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- Enhance scholarship through our nationally, peer-reviewed journal, *Bioscene*.

ARTICLES

An Introduction to Biological Modeling Using Coin Flips to Predict the Outcome of a Diffusion Activity

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Abstract: In order to increase students' awareness for and comfort with mathematical modeling of biological processes, and increase their understanding of diffusion, the following lab was developed for use in 100-level, majors/non-majors biology and neuroscience courses. The activity begins with generation of a data set that uses coin-flips to replicate movement of dye molecules at an interface of a permeable gel. The class results are then collapsed into a single data set that is used to predict the movement of real dye molecules over time, which are then measured by students in a "wet-lab" activity.

Keywords: diffusion, predictive, modeling, interdisciplinary

INTRODUCTION

In 2011, The American Association for the Advancement of Science (AAAS) released a document entitled Vision and Change in Undergraduate Biology Education: A Call to Action. This document provides a blueprint for reforming biology education that outlines key concepts and skills that prepare biology students for 21st century biology. One recommendation is that students develop skills in modeling and simulations for biological discovery. Here we describe a laboratory activity that provides this experience while elucidating a concept difficult to grasp: diffusion.

All molecules and microscopic particles in suspension undergo diffusion. This phenomenon is driven by constant collisions with surrounding molecules, which causes them to undergo random and unpredictable changes in motion. How such motion is connected to another aspect of diffusion, where bodies move predictably towards regions of lower concentrations, is a concept difficult to get across in a biology curriculum, as has been documented by Meir et al. (2005) and Fisher et al. (2011).

The following activity was developed to increase students' awareness for and comfort with modeling of biological processes, and increase their conceptual understanding of diffusion. The activity has been tested in 100-level, majors/non-majors biology and neuroscience courses and a 100-level non-majors physics course. Our approach was to build on the pedagogical principle that active learning more deeply involves students in their own learning of physical processes (Meltzer and Thornton, 2012). To that end we had our students learn how random motion drives diffusion by (1) being actively involved in generating trajectories of several molecules undergoing random motion and (2) by analyzing those trajectories and relating them to motion towards regions of lower concentrations. Here the random motion that molecules undergo is simulated with coin tosses, each representing a random displacement that a dye molecule may undergo in a gelatinous medium. Students then complete a "wet-lab" in which they measure actual diffusion of food coloring into gelatin, across a water/gelatin interface, and compare the experimental results to the simulated data set. Good agreement was obtained between the actual experimental and predicted data sets. While students' predictions may deviate somewhat from the observable diffusion, these discrepancies allow for fruitful class discussions about the strengths and weaknesses of mathematical models and fundamental properties of diffusion. Finally, we assessed students' improved understanding of diffusion in all of our classes using a questionnaire that was administered before and after instruction on diffusion. Gains achieved by students exposed to the activity developed here were contrasted with those of control course sections that experienced a traditional classroom/laboratory introduction to diffusion.

MATERIALS AND METHODS

Participating institutions and courses

The diffusion laboratory activity we developed was implemented at three institutions, all characterized as private, 4 year, liberal arts colleges, and in three disciplines. Those colleges (and disciplines) include Centenary College of Louisiana (Biology 101 and Neuroscience 101), Thiel College (Neuroscience 101), and Berea College (Physics 127). “Control” classes, i.e., classes in which students were exposed to a traditional diffusion laboratory activity, took place at Centenary (Biology 101 only). Classes in which students were engaged in the laboratory activity described in this paper are henceforth referred to as “experimental”. With the exception of Berea’s physics class, all remaining classes were populated with lower division life sciences majors and non-science majors. Most students enrolled in Berea’s class were upper-level biology and chemistry majors. Despite the difference in population, we found the initial misconceptions and activity gains to be comparable.

Pre-laboratory activities

Classroom discussion

All students including those in control classes were exposed to classroom presentations describing the phenomenon of diffusion. These included presentations containing images of particles spreading into lower concentration regions along with a discussion of how this phenomenon accounts for the transport of gases and other molecules in biological tissues, as well as its connection to osmosis. Classroom discussions also covered visual and verbal explanations of how random particle motion accounts for diffusion.

Homework assignment in experimental classes

Following classroom discussions, each student in an experimental class was given as a homework assignment the task of simulating the motion of 10 molecules undergoing diffusion, all starting at the boundary between two media (see Fig. 1). The exercise is designed to simulate the same situation that students would encounter later in the lab, i.e., the diffusion of food coloring molecules into gelatin. Instructions for this exercise are described below.

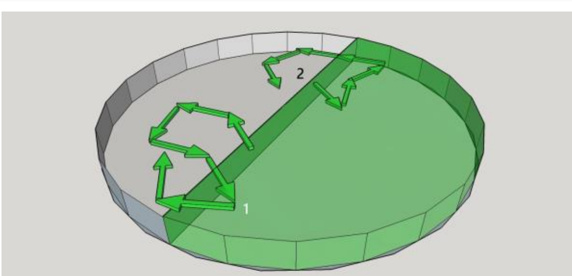

Figure 1. A petri dish is half filled with gelatin and the other half filled with a dilute aqueous solution of food coloring. The arrows illustrate exaggerated random movement of two dye molecules, both located initially near the gel-dye interface. Each student is asked to simulate the motion of 10 dye molecules over 24 time steps, according to instructions described in Figure 2 and in the procedure narrative.

Each student was assigned the task of simulating the trajectories of 10 dye molecules starting near the gel-dye interface. To illustrate how the simulation works, students conducted a practice run in class using the instructions shown in Fig. 2. The procedure chosen was designed to reproduce the main features of diffusion as they relate to random motion, but without the complexity of accounting for every possible direction or step length that a molecule can undertake. For example, each molecule was assumed to move a distance of 0.5 mm every 5 minutes, which corresponds to the root-mean-square distance obtained for a small dye molecule in gelatin[1]. For simplicity, we limited the random movements of dye molecules to one of three possible directions: a positive 0.5 mm movement into the gel, a negative 0.5 mm movement away from the gel, or no net movement (i.e., the dye moved parallel to the interface). This simplifies the modeling activity as it only keeps track of the dye movement away from the interface. Students are asked to simulate the movement of 10 molecules over a period of 4 hours at 5-minute intervals, for a total of 240 data points. The handout for the homework assignment we used is available online at http://bit.ly/butcherdiffusion.

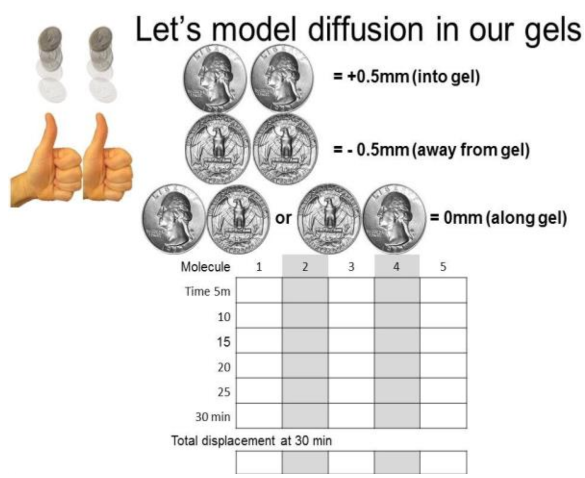

Figure 2. Graphic used to illustrate the rules of the coin flip model. Note in this illustration, each student is only asked to generate 30 data points. In the actual homework assignment they are asked to generate 240.

[1] The 0.5 mm step size corresponds to the theoretical diffusion length obtained for a dye in a gel over a period of 5 minutes. To obtained this distance we assumed that green food coloring has a diffusion coefficient similar to a common dye such as R6G in a 1.5% agarose gel, which has a coefficient in gel similar to that in water, D = 2.8×10^{-6} cm^2/s (Fattin-Rouge et al., 2004).

Laboratory activities

Homework analysis

At the start of the lab period we ask students to set up the “wet lab” portion of the project, which includes adding food coloring to each dish. These activities are detailed in the next section. Once started, and while students wait for dye molecules to diffuse, the analysis of the simulated data takes place.

First, we ask students to submit the summary data from the table in the handout to the instructor who then generates a graph of the locations of the modeled dye molecules. This graph serves as a prediction for where dye molecules will be located at a given time point (see Fig. 3). Once the class graphs are generated, we ask students to discuss what the data are telling them. This can be accomplished either as a single group session, or in a think-pair-share format. Students are often confused by what the model shows them about the leading edge of the dye. For example, in the 30 min graph (Fig. 3), a small number of molecules are predicted to reach the 2mm point. Some students will claim that this means the leading edge will be clearly discernable at that point in the gel. In reality, such a small number of molecules will likely be invisible. The graded green bars on the top of each graph are used to help students appreciate that a gradient of dye molecules will occur rather than a sharp edge. We ask each group to use the graphs to predict where the visible leading edge of the dye will be for each time point. We then discuss with the students how these predictions are really hypotheses that the model allows us to generate.

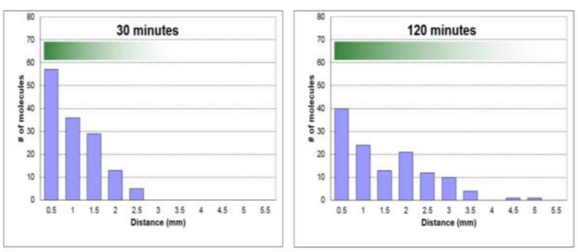

Figure 3. Representative data for two time points (30- and 120-minutes) obtained from simulated motion of 240 molecules. As noted in the panel at left, by the 30 minute time point, most of the simulated molecules are still located at or near the interface. By 120 minutes, they have diffused several millimeters into the gel. The graded bars above each graph represent how the data might be visualized in terms of concentration. Only positive movement (into the gel) is displayed in these graphs.

Wet lab procedure

The following is a list of supplies and preparation steps needed prior to lab meeting time:

• One petri dish filled with 2% clear gelatin solution (prepared the day before the lab, then ½ of gel removed just before start of lab; see Fig. 4)
• Fifty-ml colored water made with up to a 1:1 solution of food coloring and water (we used green, any dark color should work, however all groups should use the same color or the size of the dye molecules will influence the rate of diffusion producing more variability)
• Transfer pipette
• Printed ruler (see Fig. 4)

Once set, the gelatin can be easily removed from the petri dish using a scalpel to cut a straight interface, then carving out the gel using a flat spatula. This process works best if the gels are cooled in a refrigerator for several hours as the 2% solution is fairly soft at room temperature.

Students begin the lab period by being instructed to place the printed ruler under each petri dish with the zero mark precisely under the cut edge of the gel. Then they are asked to fill the ½ empty portions of the petri dishes with food coloring mixture (http://bit.ly/butcherdiffusion). Finally, students are cautioned not the bump the dishes (or the tables if they are not anchored) since doing so can cause the dye mixture to spill over the top of the gel.

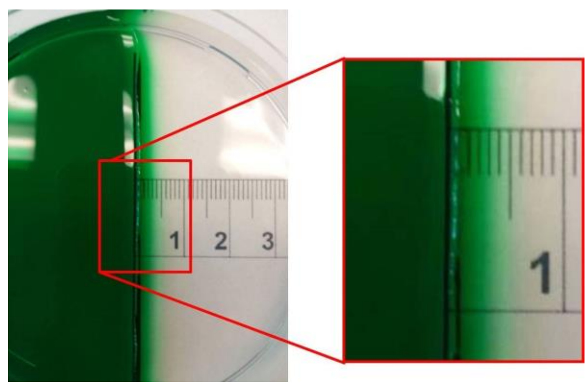

Figure 4. Representative image of gel after 120 minutes. By this point, the green dye has diffused into the gel several millimeters. The enlarged image at right illustrates how the leading edge of the dye is not sharply delineated. Each group of students is asked to discuss where they believe the leading edge is located and then reach a consensus measurement. This variability provides a point of discussion when compared to the model.

At the 30-, 60- and 120- time points, students are asked to observe their dishes and note where the visible leading edge is actually located. We found that students often have difficulty visually determining where the interface of the dye is located. To help visualize the edge, we ask each group to capture an image using their cell phone cameras. While not every student will have such a device, at least one per group is virtually guaranteed. These images can then be enlarged on their cell phones to help with this determination (see Fig. 4). Students should be repeatedly cautioned to avoid bumping the dish (or table) during this process.

After all data points have been observed, we ask students to compare their predictions from the model (e.g., Fig. 3) and the actual observed measurements. To determine the diffusion leading edge for the simulated data, we look for the distance where the number of molecules dropped to a low value such as "10". Figure 5 illustrates how the simulated and gel data compare. The results indicate that the coin-flip activity accurately models the diffusion of dye molecules through the gel.

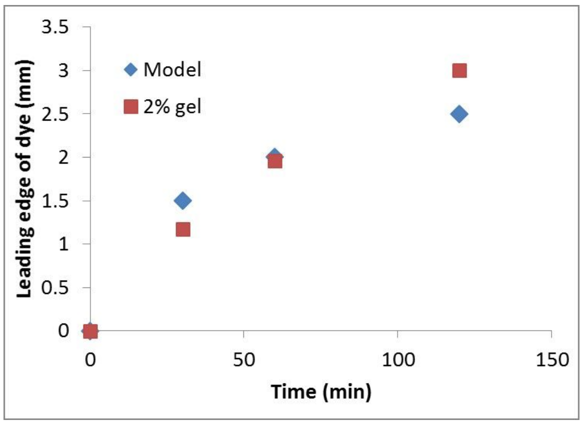

Fig. 5. Comparison of modeled and experimental diffusion through gelatin. Here diffusion is measured as the distance traveled by the "leading edge" of diffusing molecules.

The choice of "10" as a threshold value for the leading edge in the simulations was determined as follows. First we examined one of the images we captured of the gels (e.g., Fig. 4) and analyzed it using Microsoft Paint. Paint allows one to determine the luminance of a single pixel on an image with the aid of the Color Picker function under Tools. Once a pixel is selected with this tool, its color parameters can be determined with Edit Colors. The "Lum" number, or luminance, is a measure of brightness. From this we determined that what we perceive as the leading edge is the spot where the luminance of the dye increases by a factor of four relative to the luminance near the gel interface.

In terms of dye concentration, a luminance four times higher corresponds to a dye concentration four times smaller. Comparing this to the simulated data, given that the number of dye molecules typically average around "40" near the gel interface, the edge should be found where the concentration is "10". Whatever number is chosen, in this case "10", it should be used to identify the diffusion edge for all graphs.

Typically, comparisons between modeled and experimental data will produce some discrepancies. Common discrepancies include apparent outliers in the simulated data, due to statistical noise, or offset experimental data, due to poor estimation of leading edge location. These can be used as discussion points of how to improve on the experiment. More advanced classes can then follow up the lab with lecture materials on the actual equations that are used to model diffusion. In our case, the latter was left for inclusion in a course in physics many of the students would take in subsequent years.

Assessment instruments used

To assess the effectiveness of the lab activity we developed a questionnaire that probes students' conceptual understanding of how diffusion is related to random motion of every particle embedded in a medium. The full questionnaire is viewable online at http://bit.ly/butcherdiffusion. In brief the questions ascertain whether students understand that

1) Particles in suspension move randomly.
2) Solvent molecules also move randomly.
3) At equilibrium concentrations are the same in gelatin as in water.
4) Diffusing particles require no added energy to sustain their motion.
5) Diffusion is a slow process sometimes requiring hours to move distances of a few millimeters.

The questionnaire was administered before and after the lab activity, and at the end of the course as part of the final. To compare our results with a previously published report on students' conceptual understanding of diffusion and osmosis (Fisher et al., 2011), we included two of the Fisher et al. questions that pertained to diffusion in our final assessment (see http://bit.ly/butcherdiffusion).

RESULTS

Responses to assessment questions devised in this study are shown in Figure 6. The results correspond to the average responses of all students from all participating institutions. The left panel summarizes the conceptual gains achieved by students exposed to the diffusion activity we created. The results are in sharp contrast with those achieved in control classes, where students achieved modest to no gains.

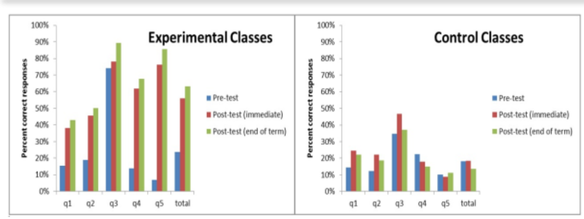

Figure 6. Summary of responses to assessment questions revised in this study.

We also broke down the responses in experimental classes according to disciplines and institutions in which the activity was carried out (data not shown). The results demonstrate remarkable consistency in post-test responses to all questions. The consistency is especially striking given the range of disciplines in which the activity was taught and of faculty backgrounds in diffusion phenomena.

Finally we compare the response of students in our experimental classes to questions derived from Fisher et al.'s survey (2011), which assesses students' conceptual understanding of diffusion and osmosis. As expected, most students responded correctly that molecules move towards regions of lower concentrations. Students from our experimental classes, however, identified the correct reason at a considerably higher rate (35%) than those surveyed by Fisher et al. (2011) (22%).

DISCUSSION

The present work was aimed at developing a laboratory activity that introduces students to the use of modeling in biology and elucidates the concept of diffusion. Our results demonstrate that the activity succeeded on both fronts.

In terms of modeling, the use of coin flips allowed students to arrive at quantitative predictions of diffusion distances for different times. Those results were consistently in fair to good agreement with experimental results. The modeling activity also demonstrated that diffusion is expected to generate gradients rather than movement with a sharply defined edge. The difficulty in defining a diffusion edge may in fact account for the difficulty that some students experienced in obtaining good results. Importantly, the predictions made about diffusion distances and gradients were achieved without mathematical manipulations, thus making the modeling activity accessible to both science and non-science majors.

In terms of conceptual understanding, our assessment tools demonstrate robust gains in the experimental classes compared to those in control counterparts. The gains cut across all concepts tested. Furthermore, those gains seem to be long lasting judging by the fact that students responded equally well on the surveys administered during finals. Importantly, our experimental classes demonstrated an improved performance over those documented by Fisher et al. (2011) for students at a large public university.

While our laboratory activity led to significant gains in conceptual understanding across all questions asked, the final score achieved for questions 1 and 2 (Fig.6) seem distinctly lower than the remaining ones in our assessment tool. We speculate that those lower gains could be accounted for by the way those assessment questions could have been interpreted. The answers to those questions were intended to be "d. All of the above" in both cases, signifying that dye or water molecules can move in any of the directions indicated in answers a, b, and c. However, one can argue that answer "e, "It is impossible to predict the movement of molecules" since the movement of the molecules is intrinsically random. In fact, a large fraction of students responded in this way. If we pooled answers "d" and "e" together, the gains achieved in the first two questions would be significantly higher than reported in Fig. 6.

ACKNOWLEDGEMENTS

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E-portfolios rescue biology students from a poorer final exam result: Promoting student metacognition

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Abstract: E-portfolios have the potential to transform students' learning experiences. They promote reflection on the significance of what and how students have learned. Such reflective practices enhance students' ability to articulate their knowledge and skills to their peers, teachers, and future employers. In addition, e-portfolios can help assess the ability of teachers and institutions to inculcate students with their core learning objectives and skills. In 2012/13, I piloted the use of an e-portfolio assignment in a sophomore molecular cell biology course to determine whether it could enhance student learning. My pilot assignment found: 1. The e-portfolio rescued students from a poorer final exam result relative to their midterm exam - students who did not complete the e-portfolio assignment had a greater probability of performing more poorly on the final relative to the midterm exam ($p = 0.004$); 2. E-portfolios can enhance student engagement; 3. Google Sites works well as an e-portfolio platform; 4. Instructors do not need to be technical experts when the e-portfolio platform is embedded in students' everyday digital life; 5. Instructors are able to focus on developing students' learning outcomes associated with e-portfolio assignments when e-portfolios are so embedded; 6. Students may choose whichever e-portfolio platform they prefer, needing only to submit a URL to their e-portfolio for grading.

Keywords: digital life; evidence of learning; Google Sites; independent learner; integrative learning; reflective practice; student engagement; student learning outcomes

INTRODUCTION

Graduating students often have difficulties clearly articulating their learning (Peet et al., 2011). Likewise, some students struggle to apply prerequisite learning to subsequent courses. Both observations indicate that students can have difficulty integrating the significance and applicability of their learning. Some students appear to view education as a series of checkboxes; once a course is checked off a student's list of requirements, students forget what they learned or fail to apply that learning to other educational contexts. E-portfolios may be able to address this situation, as there is evidence that e-portfolios can transform students' learning experiences by heightening student engagement (Herteis and Simmons, 2010) possibly by providing structure for student metacognition (Miller and Morgaine, 2009), which can improve academic performance (Tanner, 2012). E-portfolios provide a structure for students to communicate their learning to others and themselves. Externalizing their learning facilitates students' ability to transfer their learning to simultaneous and subsequent learning experiences (Eynon et al., 2014).

Metacognition has been defined as thinking about one's own thinking or the ability to plan, monitor, and evaluate our own learning processes (Tanner, 2012). Folio-thinking facilitates students' metacognition through the reflective process of collecting evidence of their learning (Chen and Light, 2010), and an e-portfolio publicly displays students' thinking about their learning. The portfolio process promotes higher order thinking (Eynon et al., 2014) by facilitating students' analysis, synthesis, and evaluation of their learning (Herteis and Simmons, 2010). The goal of e-portfolios is to teach students how to learn and improve academic performance (Tanner, 2012), which occurs when students collect evidence of their learning and write about the process used to produce their work. By writing about how they produced their work, students engage in a reflective process which connects their different educational experiences and assesses the benefits of the experience and how it could be improved for the next learning opportunity.

Written reflections within an e-portfolio can transform students' learning by providing a venue for them to consider their thought processes without being trapped by the idea that the correct answer is the only educational goal. Rather, students need to understand that how they problem-solve and think critically is also part of their learning, and focusing solely on the correct answer can sometimes interfere with deeper learning (Tanner, 2012), because they may not consider the process used to arrive at a correct answer. To promote students' consideration of how they think–to improve their critical thinking–instructors need to grade students' thought processes in addition to their final products. Instructors can promote students' reflection by grading students' honest appraisal of their own work and their articulation of the process used to improve their work. To become independent learners, students need to learn or understand how they think to improve their ability to think (Girash, 2014). Reflection enables students to articulate how they learn, allowing them to understand their ability to connect their learning to their existing mental model (Brown et al., 2014). Reflective thinking – metacognition – is active, directed learning (Rodgers, 2002), and e-portfolios – folio-thinking – are one way to facilitate students' development of their thinking ability. Thinking about learning will facilitate students' assessment of their learning process, and an e-portfolio can enable this by making visible to students their development as a learner (Eynon et al., 2014)

E-portfolios are considered to be a process (workspace) and a product (showcase), while the approach taken when assigning an e-portfolio can be either structured (for institutional assessment) or expressive (students have a choice in what is inserted and use their own voice) (Barrett, 2011). The structured approach enables institutional assessment of its teaching and programs. In contrast, the expressive approach facilitates students' metacognition. E-portfolios can serve both purposes, but the approaches can interfere with each other (Barrett, 2007). Having students develop an e-portfolio with a consideration of how it might be used after the completion of their degree, for example as a showcase for future employers (Kitchenham, 2008), can make students' learning relevant to them (Scott, 2012), as long as it does not interfere with their willingness to post and reflect on developing work (Tosh et al., 2005). This tension between showcase and learning may be solved by giving students control over who is able to view their e-portfolio. Implementation of e-portfolios needs to take this tension between structured showcase and expressed workspace into consideration by determining the primary objective of the assignment beforehand.

The ability for students to make connections within their own education is known to produce deeper learning by producing a more robust knowledge structure (Ambrose et al., 2010). E-portfolios facilitate students' connections between their learning narrative and the artifacts in their digital archive, or between assignments and courses (Herteis and Simmons, 2010), enhancing students' metacognition of their learning (Brandes and Boskic, 2008). In addition, making connections within students' knowledge structure can integrate a sometimes fragmented education (Clark and Eynon, 2009), which can result from students switching programs, institutions, or by students treating courses as islands of learning with no relationship to each other.

Social pedagogy involves students articulating their learning to their peers and external community. As such, social pedagogy can address educational fragmentation by enhancing students' learning through engagement between the learner and the larger community (Eynon et al., 2014). Web 2.0 tools (e.g. Google Sites) enable this connectivity between students, teachers, and the world outside of academia (Tunks, 2012) by facilitating the conversation. From an educational standpoint, Web 2.0 tools enable students to extend the metacognitive conversation they are having with themselves to others through the ability to comment on students' e-portfolios. The social pedagogy possible with e-portfolios can make students' learning visible to both the learner and the community. Articulating to an external community enables the student to express their learning to themselves (Greenstein, 2013).

The advantage of electronic portfolios over traditional portfolios is two-fold: they increase the diversity of artifact possible in a portfolio, and they enable social pedagogy (Lombardi, 2008, Eynon et al., 2014). Increasing the diversity of artifact beyond writing to include photos, drawings, podcasts, and more, requires the application of visual rhetoric (communication through imagery) in e-portfolio construction (Clark and Eynon, 2009) which, similar to written reflections, can affect students' learning. But it is interesting that some students do not understand the advantage of producing an electronic portfolio vs a paper-based portfolio (van Wesel and Prop, 2008), suggesting that students' use of visual rhetoric needs further development.

Part of my interest in developing students' e-portfolio use is to produce deeper integrated learning that sticks. E-portfolios can transform students' learning experiences by integrating rather than compartmentalizing students' courses. Often, students do not link learning that occurs in one course with an educational experience from another course, or from their lived experience. When students complete a pre-requisite course, the aim of instructors is to build upon that prior learning in the subsequent course. Having students record and reflect on their learning in an e-portfolio produces a learning narrative that spans academic terms, and has the potential to enable students' development and integration of their previous learning, which is retained between academic terms and campuses (Clark and Eynon, 2009). Studies demonstrate that e-portfolios develop students' ability to integrate knowledge (Peet et al., 2011). However, the connection between the e-portfolio and the course or program needs to be made explicit to students, making its role in their own learning clear (Wickersham and Chambers, 2006). Explaining to students the integrative role e-portfolios play in education will prepare them to be metacognitive about their own learning, enhancing their level of engagement (Rodgers, 2002) which should produce improved student learning outcomes (Coutinho, 2007, Girash, 2014). The present paper presents the results of piloting an e-portfolio assignment in my sophomore molecular cell biology course, which provides evidence that e-portfolios can improve student learning outcomes.

METHODS

Several issues needed to be considered before I implemented an e-portfolio assignment (Chen and Light, 2010, Chatham-Carpenter et al., 2010, Barrett, 2011, Bass, 2014). First, the focus needs to be on learning the course material; the e-portfolio platform must be sufficiently user-friendly to ensure students do not spend excess energy and time learning the technology. Second, the e-portfolio must be student-centered, giving students the freedom to create a portfolio presence that is representative of themselves, and for which they have control over who is able to view it. Third, the price must be reasonable. Finally, the purpose of the e-portfolio must be clear and distinct (i.e., is it for institutional assessment or for student learning?).

I chose to use Google Sites as the software platform for my e-portfolio assignment because it is freely available and because Gmail is our institutional email system. Thus, Google Sites and Google Drive are already embedded in the educational environment of our students. The ubiquity and familiar interface of Google Sites would facilitate a student-centered experience, which is known to enhance student engagement in the portfolio and thus, also in their own learning (Ring et al., 2008).

The e-portfolio assignment I implemented involved students' reflection on submitted coursework and resulting instructor feedback. This counters the typical student response to instructor feedback, which is to ignore the comments (Wiltse, 2002). The degree to which feedback is ignored is dependent upon the amount of feedback provided, and whether this feedback informs a subsequent assignment or resubmission (Ackerman and Gross, 2010). Students were also tasked with reflecting on how their submitted coursework exemplified their ability to think, research, and communicate; the core academic skills at Augustana (available at http://aug.ualberta.ca/core-curriculum).

Student comments quoted in this study were collected from institutional student evaluations of instruction of my sophomore molecular cell biology course. These comments are completely anonymous, and their use was approved by the university's Research Ethics Board (project #53558). The evaluation includes ten standard institutional questions (available at http://aug.ualberta.ca/USRI). For this particular course, I included the request to "comment on the e-portfolio assignment as an educational experience" on the back of the evaluation form. There were 37 students who completed the molecular cell biology course, of which 20 chose to complete the e-portfolio (the other 17 choose instead to produce a research review poster). There was a gender imbalance in the class (75% female), typical of the biology degree program at Augustana. This gender imbalance was reflected in the number of women (15) who chose to complete the e-portfolio assignment. Seventeen of the 20 students who completed the e-portfolio assignment provided comments on the back of the evaluation form. Due to the completely anonymous nature of the survey, it is unknown which comments are from males and females.

The e-portfolio assignment consisted of six web pages using a template I created for students. Students were able to modify the template to reflect their own experiences, but the basic organization of the web pages within their e-portfolio remained similar for all students. The homepage contained biographical information that students could share (e.g. their major, their interests, what they hoped to do with their degree) plus an introduction to their e-portfolio as evidence of their writing, speaking, thinking, information literacy, and biological skills (the other five web pages). The assignment required that only four of the five skills be addressed. On each of these skill web pages, students provided a hyperlink to their written assignment (in PDF or MS Word format) saved on Google Drive with an accompanying reflection in HTML in their Google Site, indicating why they had chosen the assignment as evidence of their learning. Each of these four assignments researched a different question pertinent to the discipline. This typically involved students commenting on a primary research article, but sometimes also included investigating the accuracy or implications of a newspaper article, radio or TV show, website, or podcast in the area of molecular cell biology. The e-portfolio assignment contributed 15% toward a student's final course grade. Twenty percent of the e-portfolio mark was allocated to the quality of students' reflections and the clarity of its presentation (i.e. visual rhetoric). Forty percent of the assignment mark was allocated to the depth and clarity of a student's chosen investigation. The diversity of artifacts was allocated 20% of the e-portfolio mark, with the remaining 20% allocated for timeliness and mechanics of e-portfolio entries.

RESULTS AND DISCUSSION

Students who did not complete an e-portfolio did significantly poorer on their final relative to their midterm exam (mean ± SE: 61% ± 3.2 vs 70% ± 3.2, respectively, paired t-test, $p = 0.004$, N=17). In contrast, students who completed the e-portfolio assignment had no significant differences between their final and midterm exams (61% ± 3.2 vs 64 ± 3.5, respectively, N=20); there were also no significant differences between the e-portfolio and poster cohorts' marks or exams. It appears that the e-portfolio assignment rescued students from a poorer result on the final exam (Figure 1). Students typically perform poorer on the final compared to the midterm exam in other courses I have taught over the last 25 years (Figure 2), perhaps due to the greater amount of material examined on comprehensive final exams. This result of rescuing students from a poorer final exam mark may be due to the increased reflection on why and how students are learning in the particular course.

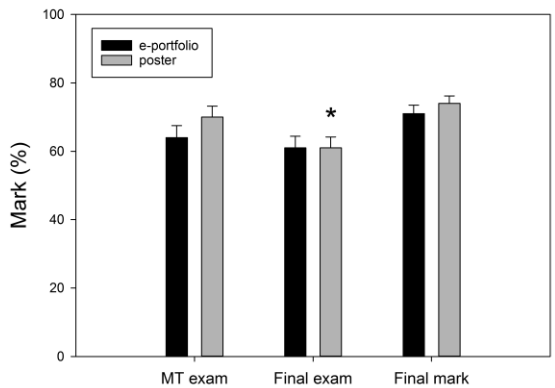

Fig. 1. The impact of the e-portfolio assignment on student learning outcomes in a sophomore molecular cell biology course. Paired two-tailed t-test detected significant differences (* $p = 0.004$) between the midterm (MT) and final exams of students completing the poster assignment ($N = 17$). There were no significant differences between the MT and final exam scores (% mark) of students completing the e-portfolio ($N = 20$) or between the e-portfolio and poster students' exams or final mark.

Overall, the e-portfolio assignment was well received by students, as indicated by student comments on their end of term evaluations of the course:

- "The ePortfolios were a useful educational activity."
- "e-portfolios helped increase my knowledge of topics in this course."
- "Portfolios developed my writing skills and searching along with my citing skills."
- "ePortfolio helped me connect my learning to the real world and encouraged out of class research!"
- "This is what linked my learning to my environment."
- "The eportfolio was interesting, helped with deeper learning and understanding."

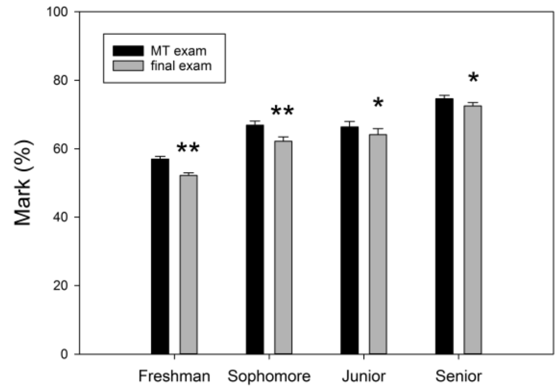

Fig. 2. Student performance (% mark) on midterm (MT) vs final exams in freshman ($N = 633$), sophomore (cell biology pre-e-portfolio assignment, $N = 161$), junior (histology, $N = 94$) and senior (capstone, $N = 138$) biology courses taught by the author since 1990. Paired two-tailed t-test detected significant differences (* $p < 0.05$, ** $p < 0.01$) between the MT and final exams for each year.

Many students thus seemed to understand its significance to them, with some students continuing to use it. In contrast, others felt it was an unnecessary addition to the course requirements (e.g. "…time consuming and pointless") and did not understand what the e-portfolio was accomplishing (e.g. "…not exactly sure what is required"). In addition, some of the students counterbalanced their positive comments with a negative comment, indicating that the e-portfolio assignment was useful for integrating learning from other courses (e.g. "…make me analyze more of my other work") but not necessarily in the course in which the e-portfolio was assigned (e.g. "…didn't enhance my learning in this course").

Student responses which indicated a lack of understanding of the point of e-portfolios (e.g. "…did not find them very educational") are interesting because both the role and utility of e-portfolios were explained to students a number of times throughout the pilot; some students received the instructor's framing of e-portfolios (e.g. "…connect my learning to the real world…") whereas others did not (e.g. "…did not see the point of making it web-based"). This lack of understanding may reflect the distinction between students who were successful in reaching a metacognitive level as opposed to those students who were unable or unwilling to think about their thinking and learning, and the role of making their learning public. Such a distinction has been previously noted: Metacognition must be explicitly part of any active learning pedagogy, otherwise, students may be engaged in the hands-on activity without engaging in their own learning (Tanner, 2012).

My implementation of an e-portfolio assignment suggests, therefore, that to be successful, the context of any e-portfolio assignment must be designed to align with students' goals and values (Ambrose et al., 2010). This close alignment requires a class discussion to ensure that students' and instructors' understanding of what and why they are teaching and learning are the same.

Four examples illustrate how e-portfolios impacted students. When I first discussed the e-portfolio assignment with the class, I was surprised when students indicated that they did not realize that implicit in their degree was the development of thinking, communication, and research skills. By finding examples of these skills in their coursework, and commenting on how these course products exemplified their proficiency, students became engaged in what, why, and how they were learning. Asking students to consider what, why, and how they learned increased students' awareness of their learning. Others have shown that using a metacognitive activity improved student learning outcomes (Mynlieff et al., 2014) and that metacognition positively correlates with student achievement (Coutinho, 2007).

In another example, a student used the instructor-feedback that their research was superficial, not even having consulted their textbook index. Subsequently, the student chose to reflect on this as a learning opportunity, using it to develop the skill of checking assumptions with deeper research. Students often ignore the feedback provided by the instructor (Wiltse, 2002, Ackerman and Gross, 2010). The e-portfolio assignment, in contrast, required that students directly address the feedback indicating what needed to be improved, and demonstrate the application of the feedback in a subsequent assignment.

In a third example, it was gratifying when, without encouragement on the instructor's part, a student included an assignment from another course to demonstrate their research skills, illustrating how e-portfolios can enable students' integration of their learning across courses within their degree program (Clark and Eynon, 2009). In contrast, we have observed that some students in courses that did not use e-portfolios were unable to apply their learning from a previous or contemporaneous course. Not all students completing an e-portfolio will make these connections, and some students who have not completed an e-portfolio do integrate their education. The point is not that e-portfolios will solve all students' difficulties in integrating their learning: It is that e-portfolios provide a valuable and explicit venue for students to make these connections within their education.

Finally, another student was able to use their e-portfolio after the course in an application for a research position using it to showcase their writing and research skills (Kitchenham, 2008). In this context, there was no tension between showcase and workspace (Tosh et al., 2005), because the student initially designed their e-portfolio specifically to meet the objectives of the course assignment without having to consider whom else might view it, because the student was in control over who was able to access it. It was not until the following year that the student realized their e-portfolio could be used in their application, and thus granted permission to the researcher to view the e-portfolio in order to assess the student's research potential.

I found that I could not assume that students are technologically proficient (Parker et al., 2012). Most students are familiar with Facebook, but not with website design. Google Sites alleviated this problem given the familiarity our students had with the Google interface, since Gmail is our institutional email system. I developed a small repository of website URLs soon after the implementation of the e-portfolio assignment when I realized that some of my students needed assistance with the technical aspects of the e-portfolio platform. This repository alleviated the need for instructors to be technical experts. Students are easily able to find online solutions to their e-portfolio questions given the ubiquity and free availability of Google Sites.

One of the advantages of using Google Sites is that students can choose or design their own website, enhancing their ability to express their own unique educational experience. This was certainly apparent in the different details that students included in their e-portfolio, and how they were arranged on their web pages, even when students used the standard template I provided. The ability for students to design their own website enhances the student-centered character of e-portfolio pedagogy, thereby increasing student engagement (Ring et al., 2008). However, as already stated, not all students are technologically adept, and thus may require support in the creation of their e-portfolio. The website template I provided gave structure for students requiring such assistance; a prepared template is also necessary if instructors desire a particular format for e-portfolios. However, in this pilot study, students required little training or technical assistance with Google Sites, because this particular website platform was already integrated with students' institutional email, calendar, and digital archive. In addition, the available online resources for both designing and developing students' personalized e-portfolios are considerable. Thus, I did not have the same technical difficulty in implementing the e-portfolio platform as has been reported elsewhere (Kitchenham, 2008, Chatham-Carpenter et al., 2010).

I found it interesting that, although the objective of the e-portfolios was reiterated a number of times throughout the term, some students still focused on the mark rather than the learning process (e.g. "… [the e-portfolio] is such a small part that it is insignificant compared to the rest of the class"). This may have resulted from how the assessment criteria were explained to students; it is imperative that instructors are clear about the criteria for the assignment, so that students understand the basis of their final mark and how it aligns with students' learning goals (Ambrose et al., 2010).

In addition to being clear about the learning objectives and grading criteria for an e-portfolio assignment, providing students with leading questions to guide them with their critical self-reflection also helps orient students to the uses and processes associated with the production of an e-portfolio. Students are typically unaccustomed to the reflective process required for metacognition of their learning. Leading questions can help scaffold students' construction of their e-portfolio and the resulting metacognitive activity that results in deeper learning (Brandes and Boskic, 2008); students need explicit prompting to enable their metacognitive process (Girash, 2014). I developed a series of questions (Haave, 2014) in consultation with colleagues about my e-portfolio assignment to engage students' metacognition about their learning, framed in terms of developing students' learning philosophies (Herteis and Simmons, 2010). Lists of metacognitive prompts for a variety of learning contexts have been published (Herteis and Simmons, 2010, Tanner, 2012, Rafeldt et al., 2014). These questions help students reflect on their course assignments, considering what, why, and how they were learning. My overall objective in the development of these metacognitive prompts for students is to deepen their engagement with the course material, producing an educational experience that will go beyond the confines of the particular assignment or course, integrating their learning between courses and across disciplines (Clark and Eynon, 2009).

A number of issues that arise with e-portfolios have been raised elsewhere (Lorenzo and Ittelson, 2005, Abrami et al., 2008, Chatham-Carpenter et al., 2010, Parker et al., 2012) that are solved by the use of Google Sites. Because Google Sites is integrated with Google Drive, institutions do not need to worry about storage on their own servers. In addition, it is clear that students own the e-portfolio and control access to it, because the website is registered to students' own Gmail account. Although privacy issues have been raised with Google Apps (Rotenberg and Barnes, 2013), the emerging consensus seems to be that social media are inherently public (Hastings, 2010), and thus users should place on the web only material that they would be comfortable reading in a public news forum. The implementation of Google Apps at the University of Alberta places control of what student information resides with Google in students' hands.

Cognitive overload for students learning how to use Google Sites is limited, because the graphical user interface does not require a knowledge of HTML coding, and is familiar to those who use Google Apps: Students are able to focus their attention on their reflective learning rather than on learning the technology. Additionally, instructors can focus on pedagogy rather than technology by directing students to online resources. The abundance of templates and inherent design flexibility of Google Sites enables students to develop an e-portfolio that is their own and not externally imposed. Furthermore, the e-portfolio is portable – it is possible for students to transfer their material over to a Google account if they no longer wish to have it attached to their institutional account. Finally, Google Sites is freely available.

The results of my e-portfolio implementation suggest that faculty be encouraged to consider using e-portfolios in their courses and degree programs as a teaching strategy that enables students' self-reflection on the skills and knowledge gained during their studies. However, I think it would be difficult to implement e-portfolios on an institutional basis because they are a pedagogy (Peet et al., 2011, Eynon et al., 2014); it does not seem right to insist that instructors teach a particular way, when teaching is best when it arises from an instructor's personal identity rather than being imposed by administration (Tanner, 2011). In addition, students should be encouraged to use whatever platform best suits them. Our role as academics is not to train software use, but rather to enable students' metacognition. Embedding e-portfolios in students' everyday online work environment limits the need for technological intervention on the part of instructors. In the end, instructors simply need to instruct their students in metacognitive practice and receive from students the URL to their e-portfolio.

My pilot clearly provides evidence of the positive impact e-portfolios can have on student learning outcomes, in this case, by rescuing students from a poorer final exam result. This impact on student learning outcomes may be due, in part, to their ability to enable connections among students' learning and lived experiences, and its ability to engage faculty in high-impact educational practices (Eynon et al., 2014). Thus, e-portfolios have the potential to transform students' learning experiences by influencing how students engage in their education and by impacting the teaching strategies employed by faculty (Miller and Morgaine, 2009).

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Comparing effects of comedic and authoritative video presentations on student knowledge and attitudes about climate change

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Key Words: Climate change, instructional video, media

Abstract: Given the diverse array of media sources available to students today, it stands to reason that some media outlets would be of greater quality than others when communicating particular subjects to students. But what constitutes effectiveness among the many choices in information sourcing might not be easily intuited. For example, previous findings have shown viewers of comedy "news" shows (the type of news show most frequently watched by younger viewers) to be better informed on some issues than viewers of other "news" outlets such as Fox News, CNN, or MSNBC. As students encounter them on their own, and as instructors often introduce topics using clips from current popular programs, we sought to compare the effects of two different sets of videos, one comedic and one authoritative scientific, on students' knowledge of and attitudes towards climate change as well as how the two sets of videos were received by students. Surprisingly, we found no difference in effects on students' knowledge of or attitudes towards climate change. We did find however, that students generally felt that the authoritative videos were more likely to influence the way someone might vote, and that liberal students felt both videos were slightly more likely to influence voting than conservative students. We also note a disjunction between self-reported understanding of climate science and actual knowledge thereof, and we make suggestions for future studies on media related to climate change and for climate change educators.

INTRODUCTION

Students in the digital age have access to a greater variety of media sources than ever before (Althaus & Tewksbury, 2000), and the rise of the smart phone and other mobile devices means news is available anytime and anywhere (Chan-Olmsted et al., 2013). Prior research has shown that different media sources align more strongly with the views of the scientific community than others. For example, a comparison of climate change news coverage across several countries found that in some countries, including the United States, a false pluralism emerges in the narrative surrounding climate change, implying that there is a debate about its factual nature; in other countries, though, coverage mirrors the views of the scientific community more closely (Dispensa & Brulle, 2003). Media literacy has also been suggested as a possible key factor in shifting attitudes towards global climate change (Cooper, 2011).

A 2012 Pew Research Center report showed that digital news media have surpassed newspapers and magazines, with television still the leading source nationwide. Among younger Americans, though, many do not consume news at all, and the sources most likely to reach them are news comedy programs such as *The Daily Show* and *The Colbert Report* (Kohut et al., 2012). This fact may seem lamentable if it were not for the curious findings that viewers of such comedy shows have been shown to be better informed on certain issues than viewers of other news outlets. For example, a study of public knowledge of proposed Net-neutrality rules found that viewers of *The Daily Show*, *The Colbert Report*, and *Last Week Tonight* with John Oliver were better informed than any other viewership to which they were compared, including Fox News, CNN, and MSNBC (University of Delaware Center for Political Communication, 2014). It has also been found that *The Colbert Report*, a comedy news show in which the host satirically plays the role of a conservative newscaster lampooning actual conservative hosts such as Bill O'Reilly, did a better job of communicating about campaign finance than any other outlet, again including Fox News, CNN, and MSNBC (Hardy et al., 2014). It is important to note that viewers of *The Daily Show* and *The Colbert Report* are upwards of 80% moderates and liberals (Kohut et al., 2012), and that conservative viewers of *The Colbert Report* are likely to view the satire as a sort of double-bluff, in which the host is only pretending to joke about the issues (LaMarre et al., 2009).

Global climate change (GCC) is a highly politicized scientific issue (McCright, 2010; McCright & Dunlap, 2011b), with conservative white males being the most likely demographic group to deny anthropogenic GCC (McCright & Dunlap, 2011a). This trend in politicization has been noted in national surveys in the United States for decades (Leiserowitz et al., 2012). Despite the purported desire of most Americans for unbiased news sources (Kohut et al., 2012), there is still large reliance on partisan media, which likely contributes to the widening gap in GCC opinions. The proposed mechanism by which this may occur is that consumption of conservative-leaning media tends to decrease trust in scientists while consumption of liberal media is associated with an increased confidence in scientific consensus (Hmielowski et al., 2014). However, whether this difference rests in the media coverage or the viewers themselves is unclear. What is clear is that representing climate science as controversial has measurable effects on media consumers' certainty about GCC (Corbett & Durfee, 2004). In terms of science communication, Kahan advises that climate communication should rely on evidence above all else (Kahan, 2013).

Given Kahan's suggestion that GCC communication should be evidence based (Kahan, 2013), the fact that most young Americans get their news from comedy shows (Kohut et al., 2012), and that viewers of comedy shows have been shown to be better informed about some issues such as net neutrality (University of Delaware Center for Political Communication, 2014) and campaign finance (Hardy et al., 2014), we wondered whether authoritative, nonpartisan, fact-laden educational documentaries on climate change are more effective or are perceived differently than comedic/satirical news stories on climate change in terms of how compelling students find the pieces, whether attitudes shift, and how knowledge of climate change science is influenced.

METHODS

We set out to compare how two different sets of videos concerning climate change might influence students' thinking about climate change after showing the videos in separate sections of a large, mixed-majors introductory biology class in a large, private university in the northeastern United States. The set of videos shown to one class section comprised authoritative, fact-laden, educational films from the Intergovernmental Panel on Climate Change (IPCC). The other class section was shown satirical, comedic videos instead of the IPCC films. These comedy videos featured humorous commentary on science, news, and policy related to climate change by Jon Stewart, Stephen Colbert, and John Oliver (Comedy). This course is quite broad in its scope, and does not focus on climate change beyond a basic introduction to the greenhouse effect, global carbon cycling, and the correlation between global temperature rise and the rise in atmospheric concentrations of greenhouse gasses. The videos were shown to the students prior to any coverage of climate change in the curriculum, and all students received the same instruction in class aside from the different videos they were shown during one class session.

The IPCC-produced videos can be found at http://www.ipcc.ch/news_and_events/multimedia.shtml, and the specific videos shown were titled "Climate Change 2013: The Physical Science Basis" and "In Harm's Way." The videos were shown in the order listed above. The first is a video summary of the Working Group I section of the IPCC's Fifth Assessment Report (AR5, IPCC, 2013). The second is a video summary of the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX, IPCC, 2012). Both videos include narration by, and interviews with, actual contributors to the respective reports as well as imagery associated with climate change effects and also display text communicating facts about climate change.

The comedy videos consisted of three segments from popular satirical or parody news shows. The first was a clip from *The Daily Show* with Jon Steward titled "Burn Noticed", which aired on September 22, 2014 and focused mainly on interactions between presidential science adviser Dr. John Holdren and various members of the US House of Representatives Committee on Science Space and Technology (http://thedailyshow.cc.com/videos/8q3nmm/burn-noticed). The second was a *Colbert Report* piece called "The Republicans' Inspiring Climate Change Message" which aired on November 6, 2014 mainly addressing the popular republican tactic of responding to questions or statements pertaining to climate change with some variant of "I am not a scientist" (http://www.cc.com/video-clips/sc6mpp/the-colbert-report-the-republicans--inspiring-climate-change-message). The third comedy video was from *Last Week Tonight* with John Oliver in which the host staged a "statistically representative climate change debate" pitting popular science author and former children's science show host Bill Nye along with 96 climate scientists as representatives of the scientific consensus on climate change against three climate change deniers in order to illustrate the extreme minority who hold this fringe position. (https://www.youtube.com/watch?v=cjuGCJJUGsg). The segments from *The Daily Show* and *The Colbert*

Report were shown as they appeared on TV, with the exception of skipping directly to the beginning of the segment in the lengthier *Daily Show* video clip. Volume on the multimedia system was briefly muted during the video from *Last Week Tonight* in order to censor an expletive.

All data were collected according to an IRB-approved protocol, and participation was voluntary. The videos were shown to two separate sections of a large introductory biology class, one viewing the IPCC videos and the other viewing the comedy clips. Students were then asked to respond to questions about their perceptions of the videos' effectiveness using individual response devices (commonly known as “clickers”). See Appendix 1 for the full list of questions asked in the lecture. Students who did not attend these lecture sections and did not see the videos served as a group for comparison, as long as they reported not having seen the videos at another time (we will refer to this group as “Control,” though the only variable controlled for is whether or not the students had viewed the videos).

Outside of class, a measure of knowledge of the science of human-induced climate change (HICCK, Lombardi et al., 2013) was administered before and after the intervention, as were survey questions assessing students' opinions about GCC and recording demographic information (Carter & Wiles, 2014). For control purposes, additional questions in the post-intervention surveys were asked to ascertain whether students had previously viewed the videos in another context. Asking students whether they had previously viewed the videos also allows the exploration of whether these students align with particular demographic or attitudinal categories, and whether these factors may influence those students who had not seen the videos. All pre-post surveys were administered online using course management software (Blackboard) as described in Carter and Wiles (2014). Each of the two groups (IPCC and Comedy) were compared to the control (Control) in terms of various items generated through pre/post surveys: their gains in knowledge about GCC, changing opinions about GCC, and thoughts about how scientists view GCC. We also examined how various demographics— especially political leanings—correlate with these results. Pre- and post-viewing numeric responses were compared using paired t-tests, while differences among groups were analyzed using box plots and chi-squared tests for quantitative and categorical variables, respectively. Correlation tests and analysis of variance tests were used to assess relationships between quantitative variables from the same time points. The sample consists of a mixed majors introductory biology class at a medium-sized private university in the northeast. The demographic breakdown is similar to that described in Carter and Wiles (2014). For this study, respondents are grouped as follows: Total N = 649, Comedy N = 288, IPCC N = 250, and Control N = 111. In this study, liberal-identifying students outnumber conservative-identifying students 2:1, with N=411 of the former, and N=199 of the later. Historically, this population is largely accepting that climate change is occurring, so we focus on the importance of the issue of climate change as our main indicator of attitudes towards climate change as in Carter and Wiles (2014).

RESULTS

Results were not appreciably different if students who had seen the videos before were excluded from analysis, so they were included in the appropriate experimental groups and the full dataset used for analyses. Despite our expectations about differential effects between IPCC and Comedy videos, little difference was observed. No group was significantly more or less likely to change their opinion about climate change. None of the three groups (IPCC, Comedy, Control) differed significantly pre- to post-treatment in terms of how well they claimed to understand climate change as a notched box plot showed no significant difference in group median values. For the full dataset with all groups together, a paired t-test shows $p = 0.0639$, mean of differences = -0.0574, and though there was a significant difference pre- to post-intervention in personal importance of climate change ($p = 0.0166$), the average difference was very small between groups.

Confoundingly, we measured a slight but significant decrease in actual understanding of climate change science for each group. For the Control group $p = 0.00116$ and mean of differences = -3.539; the IPCC group had $p < 0.001$, and mean of difference = -3.667, and the Comedy group $p < 0.001$ and mean of differences = -4.69. Pre-post differences were nearly identical when comparing students who identified as liberal versus conservative. Climate science knowledge significantly decreased pre- to post-intervention for both liberals ($p < 0.001$, mean of differences = -3.978) and conservatives ($p < 0.001$, mean of differences = -4.372).

There was a significant difference between the Comedy and IPCC groups in how influential students thought the video could be on the way a person votes, with the authoritative videos from the IPCC perceived to be more influential. A Welch two sample t-test indicates a significant difference in the means ($t = 3.975$, $p < 0.0001$). This difference is shown in Figure 1. Since whether the video might influence how a person might vote was asked in class immediately following the video, there are no data to compare with the Control group. Students perceived both video sets to be equally influential in terms of how they may change people’s attitudes or the way people might vote on issues related to GCC. However, liberal students on average thought both video sets would be more influential than their

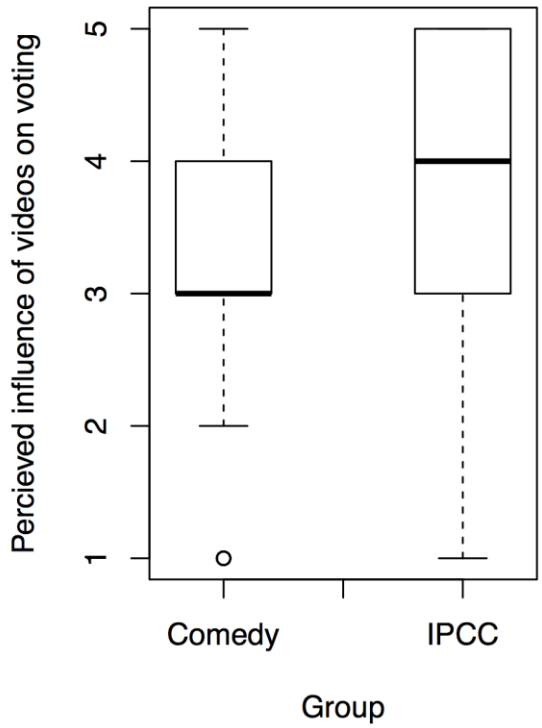

Figure 1: The relationship between which videos were viewed and response to the question "Do you feel these videos might influence the way someone might vote?" 3 corresponds to "Maybe," and 4 corresponds to "Probably." The bottom, middle, and top of the box represent the first, second, and third quartile, respectively, while the whiskers represent the minimum and maximum values within 1.5 times the interquartile range. Outliers are represented as individual points.

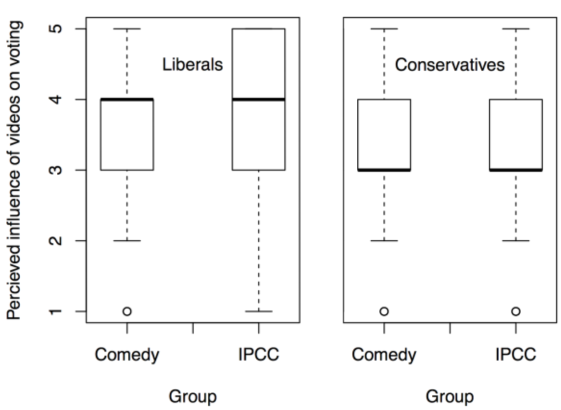

Figure 2: The relationship between which videos were viewed and response to the question "Do you feel these videos might influence the way someone might vote?" broken down by political views held by respondents. 3 corresponds to "Maybe," and 4 corresponds to "Probably." The top, middle, and bottom of the box represent the first, second, and third quartile, respectively, while the whiskers represent the minimum and maximum values within 1.5 times the interquartile range. Outliers are represented as individual points.

conservative counterparts did. This difference is demonstrated in Figure 2.

A separate interesting outcome of the analysis of these data is that the correlation between pre-intervention, self-reported understanding of climate change and actual measured understanding of climate change science, while positive and significant (r of 0.151, $p < 0.001$), is weaker than expected. This trend is shown in Figure 3. The post-intervention correlation increased ($r = 0.199$, ($p < 0.001$), but was still not at all strong. Results differed somewhat for the IPCC group, which had a larger increase, but lower p-values (pre-intervention $r = 0.167$, $p = 0.0103$, post- intervention $r = 0.25$, $p < 0.001$). The correlation between self-reported and measured understandings of climate change were greater post-intervention for the IPCC group than either of the other groups, although only 6.25% of the variance in self-reported understanding is explained by measured understanding.

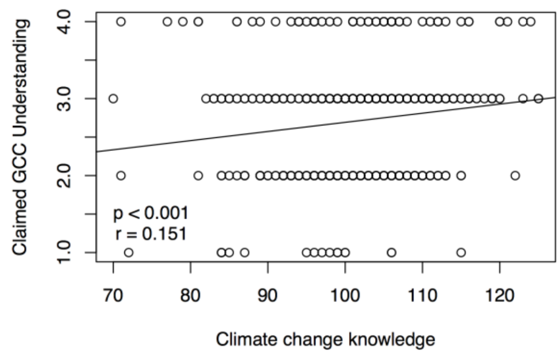

Figure 3: The pre-intervention relationship between climate change knowledge (as measured by individual scores on the HICCK instrument) and claimed climate change understanding (response to the question, "How well would you say you understand climate change?" 1 = Not at all, 2 = A little, 3 = Fairly well, 4 = Very well).

DISCUSSION

Although viewers of comedy news shows have been shown to be more knowledgeable about other issues than those who obtain their news from traditional outlets (Hardy et al., 2014; University of Delaware Center for Political Communication, 2014), our results did not support the notion that such comedic news stories are any more informative or more likely to sway opinion than authoritative educational videos focusing on serious communication of facts. Encouragingly, this study also found little evidence for politicization of climate change in that there was no statistical difference between liberal- and conservative-identifying students in terms of how important they felt the issue of climate change was for them. This finding differs from previous findings related to a more general population in the United States (McCright, 2010; McCright & Dunlap, 2011a: McCright & Dunlap, 2011b, Leiserowitz et al., 2012) as well as findings of a study with a very similar population of students (Carter and Wiles, 2014). This intriguing result may be indicative of a growing disconnect between younger and older conservatives on the issue of climate change.

We did find some support for the effectiveness of scientifically authoritative videos, at least in terms of how influential the content is perceived to be on how someone might vote, lending some evidential support to Kahan et al. (2011), who have claimed that cultural cognition heavily influences opinion. In this case, the authoritative videos presented the work of real scientists and presented climate change as an environmental crisis while the comedic videos were largely dismissive of those who oppose the climate consensus. There was no such evidence for Leiserowitz's assertion that focus on the scientific consensus on climate change is an effective strategy (van der Linden et al., 2015), although our study was not designed to test this assertion and only a portion of the comedic videos, John Oliver's “statistically representative climate change debate”, directly concerned the climate consensus. No data were collected which might support or refute the hypothesis that cultural cognition shapes how people receive information on the climate change consensus such that information about the consensus may not be helpful in swaying opinion (Kahan et al., 2011).

Future studies should incorporate an overall measure of media literacy in order to explore the role it may play in student knowledge and attitudes, per Cooper (2011), and whether interventions might differentially affect media literacy for students of different worldviews given issues with the “backfire effect” as described by Cook and Lewandowsky (2011), discussed below. Moreover, a study in which students receive more explicit climate change instruction in addition to the video interventions, might have different results both in terms of treatment groups, since adding more background material could lead to increased effectiveness for the more popular comedic videos whereas the authoritative videos may be less effective since students may already have learned much of the presented material. Further, there could be differential effects in terms of political leanings of students, since interaction effects between (self-reported) knowledge of climate change and political leanings have been observed in a previous study (Hamilton, 2011). Additional study is also warranted in order to focus more precisely on the effectiveness of instruction about the scientific consensus on climate change specifically. First, it should be determined whether instruction is more effective when it focuses on the consensus, and in the case that it isn't, it should be determined whether the lack of effectiveness might be due to barriers that result from cultural cognition. Additional studies could also pursue the question of whether liberal and conservative climate change media coverage does indeed affect viewers' trust in the science differently as has been suggested (Hmielowski et al., 2014).

In terms of their opinions about media on GCC that affirm its veracity and anthropogenic causation, and how such media might change people’s minds, it is of interest that liberal students viewed both the comedic and the authoritative videos to be potentially more influential than their conservative-leaning cohorts. It may be that pro-GCC media of any stripe amounts to “preaching to the choir” among liberal students while conservative students experience what Cook and Lewandowsky (2011) describe as the backfire effect, whereby “for those who are strongly fixed in their views, being confronted with counter-arguments can cause their views to be strengthened.” (p. 4) Perhaps conservative students perceived that both the comedic and the educational films to be unfairly biased against their viewpoint, and in the case of the comedy, even making fun of their ideas. Or, in the case of the clip from *The Colbert Report*, the conservative students took the host’s satirical deadpan at face value. This is the sort of scenario described by LaMarre, Landreville, & Beam (2009) whereby conservatives viewing Colbert’s mock-conservative comedy later forget that it was a joke and use what was intended as jest to support their prior thinking. This propensity to “see what you want to see in *The Colbert Report*” (LaMarre et al., 2009, p. 212) makes the use of such complex satire in educational settings particularly difficult.

Instructors may be tempted to use clips from popular comedy shows due to their impressions that students may find them engaging. However, our findings lead us to suggest that educators should not devalue authoritative scientific media as too boring or inaccessible to students. Nothing in our experience, including survey questions asked about how interesting the videos perceived to be and personal communication with individual students, indicates that the students felt that the authoritative videos were any less interesting or accessible, and unlike the comedic videos, very few had seen the IPCC-produced videos before. Nature of science conceptions have been shown to have positive effects on acceptance of scientific ideas (Carter and Wiles, 2014), and explicit instruction on the nature of science, specifically the role of evidence in supporting ideas, may be a helpful approach for maximizing the effectiveness of evidence-based instruction by helping students to think like scientists. The fact that the correlation between self-reported and measured climate change knowledge increased over time is heartening, and that correlation could perhaps be further strengthened by assessments. If students are afforded more opportunities to disentangle what they actually know from what they think they know about climate change, this correlation is bound to increase.

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APPENDIX 1: QUESTIONS ASKED DURING LECTURE.

Asked before the videos were viewed:

1. How well would you say you understand climate change science?
    - A. Extremely well
    - B. Very well
    - C. Moderately well
    - D. Not very well
    - E. Not at all
2. How important is it to you for policy makers (senators, congress, the president, etc.) to know about climate change science?
    - A. Extremely important
    - B. Very important
    - C. Moderately important
    - D. Not very important
    - E. Not important at all
3. If a politician did not agree that climate change was happening or thought that we don't need to do anything about it...
    - A. I would not vote for that person.
    - B. I would not agree on this issue, but might vote for them depending on how they felt about other issues.
    - C. This issue would not make a difference in how I would vote.
    - D. I would agree with them on this issue, but I might not vote for them depending on how they felt about other issues.
    - E. I would vote for that person.
4. If a politician claimed no opinion on climate change saying "I am not a scientist."…
    - A. I would not vote for that person.
    - B. I would not agree on this issue, but might vote for them depending on how they felt about other issues.
    - C. This issue would not make a difference in how I would vote.
    - D. I would agree with them on this issue, but I might not vote for them depending on how they felt about other issues.
    - E. I would vote for that person.

Asked after videos were viewed:

1. Do you think these videos helped you understand climate change better?
    - A. Yes. A lot.
    - B. Yes. But I already knew some of that.
    - C. Not much. I already knew most of that.
    - D. No.
2. How well would you say you understand climate change science?
    - A. Extremely well
    - B. Very well
    - C. Moderately well
    - D. Not very well
    - E. Not at all
3. How important is it to you for policy makers (senators, congress, hthe president, etc.) to know about climate change science?
    - A. Extremely important
    - B. Very important
    - C. Moderately important
    - D. Not very important
    - E. Not important at all
4. If a politician did not agree that climate change was happening or thought that we don't need to do anything about it...
    - A. I would not vote for that person.
    - B. I would not agree on this issue, but might vote for them depending on how they felt about other issues.
    - C. This issue would not make a difference in how I would vote.
    - D. I would agree with them on this issue, but I might not vote for them depending on how they felt about other issues.
    - E. I would vote for that person.

5. If a politician claimed no opinion on climate change saying “I am not a scientist.”…
    A. I would not vote for that person.
    B. I would not agree on this issue, but might vote for them depending on how they felt about other issues.
    C. This issue would not make a difference in how I would vote.
    D. I would agree with them on this issue, but I might not vote for them depending on how they felt about other issues.
    E. I would vote for that person.
6. Do you think these videos would change the way someone might vote?
    A. Yes. Definitely.
    B. Probably.
    C. Maybe.
    D. Probably not.
    E. No.

INNOVATIONS

A Simple Approach to Collecting Useful Wildlife Data Using Remote Camera-Traps in Undergraduate Biology Courses

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Abstract: Remote camera-traps are commonly used to estimate the abundance, diversity, behavior and habitat use of wildlife in an inexpensive and nonintrusive manner. Because of the increasing use of remote-cameras in wildlife studies, students interested in wildlife biology should be exposed to the use of remote-cameras early in their academic careers. Although there is a rich literature on the use of remote-cameras in wildlife studies, few have provided meaningful examples within an academic course setting. Due to the time constraint of a typical semester, many laboratory exercises generate data sufficient for the activity but lack inference to actual wildlife populations. This article describes a series of laboratory exercises that are both useful to student learning and provide relevant biological data. Students use remote-cameras to measure diversity, diel behavior (i.e. over a 24-hour period) and the relative abundance of mammals in a biological corridor. Other abundance methods such as mark-recapture or random encounter models that require marked individuals and/or extensive temporal and spatial methodology are often not practical in a course framework. The approach described in this article teaches students about research design and local wildlife abundance and behavior, using simple methodologies employed over a three-lab period.

Keywords: Remote camera-traps, wildlife, inquiry-based, biological corridor, undergraduate students.

INTRODUCTION

Inquiry-based laboratory exercises can encourage the scientific process and help instill a sense of scientific discovery within students (National Science Foundation, 1996, National Research Council, 2000). Laboratory experiences that further provide students with real-world skills together with an inquiry-based approach would better prepare students for successful careers in the sciences (Millenbah and Millspaugh, 2003).

Remote camera traps are becoming a common way to assess wildlife populations (O'Brien et al., 2003, Yasuda, 2004, Swan and Perkins, 2014). The popularity of remote-cameras is largely due to their cost-effectiveness and passive, non-intrusive capability to monitor wildlife. Because of the increasing use of remote-cameras in wildlife management and conservation biology, students interested in these disciplines should be exposed to the use of remote-cameras early in their academic careers. Although remote camera studies abound in the literature (O'Brien et al., 2003, Yasuda, 2004, Janecka et al., 2011, Anile et al., 2014), few examples of simple, yet relevant exercises have been provided within an academic course framework (Locke et al., 2005, Grigione and Farkas, 2012). Often, exercises designed for students provide basic training on the use of remote-cameras that only generate sufficient data for the learning experience. These types of studies, although useful in educating students on the basic use of remote-cameras, lack a study design that would generate relevant data that could be inferred to actual wildlife populations, such as abundance estimates, temporal habitat usage and diversity over temporal and spatial scales. Some effective metrics that are often applied in large research studies such as mark-recapture or random encounter modeling require marked individuals and/or extensive spatial and temporal sampling (Royle and Nichols, 2003, Sollman et al., 2013). Although these methods generate the most reliable camera-based wildlife population data (Royle and Nichols, 2003, Sollman et al., 2013), the time, space and effort required might not be feasible in a typical semester and in a typical undergraduate course, assuming other topics and laboratory activities are planned throughout the semester. Therefore, there is a need to balance simplicity with a methodology sufficient enough to generate meaningful biological data and to provide students with a realistic learning experience.

This paper describes a multi-laboratory exercise for undergraduate conservation biology, wildlife biology or animal behavior courses that teach a real-world skill with an inquiry-based approach using remote-camera technology. Furthermore, the lab sequence teaches students how to design a simple remote-camera study that generates useful data on local wildlife populations. The exercise involves students deploying remote-cameras in a biological corridor used by wildlife in an urban area. Students use a relative abundance index that allows them to compare data with other courses, across temporal and spatial scales (O'Brien et al., 2003, Yasuda, 2004). With these data, students can also identify local mammal diversity and diel (i.e. over a 24-hour period) behavior within the biological corridor. This exercise will also help students further develop the ability to design and implement a simple, yet realistic scientific field study and communicate scientific findings in written and oral format.

Remote-Camera Applications

Students were first educated on the common use and applications of remote-cameras in wildlife studies during a regular class lecture. Remote-cameras have been used to successfully measure wildlife diversity (O'Brien et al., 2003, Yasuda, 2004), estimate wildlife abundance (O'Brien et al., 2003, Janecka et al., 2011, Anile et al., 2014), examine animal behavior and habitat use (Yasuda, 2004, Vine et al., 2009, Ariefiandy et al., 2015) and determine the presence of cryptic and/or rare species (O'Brien et al., 2003, Vine et al., 2009, Schruhl et al., 2010) throughout the world. For these reasons, remote-cameras are commonly used by state and federal wildlife management agencies (Heilbrun et al., 2003), with non-government wildlife organizations (O'Brien et al., 2003, Afriefiandy et al., 2015) and in academic research studies (Vine et al., 2009, Anile et al., 2014, Rodgers et al., 2014). The broad application of remote-cameras makes an understanding of their use a priority for any student interested in pursuing a career in wildlife biology.

Although remote-cameras have been successfully utilized to examine a wide variety of species, the methodologies used can be just as diverse, all with strengths and weaknesses. For example, species abundance can be estimated with mark-recapture, random encounter and detection probability modeling but require extensive spatial and temporal sampling (Anile et al., 2014, Rodgers et al., 2014). Mark-recapture studies also require marked individuals, often felines with natural coat markings that can be used to identify individuals (Janecka et al., 2011, Anile et al., 2014). Random Encounter Models (REM) are utilized to estimate species abundance without the use of marked individuals but require the calculation of the detection zone area (Anile et al., 2014, Swann and Perkins, 2014). Another commonly used method to estimate abundance of unmarked individuals is the Relative Abundance Index (RAI), which is simply the number of detections of a species per unit time (O'Brien et al., 2003, Swan and Perkins, 2014). Although this method is easier to employ, compared to previously mentioned techniques, it often produces biased estimates of relative abundance (Sollmann et al., 2013, Swan and Perkins, 2014). However, in some cases, the RAI has been found to correlate with other methods such as mark-recapture and line-transect and is useful when other methods cannot be employed (O'Brien et al., 2003, Lynam et al., 2007). Many studies have also utilized scat-analysis, line-transects, genetic analysis and spotlighting to confirm camera-based abundance estimates of particular species (O'Brien et al., 2003, Vine et al., 2009, Anile et al., 2014).

Camera placement can also influence study results. Studies have found that with some species, such as felines, camera placement on game trails or near roads was most effective but generated a biased estimate (Anile et al., 2014, Sollmann et al., 2013). Heilbrun et al. (2003) and Anile et al. (2014) found that bobcats (*Lynx rufus*) and European wildcats (*Felis silvestris silvestris*), respectively, responded inconsistently to baited cameras while Yasuda (2004) and Vine et al. (2009) found that baited cameras were effective with nocturnal and cryptic species, other than felines, and reduced the amount of sampling time required. Because each remote-camera methodology has strengths and weaknesses, careful consideration and clear objectives are needed for a study to be successful.

LABORATORY PROCEDURES

The application of remote cameras is so diverse that their use can take on many forms in academic course work. For example, students may wish to examine wildlife diversity and behavior on campus; estimate urban wildlife abundance; monitor wildlife use of a particular habitat such as a meadow or pond; monitor wildlife road crossings; monitor the influence of human disturbances on abundance, diversity and behavior over time. This paper, however, provides an example of the use of remote-cameras to estimate wildlife diversity, diel behavior and relative abundance of wildlife within a biological corridor (The Little River Floodplain) near the Westfield State University campus, Westfield, MA. However, the lab can be adapted to meet other needs and interests.

This study requires two lecture and three laboratory periods to complete. The study can be repeated in different semesters and for multiple years so that future classes can build long-term data sets. First, students are assigned appropriate literature as homework to review regarding camera-trap case studies (See: O'Brien et al., 2003, Yasuda, 2004, Anile et al., 2014) and biological corridor theory (See: Rosenberg et al., 1997, Falcy and Estades, 2007, Cushman et al., 2013). Students are also required to research the types of wildlife they would likely encounter in our region and explore the various reasons why wildlife would utilize the Little River biological corridor. The Little River corridor connects core habitats in the Berkshire Hills with patches of habitat in nearby urban regions. During a regular lecture period, students were introduced to Google Earth (Little River, 2015) and MassGIS (regional open-source geographic software) (MassGIS, 2015) to delineate the boundaries of the Little River biological corridor and to help identify basic habitat characteristics such as vegetation and corridor boundaries (Figure 1).

Figure 1. Map of the study area. The Little River and associated wildlife corridor start on the left in the Berkshire Hills core habitat region and move past Westfield State University and through the city of Westfield, eventually connecting to other small habitat areas near the cities of Holyoke, Springfield and West Springfield further to the right. Image adapted from Google Earth (Little River 2015).

Outside of class, students meet in small groups of 3-4 people to discuss the assigned papers, share their findings on regional wildlife and corridor delineation and to develop appropriate objectives and methodologies for their study. To help students develop appropriate objectives, they are asked to consider themselves as a wildlife biologist, transportation specialist, city planner and/or a local resident concerned about the diversity and abundance of wildlife utilizing the corridor. While in these roles, students are then asked to generate appropriate questions that a wildlife biologist or city planner, for example, would want to know. We then discuss the group conclusions as a class in the next lecture. Appropriate questions may be: 1. What species of wildlife utilize the corridor? 2. When do these species utilize the corridor? 3. How many of each species are utilizing the corridor? 4. How do we answer these questions with limited time and resources? Students then develop appropriate objectives to address these and/or other questions. Some objectives might be: A. Utilize remote-cameras to measure species diversity and diel behavior within the Little River corridor. B. Utilize remote-cameras to estimate relative abundance for each species within the Little River corridor. C. Share data between classes over multiple years and in different seasons. Finally, the class agrees upon study objectives and we prepare for lab one.

Lab One: Camera-Trap Setup

During the first lab, students are instructed on the proper set-up, use and care of remote trail cameras. We use waterproof, remote, digital cameras with built-in infrared motion sensors and LED flash for daytime and nighttime use (Moultrie M-880, 8.0 MP Infrared Trail Camera, Moultrie Inc., Calera, AL 35040). Cameras are set with a photo delay of 30 seconds and programmed to take photos at anytime of the day. Each photo is stamped with the time and day and stored on a 32 GB memory card. Cameras use eight AA batteries that power the cameras for at least two weeks without intervention.

We use approximately eight cameras for seven days in October and again in March in two separate classes following the same methods. Groups of three to four students work together to set an individual camera. The eight cameras are set perpendicular across the Little River floodplain from one terrace to the next, spanning the width of the entire floodplain. Each camera is set approximately 50-100 m apart and adjacent to animal trails (Yasuda, 2004). Cameras are attached and locked to trees approximately one meter off the ground and set at a slight, downward angle in order to detect both small and large mammals. Each camera is baited with 454 g of salted peanuts during both studies to encourage animal encounters during the study period (Yasuda, 2004). Cameras are left alone until retrieved during the next laboratory period the following week.

Labs Two and Three: Camera Retrieval and Data Analysis

During lab two, students retrieve the cameras and return to the classroom. The photographs are examined for all of the cameras and each mammal is identified to species using Whitaker's (1996) Field Guide to Mammals. The time of day is recorded for each individual mammal observed. We divide the day into four distinct periods in order to estimate diel activity in observed wildlife. We consider morning to be the two hours after sunrise, evening to be the two hours before sunset and daytime and night to be the remaining time periods. Students calculate the amount of trapping effort (recorded in days) for each camera from the time the camera is set to the time it is retrieved. Total trapping effort is determined as the total of the camera-days for all cameras during each study period.

Table 1. Results of our class camera-trap study within the Little River Corridor, Westfield, MA, March 2014. Encounters represent the total number of photographs taken of each species at different periods of the day for the entire March study period. Daily encounter rate represents a total study relative abundance estimate for March.

March		Encounters					Daily
Taxa		Morning	Day	Evening	Night	Total	Encounter Rate
Gray squirrel	*Sciurus carolinensis*	19	28	6	2	55	0.98
Eastern chipmunk	*Tamias striatus*						
Eastern cottontail	*Sylvilagus floridanus*				1	1	0.02
Opossum	*Didelphis virginiana*						
Small rodent	Muridae						
Whitetail deer	*Odocoileus virginianus*						
Raccoon	*Procyon lotor*				8	8	0.14
Gray fox	*Urocyon cinereoargenteus*				6	6	0.11
Eastern coyote	*Canis latrans*				4	4	0.07
Bobcat	*Lynx rufus*				1	1	0.02
Black bear	*Ursus americanus*	2		2	4	8	0.14
	Total	21	28	8	26	83	

Students also calculate the camera-encounter rate, which is a relative abundance index (O'Brien et al., 2003, Yasuda, 2004) for each species observed. The encounter rate is determined by dividing the total number of independent sightings of an observed species from all the cameras by the total number of camera days for that study period (O'Brien et al., 2003). We follow O'Brien et al. (2003) and define an independent sighting as photographs of different individuals and/or individuals of the same species taken at least 0.5 hours apart per camera, if they can not be determined as separate individuals.

The students share the data from each camera with the class and create tables that summarize all the combined data that address the research objectives. These tables illustrate the diversity, number of sightings and relative abundance for each species they observe for all cameras together. Tables 1 and 2 represent examples of findings from two separate classes from the spring and fall of 2014. Students also create figures that illustrate the frequency of sightings during the morning, day, evening and night. Figure 2 represents an example of diel frequency of mammal sightings during the spring and fall of 2014.

During the third lab, students are given time to complete the photographic analysis, summarize and compile class data and work on presenting their data in report and oral format. Each student is provided with an example of a well-written lab report and an example of a proper oral presentation. Students are required to write a full report including an abstract, introduction, methods, results, discussion and literature cited. Students also present their findings as a PowerPoint presentation.

DISCUSSION

This lab teaches students about local wildlife diversity, behavior, abundance and the importance of biological corridors. It further educates students regarding study design and objectives, camera-traps,

Table 2. Results of our class camera-trap study within the Little River Corridor, Westfield, MA, October 2014. Encounters represent the total number of photographs taken of each species at different periods of the day for the entire October study period. Daily encounter rate represents a total study relative abundance estimate for October.

October		Encounters					Daily
Taxa		Morning	Day	Evening	Night	Total	Encounter Rate
Gray squirrel	*Sciurus carolinensis*	83	150	42	14	289	6.88
Eastern chipmunk	*Tamias striatus*		2	1		3	0.07
Eastern cottontail	*Sylvilagus floridanus*				2	2	0.05
Opossum	*Didelphis virginiana*	1			100	101	2.40
Small rodent	Muridae				19	19	0.45
Whitetail deer	*Odocoileus virginianus*	1		1	10	12	0.29
Raccoon	*Procyon lotor*			5	109	114	2.71
Gray fox	*Urocyon cinereoargenteus*				16	16	0.38
Eastern coyote	*Canis latrans*				1	1	0.02
Bobcat	*Lynx rufus*						
Black bear	*Ursus americanus*						
	Total	85	152	49	271	557	

data analysis and report preparation. The use of the camera-encounter rate as a relative abundance index simplifies the lab, as opposed to more time and space demanding approaches like mark-recapture and random encounter modeling. The relative abundance index provides a simple metric that relates to wildlife abundance that can be compared with other classes

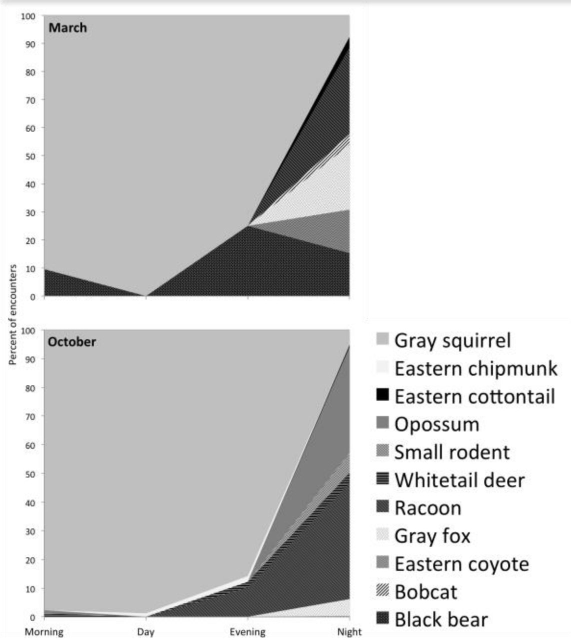

Figure 2. Percent of encounters (appearances per time of day) of each species photographed from the Little River Corridor in March and October 2014.

temporally and spatially. Simply stated, as the daily encounter rate for a particular species increases, it can be assumed that the abundance of that species also increases (O'Brien et al., 2003, Yasuda, 2004). However, students are also educated about mark-recapture and random encounter modeling to ensure they understand that other methods exist that may be more applicable to work they may conduct in their future careers.

Descriptive, field-based labs like this one are unlike experiments, where each variable is carefully controlled. Therefore, it is impossible to determine exactly what is influencing the observed. This can generate good discussion among students who can explore the possible combination of variables that may be influencing their observations and they can appreciate the variability that may exist in their data. It also allows for students to generate new questions, research objectives and design new studies.

For example, it is necessary to identify sources of variability that may influence both the diel and daily encounter rates of an organism (Yasuda, 2004). During our study, March 2014 was unseasonably cold in western Massachusetts with snow and cold temperatures prominent throughout the entire month. Cold temperatures and snow likely influenced species behavior and density. For example, black bears (*Ursus americanus*) emerging from a long winter were probably hungry and more likely to find the bait while gray squirrels may have been more abundant in the fall, before snow accumulation and were beginning to gather food for winter. The abundance, presence and absence of other species such as opossum (*Didelphis virginianus*) may have been influenced with the time of year and whether some species would utilize the area during that period. Smaller mammals such as gray squirrel (*Sciurus carolinensis*), eastern chipmunk (*Tamias striatus*), eastern cottontail (*Sylvilagus floridanus*), small rodents (Muridae) and raccoon (*Procyon lotor*) may reside within the Little River corridor while larger mammals such as whitetail deer and black bear may only use the corridor to move from one area to the next.

One of the potential problems with baited cameras is the likelihood of repeated observations, thus generating a biased relative abundance estimate **(**Sollmann et al., 2013, Swan and Perkins, 2014). Some species may be more attracted to the bait than others and return more often (Yasuda, 2004, Anile et al., 2014). For example, bobcats and wildcats often responded inconsistently to bait in past studies (Heilbrun et al., 2003, Anile et al., 2014) while black bears were more predictable and will linger until the bait is completely consumed, as observed in our study. A high number of squirrel observations in our study, for example, were likely due to repeat observations because of the bait and relatively small home range of squirrels. Therefore, baited remote-cameras may generate bias for some species and should be used with caution (Yasuda, 2003). However, the lack of bait may reduce the number of encounters and necessitate longer and more strategic camera placement, especially for nocturnal and cryptic species (Yasuda, 2004, Vine et al., 2009). It was clear in our study that most species preferred a nocturnal behavior, suggesting that baited cameras improved encounters with these species.

Potential bias can be avoided with further sampling. Laboratory studies that are limited to a few laboratory periods are likely to be biased unless extended across semesters and seasons for multiple years. Increased sampling will capture and expose trends in wildlife abundance and behavior (Yasuda, 2004). Therefore, this laboratory can be conducted in spring and fall semesters for multiple years in order to develop long-term data sets. Students can utilize these augmented data sets each semester in order to develop a more complete analysis of wildlife diversity, abundance and behavior. Students are also encouraged to maintain consistency from one year to the next when collecting biological data for comparison. For example, comparing relative abundance estimates from baited remote-cameras each year would be much more effective than comparing different methods that require a different set of assumptions and metrics.

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Exploring Experimental Design: An Excel-Based Simulation Using Steller Sea Lion Behavior

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Abstract: Experimentation is the foundation of science and an important process for students to understand and experience. However, it can be difficult to teach some aspects of experimentation within the time and resource constraints of an academic semester. Interactive models can be a useful tool in bridging this gap. This freely accessible simulation provides a unique opportunity for students to practice designing experiments and analyzing their results. The effects of sample size and variability on the usefulness and accuracy of experimental data are an important component of these exercises. In addition, students can easily repeat their experiments, demonstrating that repetition doesn't necessarily lead to exact replication due to natural variability. Lastly, the simulation provides a range of flexible input categories that allow students to develop their own experimental questions about Steller sea lion behavior, and to explore a range of parameters, including various specific behaviors, the sex of the animals, and various sampling intervals such as hourly, daily, seasonally, or even annually. While this exercise does not replace first-hand experience with experimentation, it provides a good foundation for students to build on as they begin the process of designing and implementing their own research projects.

Key words: Hypothesis testing, sample size, scientific method, Steller sea lion

INTRODUCTION

This exercise has two primary goals and one secondary goal. One primary goal is for students to gain experience designing experiments and testing hypotheses. Although this process is the foundation of science, it can be challenging to teach without defaulting to a static, formulaic description. The use of real data that can be quickly and easily "sampled" by students makes the process of designing experiments and interpreting outcomes more accessible to both students and instructors. The simulation also provides near instantaneous feedback, which is particularly useful when a student's experimental design (i.e. selection of input values) needs to be revised to produce data that will allow accurate evaluation of their hypothesis. The second primary goal is for students to develop basic skills in the analysis and interpretation of graphical data with particular attention to variation and sample size. This is another aspect of designing good experiments that can be difficult to teach in the lab or field because of the practical constraints of repeated sampling and also because it requires some statistical savvy. This simulation can stretch beyond these constraints to provide students with concrete research data to observe and evaluate, thereby gaining valuable insights into a critical component of good research. In addition, since the emphasis is on the graphical representation of the data for both statistical analysis and overall interpretation, students will become proficient in graphical analysis. This is a skill whose value extends into many aspects of their professional and personal lives.

The secondary goal of this activity is to provide a vehicle for students to investigate Steller sea lions and some circumstances under which specific behaviors may vary. This is a unique opportunity for students not only to "observe" the behaviors of a marine mammal, but to "see" how specific behaviors might be influenced by aspects of the animal's environment. The ability to manipulate observation parameters provides students with insights into the complexity of this research and the dynamic responses of these animals to the parameters represented in the simulation. This complexity is visible in spite of the fact that these data were collected under the relatively controlled conditions of an artificial habitat (that is, a large outdoor aquarium).

The simulation makes current research accessible to students, not as a presentation of findings, but as an opportunity to manipulate real data while developing and testing their own hypotheses and drawing their own conclusions. The simulation is composed of a set of macros developed for Microsoft Excel 2010™ using Visual Basic for Applications (VBA). The macros simulate data collection by selecting subsamples of the existing data set based on user inputs and presenting the results in both tabular and graphical format. There are also randomizing components within the data selection macro that may generate a different result with each iteration of the simulation. The simulation interface allows students to quickly and easily model experiments, while allowing them to repeat the same experiment or adjust the inputs to conduct a different experiment within minutes. The interface design allows students to easily manipulate a variety of inputs including sample size, sex of the animals studied, and timeframe within which the data were collected, including time of day, month, and/or year, etc. Not only will students be able to see how changing the parameters of an experiment can affect their results, but they will also learn to apply some basic statistical analysis to test specific hypotheses.

The data used in this simulation were collected during regular observations of selected social behaviors of five (three female, two male) Steller sea lions (*Eumetopias jubatus,* hereafter SSL) housed in two outdoor exhibits at Mystic Aquarium (Mystic, CT). The males were never housed together, but any year-round association is a novel condition for these animals, since in a natural population social interactions would be limited to the rookery during the breeding season (Burkanov, et al., 2011). However, studying marine mammals in a zoological setting allows investigators to control or eliminate a variety of potentially confounding factors, such as migration, foraging, and predator evasion. In an uncovered outdoor exhibit, animals can perceive external environmental cues such as day length, air temperature, and season that can influence their behavior. Monitored behaviors included bite, chase, touch, and butt, as well as vocalizations and interactions with toys available in the exhibits. The presence or absence of animal trainers was also recorded, as direct interactions with humans also occur during training, feeding, and husbandry sessions. The designated behaviors were recorded using a tally-system on data sheets similar to Table 1. An observer monitored each individual SSL for a five-minute interval, rotating among the animals throughout the day, recording each occurrence of the selected behaviors. At times, individuals were taken off display. During these occurrences data collection continued to rotate among the remaining animals.

Some Background on Steller Sea Lions

Students will need a basic introduction to SSL behaviors in order to develop informed hypotheses. The brief overview below is provided as a starting point for this exercise. In an advanced course, students are asked to look further into the available literature in order to support both their hypotheses and conclusions, but when used in a freshman/sophomore level course, the students work largely with the background information in the following paragraphs.

Pinnipeds, semi-aquatic marine mammals, are separated into the families Phocidae, true seals, and Otariidae, sea lions and fur seals. Steller sea lions are the largest member of the Otariidae family, averaging 1,000 kilograms for adult males and 273 kilograms for adult females (Jefferson et al., 2008). They are found in the North Pacific Ocean along coastal regions in Canada and Alaska and extending to Russia and Japan. From the 1970s to the 1990s the SSL population declined by 80% (Calkins, et al., 1999). In 1990 *E. jubatus* was listed as a threatened species, and then in 1997 two distinct reproductive populations were identified and the population west of 144°W (near Cape Suckling, AK) was reclassified as endangered. The eastern population recovered to the point that it was delisted in 2012, while the western population continues to be listed as endangered under the Endangered Species Act (Speegle, 2013). It is hypothesized that the decline of these large predators is due to a combination of diverse factors, including parasites and disease, declining prey diversity due to overfishing or climate change, competition with commercial fisheries for prey, negative interactions with marine debris, and direct mortality due to killer whales and humans (DeMaster, et al., 2006; Trites, 2012). The balance and impact of both natural and anthropogenic factors may change over time in an unpredictable manner, which is often the case in biological systems. The

Table 1. A sample modified data sheet for Steller Sea Lion behaviors.

STELLAR SEA LION DATA SHEET #1: BEHAVIOR DATE:________

INDIVIDUAL OBSERVED? ______________________________

		Interactions						
Observation Start Time	Vocalization	**Bite**	**Touch**	**Chase**	**Butt**	**Toy**	Trainer Present?	Observer's Initials

NOTE: Activities for an individual should be recorded continuously for 5 min using tallies.

simulation exposes students to this fact of real-world experimentation, albeit on a fairly short time-scale; from days to a few years. It also demonstrates the variability inherent in sampling itself, through the use of randomized selection of each data subset from the master data.

There is evidence that the behaviors of both sea lions and seals are influenced by a variety of factors such as day length and season, as well as the age and sex of the individuals. In wild populations of SSLs, interaction rates between individuals peak around the breeding season, from late May through July (Trites, 2012). But do these patterns carry over to animals maintained in artificial habitats? A study of juvenile captive bearded seals (*Erignathus barbatus*) found that only the males developed underwater vocalization, which is in agreement with observations of wild seals and may reflect the harem structure and dominant reproductive roles of male seals. In contrast, vocalizations in the captive seals were less complex, with the differences being attributable to either the immaturity of the seals at the time of the study or other factors associated with their artificial environment (Davies, et al., 2006). Another study of captive animals (Moulton, et al., 1999) examined the haulout duration of harp seals (*Pagophilus groenlandicus*) as a percentage of total daylight hours, finding that the maximum haulout duration of 18.2% occurred during the fall. So, not only did captive animals demonstrate seasonal variation, but changes in the amount of time spent out of the water may be linked to changes in other behaviors. These findings in related species may guide students in deciding upon hypotheses to test using the SSL simulation.

Data Analysis: Getting Started

It might be also be necessary to include a short treatment of statistics in the background information for students. The fundamental challenge of working with quantitative data is that there is variability inherent in the measures that scientists make for virtually any variable that can be measured, including the behavioral data in this simulation. Two closely timed observation periods of a single individual would most likely result in different counts for many if not all of the identified behaviors. These differences result from differences between observers and inherent variability in the activities of the animals from moment to moment.

In graphs and tables, scientists typically report the mean ($\bar{x}$), or arithmetic average, of the data they have collected from a population or from a sample of that population. If a scientist measures the number of vocalizations during a 5-minute focal period, the average frequency of vocalization is often the primary variable of interest. If the number of vocalizations were 5, 0, and 10 in three different 5-minute periods, then the mean would be the sum of all three counts divided by the number of focal periods: $\bar{x} = (5 + 0 + 10)/3 = 5$ vocalizations/5 min with a sample size n=3.

Standard Deviation (SD) is a way of expressing the variability inherent in the data and can be used by scientists to decide what sample size is needed to accurately estimate the mean for a given population. There is a formula for calculating the Standard Deviation, but in this case, SD is one of the outputs of the Excel simulation. Often, the mean and standard deviation of a sample are incorporated into a graph with the mean represented as the actual data point, in this case the height of the bars on the graph, and SD represented as an "error bar". The error bar then provides insight into the variation within the data set, since about 68% of the individual values in the sample will usually fall within one SD of the sampled mean. Increasing the sample size will give you a more accurate estimate of the variation within the population and a better estimate of the actual mean for the population.

The Standard Error (SE) is based on both the standard deviation and the number of data values in your sample. The SE expresses the variability of the estimate of the mean for the data values that have been collected. In essence, the SE indicates that if a sample of the same size were collected repeatedly from the same original population, then most (68%) means from the repeated samples would lie within one SE of the true mean of the entire population from which the samples were drawn. Thus, the larger the sample size, the closer the estimate will be to the true mean, and therefore the smaller the SE. In other words, the SE is inversely proportional to the square root of the sample size, so that if the sample size is quadrupled, our estimate of the population's true mean is about twice as accurate (because the scatter of such sample means around the population's true mean will be half as broad).

The SE is especially useful because it can be used to test for statistical differences between sampled means. If the difference between the means of two samples is "statistically significant", it means that the difference between the means is unlikely to have been caused by random sampling error; instead, the means are different probably because the sampled populations are truly different. If your goal is to use the mean and error bars from your results as the foundation for preliminary statistical analysis, then the appropriate error to use is SE, and not SD. For example, to test the hypothesis that male SSLs vocalize more frequently than female SSLs, you would need to sample the numbers of vocalizations of males and females over certain identical time periods, and then graph the two means with SE error bars to show the reliability of the estimated means. To determine whether the sample means for males and females are statistically significantly different, you could check whether the SE bars around the two means overlap (Motulsky, 1995). If the SE bars around the two means overlap or have a gap between them less than the average length of the two error bars, as in Figure 3A, then the means are not significantly different. That is, the difference between the means is likely due to random sampling error. But if there is a gap between the two SE bars at least as long as the average of the two error bars, as in Figure 3B (remember, the error bars extend both directions from their respective means), then the two means may be significantly different, although the appropriate statistical test would be needed to determine this with certainty (Cumming and Finch, 2005).

METHODS

Activity 1. Hypothesis testing.

Using the information provided above, along with additional literature research as needed (or desired on the part of the instructor), students should develop an experimental question regarding the frequency of interactive behaviors for SSLs with respect to some variation in time. For example, students might expect the frequency of behaviors to change throughout the year or at different times during the day, but then they would need to predict either an increase or a decrease in these behaviors. Once students have an experimental question, they will need to state a testable hypothesis. Using a standard format for the hypothesis: If …. (Independent variable/predictor) … then …. (Dependent variable/response) should provide a conditional relationship that can be supported or falsified by the available data. The students are now ready to run the Excel simulation. Throughout the simulation, we will refer to the experimental population as Group Y and the reference population Group Z. Using the INTERFACE sheet (see Figure 1), the Number of Data Points for both Groups Y and Z should be set at 100 for this activity, since we do not want sample size to influence this experiment. Students should then change the input values for Group Y as appropriate for their research question. For this experiment students should be manipulating an input value for time based on the month, year, and/or time range for the data as highlighted in Figure 1. They will also need to consider what changes, if any, are needed to make the Group Z data set so that it can serve as the reference or control condition.

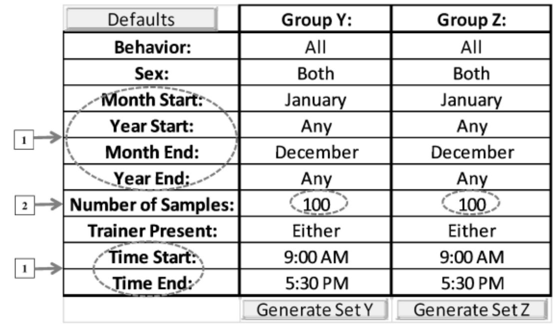

Figure 1. Image of the INTERFACE sheet of the Excel simulation highlighting the input values representing an aspect of time (1) that may be changed in order to test a question for Activity 1 and reinforcing that students should select 100 data points for both Group Y and Z (2).

Once students have selected all of their input values, they will need to click on the generate buttons at the bottom of each column on the interface tab to run the simulation (Figure 1). Both buttons must be clicked each time they want to re-run the simulation. The results will then be available under the GRAPH sheet, in both graphical and tabular format, although this exercise focuses on the graphical representations. For Activity 1, students should select Standard Deviation (SD) for the error bars from the box at the top of the GRAPH sheet. They should try running the simulation a few times to confirm that the results do indeed change! Once this has been confirmed, have students run the simulation several times. Although one might expect repeated samples from the same population to be similar, they may in fact differ due to random variation (see Figure 2). For the purpose of this exercise, choosing results that are noticeably different will make it easier for students to understand some of the principles of experimental design and data analysis that will be discussed; however, it would be appropriate to also impress upon students that when running an actual experiment all of their results must be included and evaluated.

Student Assignment

Copy the resulting graphs from two different runs of the simulation without changing any of the input values. In order to insert a graph into a Microsoft Word document right click on the graph and then do a copy/paste. Paste the graph as a picture so that it doesn't update as you continue to use the simulation. Include a short, descriptive caption for each figure, which is not only appropriate but will help you to easily identify and track all your graphs.

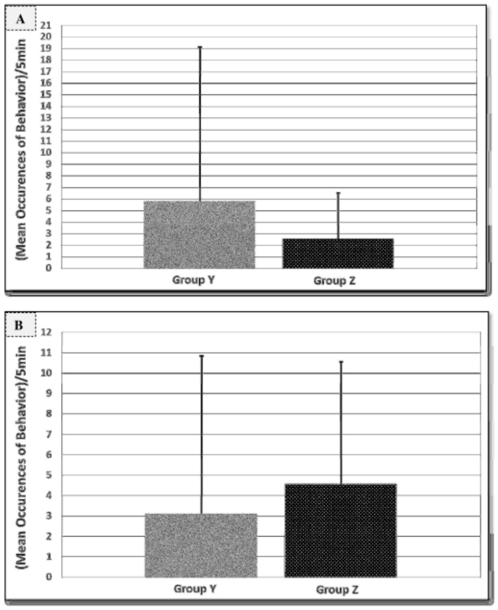

Figure 2. Sample graphs showing the average frequency of interactions for all individuals based on a comparison of activity from January to May (Group Y) vs January through December (Group Z) for two generated runs of the simulation (A and B). The error bars represent +/- 1 SD. Note that students should pay particular attention to the range of values for the y-axis as the scale may vary between their graphs.

Attempt to explain any differences between your graphs, in light of the fact that you didn't make any changes to the input values. What is responsible for the differences, if any, between your graphs? Review your two graphs, focusing only on the mean values. Indicate whether the results from each experiment seem to support or refute your hypothesis regarding SSL interactions and why. Are there differences between the two graphs such that one supports your hypothesis more strongly than the other or even that only one of the graphs supports your hypothesis? Attempt to explain any apparent contradictions in the results from your two simulated experiments. Is there a "take home" message from these results with respect to experimental design?

Now examine your graphed data again, but consider the error bars associated with each mean. First, identify the property that they represent, and describe what it conveys about the data. In combination with the mean values, can these be used to estimate whether there is a statistically significant difference between the two groups in your experiment? Why or why not?

Lastly, identify one additional research question that is raised by your results and clearly explain whether or not this new question can be examined using the current simulation.

Activity 2. Experimental design and sample size.

Now students should examine what other information is available within the simulation and the range of selections that can be made using the categories available on the INTERFACE sheet. Note that all of the parameters on the INTERFACE sheet can be changed; some are drop-down selections and others are manual entries. Based on observations, curiosity, and additional literature research as needed (or desired by the instructor), have students develop an experimental question about the interactive behaviors of SSLs. There are many possible questions and combinations for this data set, so the ideas should be as diverse and different as the number of different students in the class. Once students have an experimental question, they again need to develop a testable hypothesis before running the Excel simulation.

However, there is another underlying question for this particular activity, specifically, to what extent will the results differ based on sample size? So, in addition to an experimental hypothesis, students should predict the outcome of their experiment when using a very small sample size as compared to when using a larger one.

First, change the Number of Samples (or the sample size) to be used for both Group Y and Z on the INTERFACE sheet. The simulation interface allows for the selection of a sample size from 1-1096 (the maximum number of data points); however, depending on the experimental question and subsets of the data used, the actual number of available data points may be much smaller. Therefore, for this exercise it would be best to select a particularly small sample size first (15 or less), then one in the mid-range of the options (less than 30), and lastly one using all available data (up to 1096 data points). This ensures the largest sample size will be clearly bigger than the small and medium samples. In the example (Figure 3), the experimental question is whether the presence of a trainer would affect the frequency of behaviors for the SSLs. However, since we are also considering the impact of sample size and how it might affect the results, sample size for both groups was initially set at 11 (small) and then increased to 25 (moderate).

Once the experimental parameter inputs have been selected, and an initial (small) sample size has been set for both groups, students should click the generate buttons on the INTERFACE sheet, and view their results under the GRAPH sheet. Students should use error bars representing Standard Error (SE) for this activity.

Student Assignment

It is suggested that you observe the results of a number of different iterations of the simulation before proceeding as this will provide valuable

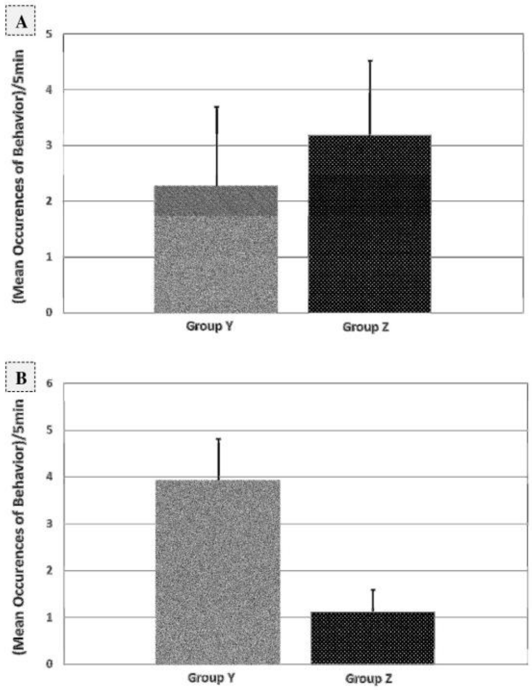

Figure 3. Sample graphs showing the average frequency of vocalization for all individuals in the presence (Group Y) and absence (Group Z) of a trainer based on a small sample of 11 (A) and then a moderate sample size of 25 (B). The error bars represent +/- 1 SE.

insight into the impact that a small sample size can have on your experimental results. Copy the resulting graphs from two different runs of the simulation, both using the same input values for your experimental question and a small sample size. In order to insert a graph into a Microsoft Word document follow the same process used in Activity 1, and again be sure to include a short, descriptive caption for each figure.

Now, return to the INTERFACE sheet and select a moderate sample size for both groups, but don't change any other experimental inputs. Once you have done this, use the generate buttons and view the graphical results. Insert two additional graphs into your Word file representing the results of your experiment using a moderate sample size.

Return to the INTERFACE sheet one last time and select the maximum sample size (1096) for both groups. Again, don't change any other inputs. Once you have done this, use the generate buttons and view the graphical results, and insert one additional graph into your Word file representing the results of your experiment using a larger sample size.

Why did you run only one simulation with the larger sample size? Hint: Rerun the simulation several times to help you with this.

Now, use the graphs to evaluate your hypothesis. Do the results using the small sample sizes support your hypothesis? The moderate sample sizes? The large sample size? For each sample size, record your conclusion and justify/support your findings.

Are the results of your experiment statistically significant or not? How did you determine this? Hint: You should not have to do any additional calculations to come to a preliminary conclusion here.

What conclusions would the researchers on this project come to if they asked your experimental question? Explain your reasoning.

What insights did you gain regarding the impact of sample size on experimental outcomes? How will the results of this exercise influence your experimental design for future research projects?

DISCUSSION

The background information provided here can be shared with students in a discussion format or as a handout. If time and resources permit, students can also be encouraged to expand their knowledge of pinnipeds, and specifically SSLs, by doing their own literature search. A Google search for "Steller sea lions" will generate links to reputable websites (NOAA, The Marine Mammal Center, etc.) with additional, basic information on SSLs appropriate for most undergraduate students, while Google Scholar will provide links to published literature, although very few articles address the behavior of these animals.

The instructor can choose to structure this activity in many different configurations, using a single part of the exercise as a standalone activity or using the material in its entirety. In addition, Activity 2 can easily be expanded by requiring students to explore the impact of specific categories from the interface tab, such as sex, specific behaviors, etc. Students could work on this activity as collaborative research teams or individually, possibly even as out-of-class projects. Lastly, the exercise can be very interactive with discussion and assessment after each part of the activity. This would provide students with the benefit of learning more about pinnipeds, the development of hypotheses, and designing experiments.

In reviewing the outcomes of the students' tests of their hypotheses, emphasis should be placed on the process used and not on the accuracy of their predictions, as false hypotheses that are ultimately refuted by the evidence—so-called "negative results"—are as useful as correct hypothesis that are confirmed by the evidence, as long as the hypotheses lead to effective tests in each case. Students should be able to support both their predictions and conclusions with rational arguments and evidence, going beyond whether they were right or not. Some justifications that students might use to explain why their predictions are not confirmed by the outcomes of the simulation include:

- recognizing the high level of variability in the data due to the limited size of the data set and somewhat sporadic sampling over four years, such that few significant differences would be expected;

- acknowledging that any particular random subsampling of data within the simulation could return an “outlier” result which may incorrectly support or reject the student’s hypothesis, while realizing that this mimics some of the confounding aspects of data collection and experimental design;
- challenging the limited amount of data on SSL behaviors available in the published literature as a basis for making accurate predictions.

The simulation and data set described in this activity can be accessed for classroom use via the faculty webpage for W. Ryan at Kutztown University **http://faculty.kutztown.edu/ryan/.**

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Classroom Use of Narrative and Documentary Film Leads to an Enhanced Understanding of Cultural Diversity and Ethics in Science

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Abstract: For a first-year seminar, Windows on Science, the authors developed a cooperative learning activity around film designed to meet two of the campus-wide Principles of Undergraduate Learning. The teaching method utilizes the power of storytelling by screening narrative and documentary films. In the process, the methodology helps students to realize the contributions of many cultures, specifically African Americans, to our knowledge of science and the advancement of scientific methodology. Additionally, students are exposed to issues that focus on ethical conduct in the sciences and that provide an opportunity to discuss the leadership role that women have played in advancing science and technology. A pedagogical approach using narrative and documentary film in a freshman science course is an effective means for promoting an understanding of the endeavors and contributions of minorities and women in science, and for developing an increased awareness of issues concerning diversity and ethics.

Key words: African Americans, Science Instruction, Science Education, Multicultural Education, Ethics, Identity Concept, Narrative Theory, Documentaries, Films, Scientists, First Year Seminar.

INTRODUCTION

Indiana University - Purdue University Indianapolis (IUPUI) is an urban campus with over 200 programs and an enrollment of 30,000 students. Since 1996, the School of Science has required entering freshman to take a first year seminar course called Windows on Science. This course is intended to guide students along the pathway to success and at the same time introduce them to significant historical events and challenges that have had an impact on science. IUPUI has adopted six Principles of Undergraduate Learning (PUL) that have been integrated across the IUPUI curriculum (Hamilton, Banta and Evenbeck, 2006). PUL 5: Understanding Culture and Diversity and PUL 6: Values and Ethics are key components of the exercise described here. The sections of the Windows on Science taught by the authors each had a total of 20 to 30 biology students with an additional 3 or 4 students pursuing other science majors. The method has been employed for 6 semesters.

To facilitate the process of teaching cultural diversity and ethics in the context of science we have instituted a novel approach that combines: 1) development of a central prompt (Andrews, 1980); 2) multicultural science education goals; and 3) media and communication research on character identification concepts and narrative theories related to the power of film to transform (Cohen, 2001; Kozloff, 1987).

A literature review in the Education Resources Information Center (ERIC) index indicates the use of teaching methods integrating narrative and documentary films in primary, secondary and higher education is a ubiquitous practice in the humanities and social sciences. Moreover, a review of the literature covered by the General Science Abstract Index failed to find any reference to the use of both narrative and documentary films on the same topic, such as, *Something the Lord Made* and *Partners of the Heart,* to facilitate classroom discussion on the understanding of cultural diversity and ethical values in science.

Both of the aforementioned films are based on the story of Mr. Vivien Thomas, an African American who pioneered and taught heart surgery procedures at Johns Hopkins Medical School. When viewed together these films provide a unique opportunity to highlight the multicultural aspects of science and medicine, while at the same time providing a context in which to discuss the contribution of minorities, women and ethnic groups to the advancement of science. Using narrative and documentary films about the life of Thomas is not only innovative in the science curriculum; it provides two distinct approaches to the topic, each with their own effects on viewers. The narrative film takes advantage of the concept of identification, according to which viewers strongly empathize with the protagonist and temporarily assume his perspective and goals. (Cohen, 2001; Kozloff, 1987). The veracity associated with the documentary film appeals to viewers' sense of rationality and truthfulness as the film informs and makes a case for the accomplishments of Thomas.

The originality of the teaching method and its use in Windows on Science is strengthened by

Southerland (2000) who argues that science instruction and diversity education – multicultural science education –should pay particular attention to portray science as a human endeavor influenced by the culture in which it was developed. She continues by arguing for the introduction of the history of science, particularly biographies of individual scientists or a personal recounting of the development of specific theories, which can help students understand the influence of culture on the doing of science (Yost and González, 2008)

PROCEDURE

The complete exercise described here takes place over two class periods of 1hour and 50 minutes each. The first period utilizes storytelling through film, and it is focused on Mr. Vivien Thomas' experiences at Johns Hopkins. The film includes highlights of his time working as a research technician in Dr. Alfred Blalock's research laboratory as well as the time he spent in other areas of the hospital. The exercise does not include information on his experiences when he was initially hired and worked in Blalock's laboratory at Vanderbilt University. The presentation does make it clear that although he was working as a lab technician, he was receiving the salary equivalent to that of being a janitor. Interestingly, Mr. Thomas's creativity can be related to his original career path as a carpenter.

In order to convey the disenfranchisement of Mr. Thomas' achievements, leading up to the overwhelming recognition for Dr. Blalock's success as a pioneer in open heart surgery and specifically the treatment of blue babies, chapters 3 through 13 of the narrative film *Something the Lord Made* are shown. Showing these chapters requires about 1 hour of class time. Chapter 3 opens with Thomas mopping the floor in the science laboratory, while the remaining chapters continue to unfold as a dramatic storytelling of friendship, genius, and courage while also providing some insight into the racial and social norms among hospital staff, patients, and medical personnel at that time. Chapter 13, which completes this portion of the exercise, shows Thomas summarizing his place in the many achievements for which Dr. Blalock was internationally recognized (e.g., that Thomas has been invisible).

Prior to showing *Something the Lord Made* , the instructor tells the students that they will be viewing a historical event that occurred prior to the civil rights movement and at a time when a significant racial divide existed in the United States. The students are given the assignment of identifying and listing a minimum of ten ethical issues they observe while viewing the film. The students are prompted that the issues are not limited only to the racial divide and that they may also observe ethical questions related to scientific and personal conduct that occurs in the film (Andrews, 1980).

Following the screening, the students are placed into groups and instructed to discuss the observations they made while viewing the film. After calling the class back together, the instructor asks each group to report out to the class. As each group responds, the instructor organizes the observations into categories on the white board. The class is then asked to consider which of these ethical issues have been resolved over the course of time and how they were resolved (e.g., legislation, institutional committee review). If the class feels that an issue has not been resolved, which in our experience occurs very rarely, the students are asked to describe why they think this non-resolution is the case and to offer a way to resolve the issue. Following the discussion on resolution, the class is dismissed and told to bring their list of ethical issues illuminated in the film to the next class.

During the second class, the documentary film *Partners of the Heart* from the PBS *American Experience* series, is shown. Viewing the documentary film compliments the narrative film with the power of eye witnesses sharing their feelings and recollections of the remarkable relationship between Mr. Vivien Thomas and Dr. Alfred Blalock. The exercise begins with Chapter 2 titled *Johns Hopkins*. This segment unfolds with Mr. Thomas and Dr. Blalock's arrival in Baltimore, Maryland in June 1941. Dr. Blalock begins his appointment as Surgeon in Chief at Johns Hopkins University, School of Medicine. What awaits Mr. Thomas is continued racial segregation in Baltimore and Johns Hopkins Hospital. Chapter 3 is titled, *Blue Babies*. Here Dr. Taussig, a heart specialist at Hopkins, introduces Dr. Blalock to the idea of a surgical solution to the heart defect commonly referred to as Blue Babies. With the success of the Blue Baby operation, they open the door to heart surgery once considered impossible. Chapter 4 titled *The Journey*, tells the story of the most famous surgical department in the world. With Dr. Blalock's pioneering achievements comes worldwide recognition, while Mr. Thomas' contributions remain undiscovered – invisible. The documentary concludes with chapter 5, *Recognition*. Revealed are the positive results of the civil rights movement to end racial inequality throughout America and Johns Hopkins, In the midst of these dramatic historical events Mr. Thomas' long awaited recognition and contribution to cardiac surgery are realized. Showing these chapters requires about 45 minutes of class time.

*Partners of the Hear*t is a powerful and dramatic documentary that combines historical film footage with interviews of patients, staff, interns, medical doctors, family and friends of Mr. Thomas and Dr. Blalock. The interviews provide personal insight into the pioneering work of Dr. Blalock and Mr. Thomas and an indication of the social constraints of the times in which they lived. These individuals express sadness over the events of the past and at the same time express gratitude in recognition of Thomas' significant contribution to the fields of heart surgery, the development of unique surgical instruments, and the teaching of surgical procedures to medical interns at Johns Hopkins. The film also addresses the positive impact of the civil rights movement in opening the doors for minority students and women to enter and train in professional schools, such as Johns Hopkins Medical School.

Additionally, *Partners of the Hear*t clearly shows the significant contribution of Dr. Helen Taussig, a pediatric cardiologist, in developing a surgical shunt to alleviate the problem responsible for causing the blue baby syndrome. These patients were of particular interest to Dr. Taussig and she was very interested in finding a solution to this fatal medical problem. The recognition of Dr. Taussig in the documentary film makes a good connection back to *Something the Lord Made*, a film that makes it clear that the development of the shunt was ultimately accomplished by Taussig's surgical colleagues at Johns Hopkins, Thomas and Blalock. For their success, Dr. Blalock received many personal accolades that included nine honorary degrees. The shunt was initially called the Blalock-Taussig shunt. It was later renamed the Blalock-Taussig-Thomas shunt (Brogan, 2003).

Prior to viewing *Partners of the Heart*, students are instructed to refer to the list of ethical issues they made while viewing *Something the Lord Made*. After screening *Partners of the Heart*, the students are asked to identify any resolutions they observed to the issues they listed while viewing *Something the Lord Made*. A comparison is then made between the resolutions discussed at the end of the first class and those that were identified in *Partners of the Heart*.

DISCUSSION

The classroom presentation of the story of Mr. Vivien Thomas through both a narrative and a documentary film engages students through two distinctly different presentations using the same medium. The screening of the narrative film, *Something the Lord Made*, anticipates an engagement on behalf of students largely through empathy and character identification. The allegorical world of narrative film invites audiences to momentarily forget themselves and assume the perspectives and emotions of various characters, in this case those of Thomas (Cohen, 2001). Consequently students can form strong empathetic and emotional bonds by identifying with the Thomas character as he challenges the racial conventions of the period and the conventions of the medical establishment (both in terms of the procedures he is pioneering and the medical credentials expected by the profession). The narrative depiction of this story provides a dramatic account that strongly appeals to an audience's sense of compassion, justice, and equality.

The screening of the documentary film, *Partners of the Heart*, engages students through rhetorical strategies that give the impression of fairness and accuracy (Nichols, 2010). This type of biographical or commemorative documentary is built on fact and presented with a degree of detachment from the subject. Yet a strong emotional effect is also achieved through the participation of people who have first-hand knowledge of Thomas and who express poignant stories and heartfelt feelings.

Through the combination of emotional engagement, character identification and the persuasiveness of the rhetorical strategies of documentary that present primary material and emotional testimonies, students are presented with a comprehensive depiction of Vivien Thomas's story as it embodies the themes of the course. The goal of this pedagogical approach is to help students consider and understand the value of diversity as they themselves aspire to participate in a historically exclusive field. This inspiring story focused on a specific part of Thomas' life, as presented in two different modes of filmmaking, makes a highly effective presentation to achieve this goal.

In summary, Table 1 provides an overview of the consensus responses related to major ethical and diversity concerns observed while viewing the narrative film *Something the Lord Made*. Table 2 highlights responses regarding what society has done to resolve some of the concerns noted in the aforementioned table while viewing the documentary film *Partners of the Heart* and the accompanying in-class discussions. In the end, this activity provides a range of possibilities for discussing ethical and cultural issues in the sciences. In particular, it enables students to develop a broader more sensitive understanding of the power of inequality on society, culture, race and gender when determining who receives credit for discoveries, inventions or contributions made by individuals within a team. Additionally the authors felt this method achieved a

Table 1: Consensus ethical issues noted while viewing *Something the Lord Made*

Lack of credit given to Vivian Thomas	From experiments to humans too fast
Food, alcohol, and coffee in the lab	Pay inequity
Issues of religion vs advancement of science	Mistreatment of women scientifically
Racial segregation	Procurement of experimental animals
Mistreatment of African Americans	Uninformed consent for operating on baby

goal of providing a vehicle for a deeper appreciation of the historical disenfranchisement of minorities and women in the sciences and in medicine in particular.

Table 2 Resolutions discussed that address issues in table 1

Vivian Thomas receives recognition
Institutions have formed animal care committees
Institutions have formed safety committees (SRCs)
Institutions have formed review boards (IRBs) for experimentation and patient consent forms
Civil rights legislation and other laws have been passed
Gender equity has or is being addressed across the country
Eating and drinking in research labs has been banned
Conditions in the operating room have improved
Patient care has advanced

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ACUBE 59TH MEETING ABSTRACT SUPPLEMENT

Association of College and University Educators 58th Annual Meeting

October 23-125, 2015

Hosted by

Missouri Western State University
St. Joseph, MO

TALKS, WORKSHOPS AND ROUNDTABLE DISCUSSIONS

Workshop: Teaching Like a Pro in Your First Years
Rebecca Burton, *Alverno College*
Explore topics such as effective pedagogy, excellent resources, classroom management, and authentic assessment with experienced educators.

Workshop: DNA Time Travel: From Discovery to GWAS
Melissa Csiskari, *Howard Hughes Medical Institute Education Resources Group*
Come and learn an engaging way to teach students about DNA and Genomics. We will follow the trail of evidence that led James Watson and Francis Crick to discover the structure of the DNA molecule by combining clips of HHMI's short film The Double Helix and primary literature. Then we'll fast-forward to explore how current genomic technologies, particularly genome-wide association studies (GWAS), are used to map genotypes and phenotypes. Participants will complete a hands-on activity that uses real data to help students understand how to link Single Nucleotide Polymorphisms (SNPs) to specific traits in dogs. Explore HHMI BioInteractive's free activities and materials to help bring DNA, gene mapping, and statistical analysis successfully into your introductory biology course

End of Lecture? The Future of Evidence-Based Teaching
Mary Pat Wenderoth, *University of Washington*
We recently published a meta-analysis of 225 papers that compared student performance under active learning versus lecturing in undergraduate courses across the STEM disciplines. The results indicate that on average, students are 1.5 times more likely to fail when being lectured to compared to taking the same course with an active learning component, and that active learning increases exam scores by almost half a standard deviation. I will summarizes the research results that provide robust data on teaching methods that increase student achievement and I will engages participants in discussion of the way even small changes can close the gap between our teaching and student learning. These teaching methods are based on results from cognitive and learning sciences and rely heavily on the "Testing Effect" and "Desirable Difficulties". I will engages participants in discussion of the way even small changes can close the gap between our teaching and student learning because shrinking that gap has tremendous implications for all students, but especially those from underrepresented groups.
Says Toby Bradshaw, Chair of Biology at UW: "'By reducing the failure rates, capable students are able to go on, rather than being washed out of the system because they came in a bit underprepared and no one was willing to change the way they did things to help them out…. The impact down the road is that we will have a larger, more diverse, more capable work force.'"

Top Hat is a New and Accessible Class-response System in Genetics Teaching
Khadijah Makky, *Marquette University*
With new advances in the field of precision medicine, courses on human genetics and genomics become increasingly critical to pre-health profession students. As with many biology related classes, the goal is to keep students interested, engaged, and to improve their retention of the material beyond the semester and the final exam.
Active-based learning has been proven to be fundamental for student education. Class response systems (to aid in student engagement in large classes) such as the Clicker; have been in use since the mid 1900s and after that many others were developed. Top Hat is a relatively newer classroom response system. It was developed in 2009 and it allows students to use many of their electronic

devices (laptop, tablet, and cellphone). As an instructor using this system I have found it easy to set up for each lecture and have had an excellent experience with technical support from the developer. Here, I describe our experience using this class response system in the course Human and Applied Medical Genetics. The advantages and disadvantages of the system will be presented and complimented with a demo course. Students' evaluation designated several positives such as price, class engagement and the ability of the system to help understanding the topics taught. In conclusion, the system was easy to use for both students and instructors, it proved to be a useful tool for interactive learning, and helped our students with the application of the material presented.

Immediate Feedback on Biology Lab Group Review Quizzes Improves Retention of Concepts

Heather Wilkins, *University of Cincinnati Blue Ash College*

Introductory biology courses often cover many topics very broadly in quick succession, and therefore, mastery of concepts and critical thinking can sometimes be challenging. Providing immediate feedback to students as they are learning material has been shown to improve their retention of correct concepts, especially if they first give an incorrect response (Pashler et al. 2005). Immediate correction of misconceptions through use of the Immediate Feedback Assessment Technique (IF-AT) can prevent students from internalizing incorrect information and has been shown to increase performance on tests (Dihoff et al. 2004). Two biology lab sections completed multiple choice review quizzes. One group used the IF-AT scratch-off answer sheet where the correct answer is revealed by a star. Retention on individual lab practical tests was compared. The IF-AT could help to improve student retention of scientific concepts in an introductory biology lab class.

Building Synergy and Connection Among Students and Faculty in Different Courses at Multiple Levels of a Program, through Shared Study of a Microbe

Tamara Mans and Paul Melchior, *North Hennepin Community College*

By focusing diverse lab work on a single organism, we were able to collaborate across courses, share resources, and energize our students' research. We used one bacterial species to study genetics, biochemistry, growth characteristics, and ecological roles during extended projects in multiple courses and levels of a bachelor degree program. Senior students took a leadership role: as a capstone project, they tested and adjusted protocols for use with the bacterium, then co-wrote a detailed manual aimed at students for the second year of the program. Students in introductory biology courses, genetics, advanced biochemistry, and other research students worked with the same microbe, each with varying goals which matched their courses' objectives. The explicit connection between projects at different levels demonstrated the cumulative nature of scientific research. It increased student confidence and project momentum, and thus motivated participants. Intentional collaboration fostered growth of a scientific community among a wide group of students and faculty.

Poop Pills and Deadly Pandemics: How to get First Year Biomedical Sciences Majors Excited about Microbiology

Lauriann Klockow, *Marquette University*

Watching the trailer of the medical thriller, "Contagion", students see how a novel virus transmitted by aerosols and fomites can rapidly spread through a population. They see how medical researchers and public health officials attempt to identify and contain the disease and the loss of social order that could occur as a result of a deadly pandemic. "Could this happen in real life?" I ask. This is how I introduce freshmen biomedical science majors to the course they will take in their junior/senior year: Medical Microbiology. In this presentation, I will briefly describe and give examples of the small group activities I do during 2 class periods with 150+ first year biomedical sciences undergraduates to introduce them to the field of medical microbiology. One class period focuses on pathogens, specifically on viral outbreaks comparing the pandemic potential of influenza to Ebola. The second session uses the topic of fecal microbiota transplants as a way to engage students in learning about the healthy bacteria that make up our microbiome. I will describe how I use excerpts from the popular press and from journal articles as well as video clips to prompt group discussion. The activities I will describe have also been adapted for science outreach with a small group of high school students. They could also easily be adapted for teaching the microbiome and viral outbreaks to more advanced undergraduate students in a large or small class setting.

pClone: Synthetic Biology Tool Makes Promoter Research Accessible to Beginning Biology Students

Todd Eckdahl, *Missouri Western State University*

The Vision and Change report recommended genuine research experiences for undergraduate biology students. Authentic research improves science education, increases the number of scientifically literate citizens, and encourages students to pursue research. Synthetic biology is well suited for undergraduate research and is a growing area of science. We developed a laboratory module called pClone that empowers students to use advances in molecular cloning methods to discover new promoters for use by synthetic biologists. Our educational goals are consistent with Vision and Change and emphasize core concepts and competencies. pClone is a family of three plasmids that students use to clone a new transcriptional promoter or mutate a canonical promoter and measure promoter activity in Escherichia coli. We also developed the Registry of Functional Promoters, an open-access database of student promoter research results. Using pre- and posttests, we measured significant learning gains among students using pClone in introductory biology and genetics classes. Student posttest scores were significantly better than scores of students who did not use pClone. pClone is an easy and affordable mechanism for large-enrollment labs to meet the high standards of Vision and Change.

Infusing Creative Writing Assignments in an Upper Level Biology Class to Promote Active Learning

Marlee Marsh, *Columbia College*

Histology, like many biology courses, is a content-heavy course where students tend to focus on rote memorization of facts in order to understand structure and function in a biological context. In the hopes of infusing more critical thinking and active learning into this course, a creative writing assignment was added in which students produced a case study on a histologic topic of their choice. In addition, students were tasked with writing extensive teaching notes for their case. Students were also asked to design or find a video to supplement their case study so that their case could possibly be used in a flipped classroom setting. Students chose to write cases about a variety of topics including diseases of the blood and autoimmune diseases. In this presentation, I will give a quick background of the course, the assignment, results and feedback from students.

Implementation of Introductory Biology Courses Aligned with Vision and Change Recommendations

Tessa Durham Brooks, Erin Doyle, Scott Dworak, Brad Elder, Ramesh Laungani, Barb Clement, Kate Marley, *Doane College*

The Doane College Biology Department has undergone steady transformation over the last fifteen years starting with a required senior research experience for majors, which led to integration of inquiry laboratories throughout introductory Biology courses and most electives. When the Vision and Change report was published in 2011, the department was well positioned to re-evaluate the introductory course sequence in light of the report's Core Concepts and Competencies. This re-evaluation led to the design of a new introductory sequence, launched in Fall 2013, consisting of a freshman-level inquiry laboratory (BIO 110 - Inquiry Laboratory) followed by two integrative lecture based courses (BIO 111 - Energy of Life and BIO 112 - Information of Life). Student perceptions of learning gains in BIO 110 were assessed using internal IDEA survey administration. Learning gains in experimental design in BIO 110 compared to pre-V&C implementation were measured using the EDAT instrument. Gains in understanding of biological concepts between students who had completed the new introductory core compared to pre-V&C graduating seniors were measured using an in-house adaptation of several currently available biology concept inventories. Initial results suggest high student satisfaction in BIO 110 and strong learning gains in Core Concepts in BIO 111 and 112.

Integrating Evolution into a General Education Human Biology Course

Janice Bonner, *Notre Dame of Maryland University*

Successfully integrating evolution into a General Education biology course can be challenging because students often don't have sufficient background to which they can relate the evolution-based concepts presented in the course. This session describes how the trade book , The Story of the Human Body: Evolution, Health and Disease (Lieberman, 2013), was integrated into a Human Biology course for non-majors. It explains how the course was designed to provide an ongoing foundation to support the explanation of human evolution, how it incorporated student activities carried out both in class and as course assignments, and how the instructor ensured that students had read the designated chapter of the book prior to class.

Toxins-The Good, The Bad, and the Beautiful as a General Education Course

Mark Milanick, *University of Missouri*

I will outline my experience teaching a General Education science class, Toxins, the Good, the Bad, and the Ugly and then lead an audience discussion of what should be the goals of such a class. On the one hand, this course could be aimed to get the students interested in science and thus concentrate on interesting stories and puzzles about toxins, but would this be like having a General Education chemistry class that is driven by neat demonstrations? If so, is that good or bad? In my class, I am attempting to provide some idea of how science is done by providing some examples of solid scientific conclusions, for example, the grasshopper mouse that can eat scorpions with feeling any pain. I intersperse examples where there is controversy, including whether lead or digitalis could have affected van Gogh's color perception. I will share other examples and my experiences trying to motivate student discussions by posing questions about whether the students, if they were an investor, which toxin diagnostic or therapeutic based company would they invest or if a relative had cancer or altered pain perception, which research trial toxin based medication would they recommend that the relative join.

Workshop: Using Bloom's to Design Assessments that Measure Meaningful Learning
Mary Pat Wenderoth, *University of Washington*
Most faculty agree that academic success should be measured not just in terms of what students can remember, but what students are able to do with their knowledge. However, frequently the exams and other assignments that faculty use to gauge student learning do not measure this type of meaningful learning. In this workshop, we will discuss how to better align formative and summative assessments with course learning goals. We will introduce Bloom's taxonomy of cognitive domains and teach participants how to determine the "Bloom's level" of exam questions. Participants will practice designing questions and/or assignments that address each of the six Bloom's levels: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Participants are encouraged to bring one of their exams or class assignments with them to the workshop.

Four Years into Weaving a Thread: This is not the Tapestry I Expected
Conrad Toepfer, *Brescia University*
In the fall of 2011, two of us began an intra-disciplinary project, "Weaving a Thread," involving six of our courses over the academic year. Seventy-five students from those classes examined a common topic from the specialization of each class and all students interacted at semester-end symposia. Students were expected to synthesize content at the end of the fall term and apply that content to a novel situation at the end of the spring term. We presented early results and our plans for tweaking the thread at the 2012 ACUBE meeting and provided an update at the 2013 meeting. Our plans, however, did not involve the project unexpectedly taking on a life of its own. Since 2012, the project has grown to include faculties from chemistry, physics, math, psychology, political science, business, and art, and has the potential in the 2014-15 year to involve 40-50% of our entire on-campus enrollment. This presentation will focus on the elements leading to the unexpected growth, the challenges associated with that growth, and a discussion of which pieces of the project are most critical if anyone is interested in implementing a version at another institution.

Math of Microbiology: An Approach to Increase Math Skills in Undergraduate Science Majors
Jason Baker, *Missouri Western State University*
Mathematics is an integral part of many science-based careers yet a large percent of science undergraduates (Biology, Biochemistry and Molecular Biology, Medical Technology, Natural Science, Biotechnology, etc) at Missouri Western State University lack confidence in mathematics. A life science industry summer sabbatical in 2011 reinforced the need to teach math skills in the undergraduate science curriculum. In an effort to increase math skills relevant to science careers I have implemented a systematic integration of basic algebra, units and unit conversions, and math problem solving into the microbiology course taken by science majors. Students must master calculations related to microbial cell enumeration, growth rate, thermal death rate, solution preparation, concentrations, and dilutions. Integrated into this are the skills of unit conversions, magnitudes, estimating, correct use of calculators, and scientific notation. Interactive math activities are integrated into lectures, labs, a lab report, a math worksheet, and ultimately a 30 pt math skills quiz as part of the course final exam. A four-year evaluation shows a 73.1% average score for mastering these math skills.

Overlap in Upper Level Biology Majors' Courses: Necessity or Wasted Time?
Jim Clack, *Indiana University-Purdue University*
I have previously demonstrated significant overlap in the course material of several majors' and non-majors' introductory biology courses. Analysis of upper level courses covering different sub-disciplines has revealed similar overlap in material. Is this overlap in coverage a necessary evil or does it simply waste time that might be spent expanding on topics more central to the particular sub-disciplines?

Do Multidisciplinary Science Camps Enhance High School Student Learning and Interest in Pursuing a Career in Life-sciences?
Csengele Barta, Steven Hatch, Stan Svojanovski, John Rhoad, Michael Ducey and Todd Eckdahl, *Missouri Western State University*
STEM education increases science literacy, fosters critical thinking and problem-based learning and enables the next generation of innovators. While science camps have been frequently offered in the past as means to enhance science literacy and discovery-based learning, the impact of multidisciplinary applied science camps on student learning and interest in pursuing a future career in life sciences is still not understood. Here we report on the design, implementation and impact of a novel, short-term, multidisciplinary science camp, developed at Missouri Western State University (MWSU) offered to junior- and senior level high school students in

2014 and 2015. Students enrolled in the week long "Discover Science! Summer Day Camp" learned research techniques and applied them in the laboratory through two, interconnected and hands-on protein biochemistry and molecular biology experimental modules. The impact of the camp on student learning/interest in pursuing a career in life-sciences was assessed using pre- and post- camp knowledge and perception surveys and self-reflective essays. Preliminary analysis of data supports a significant increase in the content knowledge of students and an increase- or sustained interest in pursuing science careers in the future. Future work will target the long-term impact of applied multidisciplinary, integrated science camps, and the longer term academic success of summer camp alumni.

Incorporating Geospatial Technology in Undergraduate Education: Applied Learning in Undergraduate Courses and Research in Mammalogy

Cary Chevalier, *Missouri Western State University*

Geospatial technology (mapping Global Positioning Systems, GPS, and Geographic Information Systems, GIS) are essential to modern organismal biologists (as well as many other non-biological disciplines). There is increasing use of geospatial technology in answering questions involving organismal ecology, behavior, conservation, and management. I introduce students to the use of mapping grade GPS and GIS for various applications in the undergraduate course in Mammalogy I teach as well as in every research project I have (habitat selection, roundworm distribution, population monitoring, population density estimations and dynamics). Examples include 1) locations of specimen collection, 2) construction of trapping grids and transects using GPS and special techniques such as offsetting of points, 3) precision navigation to transect sites, 4) how to analyze spatial data such as home range data to determine use patterns and use intensities (using GIS). These technologies can be easily adapted to a wide variety of biological exercises, thereby enhancing students' experiential Applied Learning enrichment. Further, these types of experiences can be incorporated into courses and field exercises that can be accomplished right on campus.

The Drosophila Ovary as a Laboratory Model for Introducing the Genetic and Cellular Basis of Cell Migration

Melissa Daggett, *Missouri Western State University*, Leonard 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.

Botany in Animal Behavior Lab

Lynn Gillie, *Elmira College*

Interdisciplinary work can reveal patterns and relationships among organisms that may be challenging to unravel. Students tend to compartmentalize their learning rather than draw from a range of experiences. A guided research project can help them integrate multiple disciplines. Using multi-week field projects, students in a mixed science major and non-science major Animal Behavior course applied botany and chemistry to explain behavior of organisms. Habitat selection of aquatic invertebrates and foraging behavior of butterflies in a meadow were the two main projects that students completed. The labs always generate more questions than answers, and illustrate how science is done.

Restructuring BIOL 152: Principles of Organismal Biology to Incorporate Active Learning and Student-Engagement with Scientific Data

David Hall and Kathy Denning, *University of Kansas*

Here we present our approach to redesigning the ecology laboratory component of BIOL 152: Principles of Organismal Biology; a four credit hour integrated lab-lecture course at the University of Kansas that serves as a foundational course for biology majors. The overarching goal of our redesign is to implement a series of three lab sessions that will: 1) familiarize students with how scientific inquiry is carried out and how ecologists collect and visualize data, and 2) allow the students to formulate and test hypotheses, using data collected by KU researchers. In this lab series, students will first learn how to critically evaluate data and data sources using real-world examples collected from print and online media. Next, students will use publically available scientific data repositories (GBIF, eBird) to visualize and develop hypotheses regarding temporal changes in the distribution of three focal species. Finally, students will read a selected peer-reviewed journal article, then use data collected by KU researchers to formulate a hypothesis related to the article's theme. Students will test these hypotheses by creating a graph in MS Excel and will present and receive peer feedback from the class.

The PULSE Midwest and Great Plains Regional Network: A Community of Practice for Implementation of Vision and Change Recommendations

Karen Klyczek, *University of Wisconsin-River Falls*, and Michael Kelrick, *Truman State University*

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 achieving 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 the Midwest/Great Plains (MWGP) region have organized two regional conferences (June 2014 and 2015) that brought teams from institutions to work on developing a shared vision and a plan for achieving that vision, and to learn creative problem solving strategies to facilitate effective, productive collaboration toward departmental transformation. In addition, groups of participants in sub-regional hubs have received project-driven funding to hold local workshops, as well as to promote and expand the network. This poster will summarize activities in the MWGP network and describe how participants can connect with MWGP network resources.

Integration of Genomics Research in an Undergraduate Genetics Course: A Seven Year Snapshot

Nighat Kokan, *Cardinal Stritch University*

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 research question under investigation uses comparative genomics in Drosophilae species: how do the sequence organization and gene characteristics differ between heterochromatic and euchromatic domains? The genome annotations research curriculum has been implemented mainly in an upper level genetics course in the Biology majors program. The annotation experience has been instrumental in providing Cardinal Stritch University students with the use of bioinformatics tools and databases and providing the students with a real research experience over the past seven years, given the limited resources at a PUI. Forty-two students have enrolled in the BL308 genetics course and have participated in the annotation research from 2009 to 2015. Sixteen out of the thirty students who contributed annotations on four drosophila species during the 2009 -2012 period are co-authors on publications. This poster will share insights, challenges, solutions and student responses over the seven years.

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Differential Effect of Active-based-learning on Exam Performance of Different Student Populations

Khadijah Makky and Judith Maloney, *Marquette University*

A classroom response system (CRS) was used in a large lecture hall to apply Active-based-learning (ABL), and determine which population of students benefits the most from CRS. A CRS was used in two different classes, a required and elective course. Students utilized CRS to answer critical thinking questions that were incorporated into the lecture and received bonus points for these questions. Results showed that students' exam performance correlated with both their participation and bonus score. Moreover in both classes, the percent of students that achieved the maximum bonus scores correlated with their letter grades. Which student benefited the most from ABL? In both classes, achieving the maximum bonus points did not significantly alter the grades between the midterm and final for strong and highly motivated students. In contrast, for lower performing students this parameter differed between the two classes. Excitingly, in the required class, the data identified a group of students in the BC range that benefited significantly from the CRS, whereas this was not the case in the elective class. In conclusion, our study suggests that the academic benefit of ABL may differ depending on the population of students and their motivation to take the course.

Introducing Primary Literature in a Special Topics in Biology Course

Shauna Marvin, *St. Jude Children's Research Hospital*

Special topics courses offer students an opportunity to study important issues in biology not covered in regularly offered courses, often with a smaller class size. This provides an opportunity to use a variety of material for teaching a particular topic, including primary literature. Multiple strategies were used in a Special Topics-Virology course with the ultimate goal of students being able to understand and discuss primary literature. Approximately 50% of the students in this junior-senior level course had not been exposed to primary literature. The beginning of the course included introductory lectures about the viral lifecycle and of particular viruses that would later be discussed using primary literature. To help prepare students for the primary literature paper, specific virus lectures included the common methods used to study that virus and examples of primary data. Additionally, to encourage student participation and provide preparation for discussion-based courses, lecture classes ended with a discussion on a current news topic about a particular virus. To help prepare the students for discussion, pre-class homework assignments for each primary literature paper were turned in prior to class. Examples of key lecture components, assignments and literature used will be presented and discussed.

Case Studies Illustrating the Use of Collaborative Projects Across The Curriculum (CPAC) as Applied Learning Activities in Biology Classes at Missouri Western State University

Mark Mills and David Ashley, *Missouri Western State University*

We will illustrate our use of long-term collaborative research projects in biology courses on our campus by focusing on two or three case studies, detailing learning objectives, logistics and outcomes. These research collaborations involve multiple courses over multiple years and generate datasets that can be examined by students during applied learning experiences. One such research project, a coverboard study in a campus natural area, has involved students in introductory-level classes (Organismal Biology and Evolutionary Ecology) and in upper-level courses (Herpetology, Invertebrate Biology, Entomology). Another case study will describe a project monitoring invertebrates at cave decomposition stations that has been repeated over multiple years by students in different courses (i.e. Cave Ecology, Invertebrate Biology, and Entomology). Students in classes conducting such research projects (or mini-projects) are expected to enter data to common datasets and then manipulate and analyze the datasets to test hypotheses they generate. In some courses, all students enrolled will prepare individualized manuscripts concerning the same project while in other courses, students (or teams of 2-3 students) are responsible for summarizing one of several class mini-projects conducted that semester. A student might be exposed to the same research project over several years and courses.

A Simple Method to Culture a Micrometazoan for Use in Teaching and Undergraduate Research

Barbara Sisson, Raymond Allen, Elizabeth Thompson, and Robert Wallace, *Ripon College*

Rotifers are often raised for aquaculture, and serve as an excellent food source for developing larval zebrafish. In particular, the halophillic rotifer, *Brachionus plicatilis*, is an excellent model system for use in undergraduate teaching and research. Here we describe a culture apparatus that permits growth of *B. plicatilis* in amounts sufficient to raise larval zebrafish to adulthood with little daily maintenance in a small academic setting. Culturing rotifers enables students to conduct a wide variety of experiments on larval zebrafish development and address toxicology questions related to the food chain. This species also is suitable for studies of predator prey dynamics, aging, and toxicology.

Exploring Peer-Led Team Learning in Introductory Biology Toward Recruitment and Retention of Underrepresented Minority Students in STEM Fields

Jeremy Sloane, Julia Snyder, and Jason Wiles, *Syracuse University*

The President's Council of Advisors on Science and Technology (PCAST) has predicted a deficit of one million college STEM graduates over the next decade and called for diversification of instructional strategies to increase student persistence in STEM. The report also suggested that recruiting and retaining members of underrepresented minority groups (URMs) is of particular importance. Prior research indicates that active and team-based learning approaches foster environments more conducive to student achievement, recruitment, and retention in STEM fields, and suggests that underrepresented populations may benefit most from these approaches. The present study explores the effectiveness of Peer-Led Team Learning (PLTL) in a mixed-majors Introductory Biology course toward increasing recruitment and/or retention of undergraduates in STEM fields with a focus on URM students. Students frequently cite uninspiring introductory courses as a factor in their decisions to leave STEM majors, and previous work on discursive identity suggests that URMs can benefit substantially from small-group learning environments with an instructor who is more like them. Hence, we predicted, and analyses have revealed, that students who participated in PLTL workshop sessions associated with introductory biology had higher rates of recruitment and retention over four years in STEM majors compared to students who did not.

Using Primary Literature in a Journal Club Format to Teach Science Literacy in an Introductory Biology Course

Aeisha Thomas and Natalie Holty, *Crown College*

Reading primary literature has been shown to be effective at developing science literacy (Johanna Krontiris-Litowitz, 2013). This study tries to address whether science literacy can be developed in a course where a journal club format is used to read these articles. Students from an introductory Biology course met and discussed primary science literature with the instructor. Science literacy development was also likely complemented by other aspects of the course such as the librarian teaching students how to choose sources, traditional laboratory work and other instruction. The approach was successful since there was an increase in science literacy total scores. Further, most students liked the journal club format and found reading the article helpful. Overall student attitude to science however did not change. Although the study included an investigation of the role of student choice of the topic of the primary literature on their learning, the results of that part of the study are less clear and the data will be presented. Most students however liked being able to choose the topic for the article and thought it made them more interested in primary science literature indicating that choice of article is of value to the students.

Assessment of Improvement in Student Data Analysis Skills after Out-of-class Assignments

Kristen Walton, *Missouri Western State University*

The ability to understand and interpret data is a critical aspect of scientific thinking. However, although data analysis is often a focus in biology majors classes, many textbooks and lab manuals for allied health majors or general studies classes are primarily content-driven and do not include substantial amounts of experimental data in the form of graphs and figures. In a lower-division allied health majors microbiology class, students were exposed to data from primary journal articles and their data analysis skills were assessed in a pre/post test format. Students were given 3-4 assignments that included data analysis questions. Assignments ranged from case studies that included a figure from a journal article to reading a short journal article and answering questions about multiple figures or tables. Data were represented as line or bar graphs, gel photographs, and flow charts. A pre- and post-test was designed incorporating the same types of figures to assess whether the assignments resulted in a change in data analysis skills. The mean class score showed a small but significant improvement from the pre-test to the post-test (50.4% correct versus 60.0% correct, $p<0.001$ by paired t-test). Scores on individual questions testing accurate conclusions and predictions improved the most. This supports the conclusion that a relatively small number of out-of-class assignments through the semester resulted in a significant improvement in data analysis abilities in this population of students.

Peer Led Team Learning Helps Improve Achievement of Minority Students

Julia Snyder, *Syracuse University*

We implemented Peer-led Team Learning (PLTL) in the context of a mixed-majors introductory biology course at a large, private university in the northeastern United States with the aim of improving achievement among underrepresented minority students (URMs), particularly those who had elected not to enroll in an optional lab associated with the second course of the introductory sequence. Students who did or did not take the lab course were not found to be statistically significantly different in terms of prior achievement. Results indicate that for URM students opting out of the laboratory course, achievement as measured by final course grades was markedly and significantly improved if they participated in PLTL workshops. There were no statistical differences among other groups indicating that PLTL has the highest potential for increasing achievement among URM students, which may have implications toward recruitment and retention among populations underrepresented in STEM fields.

Does Watching Online Lecture Videos Increase Student Engagement and Exam Performance?

Katie Shannon, *Missouri S&T University*

I have flipped one day a week of my Cell Biology course. For the flipped day, students watch online videos before class. During class, students work in groups on application level problems. For the other two days of the week, students are assigned a textbook reading before the lecture. Although there are incentives for both types of pre-class preparation, studies have shown that students rarely read the textbook before class. I hypothesized that more students would watch the videos than read the textbook. The online videos provide a vast amount of data on student viewing including number of plays and total minutes watched. To collect data on student reading, I give questions at the end of each exam asking how often they read the textbook before class, beginning in fall 2014 semester (58 students) and continuing in spring 2015 (38 students). Preliminary analysis of the data shows that exam performance correlates most frequently to reading and less often to watching the online videos. Multivariate analysis to control for student GPA and ACT score needs to be performed. Engagement was mixed, with approximately equal numbers of students watching videos more or reading the textbook more often.

The Process of Curriculum Reform: Adopting Vision and Change
Laura Salem, Christina Wills, and Jamie Dyer, *Rockhurst University*
The Biology Department at Rockhurst University worked collaboratively over a two year period to examine our curriculum. We will present the steps we took in the process including the hiring of two new faculty and the addition of a new course to our curriculum. The process included lengthy discussions and reflection, a visit from a Vision and Change colleague, the use of rubrics and matrices to evaluate our current curriculum, and the development of an assessment plan.

What Makes Osmolarity, Membrane Potential and pH so Tough?
Mark Milanick, *University of Missouri*
Why, when referring to hyperosmolar, is it the outside of the cell compared to inside of the cell? But for membrane potential, we do the reverse? Most students understand that molecules can move from the more concentrated solution to the less concentrated solution. Thus some students are confused by the fact that water moves from the lower osmolar solution to the higher osmolar solution. Perhaps we should say that water moves from the more dilute to the less dilute solution and define a measure of dilution as amount of water per particle with a unit of osmolar for dilution just as mho's are used for conductance units. I tell my students that most scientists cannot quickly answer the question, which is higher inside animal cells, the free proton concentration or the free calcium concentration. Why do we insist on using pH for the former but nanomolar for the latter? I will briefly discuss the historic reasons for these terms and then lead an open discussion on the audience's opinions on how to balance introductory science class coverage of the concepts with student friendly terms or of providing students with the vocabulary to read the scientific literature.

Teaching the Nature of Science Outside the Scientific Method
Debbie Meuler, *Cardinal Stritch University*
Understanding the Nature of Science (NOS) is critical for scientific literacy. Teaching how science works allows one to recognize good science from bad and distinguish real science from non-science. So what does it mean to teach the NOS? Is it more than just the scientific method? During this session I will share some of the ways I teach the NOS outside of the scientific method and then I will open it up to the audience to share their ideas and experiences. We will look at definitions used in science that differs from how they are used in everyday language and what it means to say science is tentative, historical, and self-correcting.

Promoting Student Engagement and Collaboration in Physiology Lectures
Judith Maloney, *Marquette University*
This study describes a method that utilizes the Immediate Feedback Assessment Technique (IF-AT) to incorporate active learning into lecture. This method is inexpensive, easy to develop, and promotes student engagement and collaborative learning. In a small physiology class, students worked in groups to answer multiple choice questions using IF-AT cards. This enabled the questions to be part of their course grade, and gave students partial credit for second or third choices. Another component of the course was team based learning (TBL) for review of the week's material. The assessment of this strategy consisted of a student survey on the use of the in-class IF-AT cards and TBLs, gaging class attendance, and open ended comments on the course evaluation. Survey results and the course evaluation indicate that students were overwhelmingly positive toward the course and especially the use of IF-AT cards. The cards and working as a team was beneficial to their understanding of the material; encouraged them to be more attentive; and motivated them to come to class. Class attendance during the sessions that utilized the IF-AT cards was 98.5%. Therefore, the use of IF-AT cards appears to be an alternative way to positively engage students in lecture.

Using History and Philosophy as the Capstone to a Biology Major
Neil Haave, *University of Alberta, Augustana Campus*
Capstone experiences have high educational impact (Hauhart and Grahe, 2015) with a number of approaches for biology (Davis 2011 Bioscene 37(1)). In most capstones, students produce a major project (Hauhart and Grahe, 2015), typically as an undergraduate research experience (Haave 2015 Bioscene 41(1)), with a primary goal to integrate students' learning (Smith 1998 The Senior Experience). At Augustana, our biology capstone uses history and philosophy to frame students' reflection and integration of their biological education within our liberal arts and sciences curriculum. In a flipped classroom approach, students write a response to the assigned reading before class, when the paper is discussed through student-lead seminars. Assigned papers consider the philosophy and historical development of biology focusing on its three conceptual pillars: function, development, and evolution (Haave 2012 Bioscene 38(2)), allowing students to examine how biologists arrived at their current understanding of life. Assessment of ten years of course offerings indicates students' ability to write and speak are being successfully developed in students, but that thinking shows no significant learning gains between the midterm and final exams. Student quantitative and qualitative ratings of the

course indicate that it is a valuable learning experience, despite its heavy workload and difficult nature.

Pre-health Academic Advising Workshop: Preparing Students for a Career in Health Care
Steven Daggett, *Avila University,* and Khadijah Makky, *Marquette University*
Academic advising is a critical component of a successful college or university education. The manner in which pre-health advising is carried out at different institutions varies. However, many of the methods and concerns overlap regardless of the institution. It is an on-going challenge for advisors of students who express interest in the health professions, to advise students who have clear misconceptions about what it takes to succeed. This workshop will focus on strategies for advising well-prepared students in addition to those who are not as prepared. The facilitators will each give a short presentation and then guide a discussion on ways of addressing this challenge. Part of the discussion will be to focus on what the term "success" means in each of these situations and the importance of teaching professionalism to both groups during the advising process. In addition, the facilitators will provide updates on aspects of the application process for a several health professions.
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Facilitative Leadership as a Tool for Departmental Transformation
Michael Kelrick, *Truman State University*, and Karen Klyczek, *University of Wisconsin-River Falls*
The primary goal of the PULSE Ambassador program is to facilitate productive discussions in life sciences departments, to catalyze institutional change and promote department-wide implementation of the Vision and Change recommendations. Based on lessons learned from our pilot visits to date, workshop participants will gain experience with some of the strategies used during Ambassador visits to departments, aimed at enabling department members to work collaboratively toward a common vision. The practice of listening with empathy will be highlighted using active role-playing, engaging participants in scenarios that represent challenges faced by department members with varying perspectives on important issues. Such empathetic listening skills are critical when tackling the long-term organizational change efforts, at the heart of the transformation recommended by Vision & Change. In addition, participants will identify various leadership styles and learn strategies that invite all department members to contribute to the transformation efforts

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 (≥ 300dpi) 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 fables. All figures should be accompanied by a descriptive legend using the following format:

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

Color figures: When color is involved in a figure, it should be encoded as RGB and the resolution should be 300 dpi. Manuscripts that include color figures accepted for the May issue (online only) will appear in color at no charge to the author(s). For color reproduction in the December issue (print and online), there will be a page charge of $300. Author(s) will be notified of the costs and will have the option of either delaying publication until the May issue or paying the page charge. There is no fee for color in an image used on the cover of *Bioscene*.

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.

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