester/summer long internships, to long-term projects suitable for capstone or thesis level work that include improvements to recreation facilities and historic sites, trail rehabilitation, protection and restoration of natural resources, and environmental education. These Natural Resource Stewardship projects support and enhance park visitors' experiences, strengthen college academic programs, and forge personal life-long connections with these students to NYS Parks.

FORCES students learn organizational, leadership, and communication skills that they are able to apply in their personal and professional lives. The FORCES program provides students with opportunities for personal growth and involvement in their community through service projects and outreach. In addition, students assist State Parks staff to recruit and collaborate with other interested colleges, volunteers, organizations, and community groups.

By formalizing relationships with academic institutions, agencies, organizations and individuals, the FORCES Program creates successful, long-term, mutually beneficial partnerships that seek to enhance college curriculum, provide hands on experience for students and facilitate the way New York State Parks can maintain, enhance, preserve, and protect its rich natural and cultural resources."

Testing the antimicrobial effect of honey in an undergraduate introductory microbiology lab

Daniel Westholm and Jen Maki, *The College of St. Scholastica*

Traditional introductory microbiology labs are often comprised largely of technique based exercises, a tendency borne out of the necessity to teach students to safely handle potentially infectious microorganisms. Recently, however, many undergraduate labs have transitioned to more inquiry and research based lab experiences shown to improve student learning and retention. We have developed a lab experiment in which students determine the antimicrobial activity of honey samples on a variety of bacteria in an effort to incorporate both of these important outcomes into one experience. Students are encouraged to select honey from local beekeepers or from other sources of personal interest. The selection process requires student consideration of variables including the geography of the bee colony, nectar sources, bee stock, harvest time, and plant and bee phenology. Students then test the honey for antimicrobial properties on various liquid bacterial cultures. In this single experiment, students gain ownership of original data, while developing fluency in basic microbiological techniques such as aseptic technique, dilution and plating, spectrophotometry, and graphical representation of data. We recently piloted this lab in two sections of an introductory microbiology lab course (50 students) and found it to be accessible to students, inexpensive and easy to expand upon. Students expressed enthusiasm for the experiment and many were willing to put extensive effort into securing a novel honey source. The results, methods, and future ideas will be presented in this poster.

CONFERENCE PHOTOS



Keynote Address



Attentive Participants



Biology of Lewis and Clark Talk



Biology of Lewis and Clark Artifacts



Out of this World Teaching Award



Excellence in Teaching Award

Bioscene: Journal of College Biology Teaching

Submission Guidelines

I. Submissions to *Bioscene*

Bioscene: Journal of College Biology Teaching is a refereed quarterly publication of the Association of College and University Biology Educators (ACUBE). Submissions should reflect the interests of the membership of ACUBE. Appropriate submissions include:

- **Articles:** Course and curriculum development, innovative and workable teaching strategies that include **some type of assessment** of the impact of those strategies on student learning.
- **Innovations:** Laboratory and field studies that work, innovative and money-saving techniques for the lab or classroom. These do not ordinarily include assessment of the techniques' effectiveness on student learning.
- **Perspectives:** Reflections on general topics that include philosophical discussion of biology teaching and other topical aspects of pedagogy as it relates to biology.
- **Reviews:** Web site, software, and book reviews
- **Information:** Technological advice, professional school advice, and funding sources
- **Letters to the Editor:** Letters should deal with pedagogical issues facing college and university biology educators

II. Preparation of Articles, Innovations and Perspectives

Submissions can vary in length, but articles should be between 1500 and 5000 words in length. This includes references and tables, but excludes figures. Authors must number all pages and lines of the document in sequence. This includes the abstract, but not figure or table legends. Concision, clarity, and originality are desirable. Topics designated as acceptable as articles are described above. The formats for all submissions are as follows:

- A. **Abstract:** The first page of the manuscript should contain the title of the manuscript, the names of the authors and institutional addresses, a brief abstract (200 words or less) or important points in the manuscript, and keywords in that order.
- B. **Manuscript Text:** The introduction to the manuscript begins on the second page. No subheading is needed for this section. This supply sufficient background for readers to appreciate the work without referring to previously published references dealing with the subject. Citations should be reports of credible scientific or pedagogical research.

The body follows the introduction. Articles describing some type of research should be broken into sections with appropriate subheadings including Materials and Methods, Results, and Discussion. Some flexibility is permitted here depending upon the type of article being submitted. Articles describing a laboratory or class exercise that works should be broken into sections following the introduction as procedure, assessment, and discussion.

Acknowledgment of any financial support or personal contributions should be made at the end of the body in an Acknowledgement section, with financial acknowledgements preceding personal acknowledgements. Disclaimers and endorsements (government, corporate, etc.) will be deleted by the editor.

A variety of writing styles can be used depending upon the type of article. Active voice is encouraged whenever possible. Past tense is recommended for descriptions of events that occurred in the past such as methods, observations, and data collection. Present tense can be used for your conclusions and accepted facts. Because *Bioscene* has readers from a variety of biological specialties, authors should avoid extremely technical language and define all specialized terms. Also, gimmicks such as capitalization, underlining, italics, or boldface are discouraged. All weights and measures should be recorded in the SI (metric) system.

In- text citations should be done in the following manner:

Single Author:

"... when fruit flies were reared on media of sugar, tomatoes, and grapes" (Jaenike, 1986).

Two Authors:

"... assay was performed as described previously (Roffner & Danzig, 2004).

Multiple Authors:

“...similar results have been reported previously (Baehr et al., 1999).

- C. References: References cited within the text should be included alphabetically by the author's last name at the end of the manuscript text with an appropriate subheading. All listed references must be cited in the text and come from published materials in the literature or the Internet. The following examples indicate *Bioscene's* style format for articles, books, book chapters, and web sites:

(1) Articles-

(a) Single author:

DEBURH, L.E. 1991. Using *Lemna* to study geometric population growth. *American Biology Teacher* 53(4): 229-32.

(b) Multi-authored:

GREEN, H., GOLDBERG, B., SHWARTZ, M., AND D. BROWN. 1968. The synthesis of collagen during the development of *Xenopus laevis*. *Dev. Biol.* 18: 391-400.

(2) Books-

BOSSEL, H. 1994. *Modeling and Simulation*. A.K. Peters, London. 504p.

(3) Book chapters-

GLASE, J.C., AND M. ZIMMERMAN. 1991. Population ecology: experiments with Protistans. In Beiwenger, J.M. 1993. *Experiments to Teach Ecology*. Ecological Society of America, Washington, D.C. 170p.

(4) Web sites-

MCKELVEY, S. 1995. Malthusian Growth Model. Accessed from <http://www.stolaf.edu/people/mckelvey/envision.dir/malthus.html> on 25 Nov 2005.

For references with more than five authors, note the first five authors followed by et al.

D. Tables

Tables should be submitted as individual electronic files in Word (2003+) or RTF format. Placement of tables should be indicated within the body of the manuscript. All tables should be accompanied by a descriptive legend using the following format:

Table 1. A comparison of student pre-test and post-test scores in a non-majors' biology class.

E. Figures

Figures should be submitted as high resolution (≥ 300 dpi) individual electronic files, either TIFF or JPEG. Placement of figures should be indicated within the body of the manuscript. Figures only include graphs and/or images. Figures consisting entirely of text will not be allowed and should be submitted as tables. All figures should be accompanied by a descriptive legend using the following format:

Fig. 1. Polytene chromosomes of *Drosophila melanogaster*.

III. Letters to the Editor

Letters should be brief (400 words or less) and direct. Letters may be edited for length, clarity, and style. Authors must include institution address, contact phone number, and a signature.

IV. Other Submissions

Reviews and informational submissions may be edited for clarity, length, general interest, and timeliness. Guidelines for citations and references are the same for articles described above.

V. Manuscript Submissions

All manuscripts are to be sent to the editor electronically. *Authors must clearly designate which type of article they are submitting (see Section I) or their manuscript will not be considered for publication.* Emails should include information such as the title of the article, the number of words in the manuscript, the corresponding author's name, and all co-authors. Each author's name should be accompanied by complete postal and email

addresses, as well as telephone and FAX numbers. Email will be the primary method of communication with the editors of *Bioscene*.

Communicating authors will receive confirmation of the submission within three days. Manuscripts should be submitted either as a Microsoft Word or RTF (Rich Text File) to facilitate distribution of the manuscript to reviewers and for revisions. A single-email is required to submit electronically, as the review process is not necessarily blind unless requested by an author. If the article has a number of high resolution graphics, separate emails to the editor may be required. The editors recommend that authors complete and remit the [Bioscene Author Checklist](#) with their submission in order to expedite the review process.

VI. Editorial Review and Acceptance

For manuscripts to be sent out for review, at least one author must be a member of ACUBE. Otherwise, by submitting the manuscript without membership, the corresponding author agrees to page charges. Charges will be the membership fee at the time of submission per page. Once the authors' membership or page charge status has been cleared, the manuscripts will be sent to two anonymous reviewers as coordinated through the Editorial Board. Authors' names will be withheld from the reviewers. The associate editors will examine the article for compliance with the guidelines stated above. If the manuscript is not in compliance or the authors have not agreed to the page cost provisions stated above, manuscripts will be returned to authors until compliance is met or the page cost conditions have been met. Reviewers will examine the submission for:

- **Suitability:** The manuscript relates to teaching biology at the college and university level.
- **Coherence:** The manuscript is well-written with a minimum of typographical errors, spelling and grammatical errors, with the information presented in an organized and thoughtful manner.
- **Novelty:** The manuscript presents new information of interest for college and university biology educators or examines well-known aspects of biology and biology education, such as model organisms or experimental protocols, in a new way.

Once the article has been reviewed, the corresponding author will receive a notification of whether the article has been accepted for publication in *Bioscene*. All notices will be accompanied by suggestions and comments from the reviewers. Acknowledgement of the reviewers' comments and suggestions must be made for resubmission and acceptance. Further revisions should be made within six months if called for. Manuscripts requiring revision that are submitted after six months will be treated as a new submission. Should manuscripts requiring revision be resubmitted without corrections, the associate editors will return the article until the requested revisions have been made. Upon acceptance, the article will appear in *Bioscene* and will be posted on the ACUBE website. Time from acceptance to publication may take between twelve and eighteen months.

VII. Revision Checklist

Manuscripts will be returned to authors for failure to follow through on the following:

- A. Send a copy of the revised article back to the associate editor, along with an email stating how reviewers' concerns were addressed.
- B. Make sure that references are formatted appropriately.
- C. Make sure that recommended changes have been made.
- D. Figures and legends sent separately, but placement in manuscript should be clearly delimited.

VIII. Editorial Policy and Copyright

It is the policy of *Bioscene* that authors retain copyright of their published material.