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Cover image: Cover image of a Great Egret, *Ardea alba*, was taken by Conrad Toepfer at Ft. DeSoto Park near St. Petersburg, Florida.

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ARTICLES

Readability, Logodiversity, and the Effectiveness of College Science Textbooks

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Abstract: Textbooks are required in most introductory college science courses, but students may not be benefitting from the textbooks as much as their instructors might hope. Word use in the textbooks may influence textbook effectiveness. I tested whether either the amount of technical vocabulary or the readability had a significant effect on students' ability to learn general biology concepts. I provided different versions of the same reading, then tested students on the content. On the topic with the lowest overall post-reading quiz scores, students who received readings with less technical vocabulary outperformed their peers ($P = 0.03$). Textbooks did not appear to be an important source of learning for students in this study; fewer than half the students reported that they were reading the assigned chapters near the start of the semester, and this number declined sharply. Students had difficulty correctly answering questions immediately after reading brief selections, indicating a low level of comprehension. Changes in textbooks and teaching strategies may improve student learning and reading compliance.

Key words: readability, logodiversity, textbooks

INTRODUCTION

Unless students can learn from their textbooks, there is little purpose in requiring them. Overwhelmingly, introductory college science courses use textbooks, but questions remain about what aspects of the actual prose result in greater student learning of scientific concepts. When students enter college from high school, they encounter textbooks that are more difficult to read and may find that their literacy skills are inadequate (Williamson, 2008). There is no guarantee that students are actually reading at the level that corresponds to their years of education. A national study (Baer et al., 2006) revealed that only 38% of students nearing graduation from 4-year colleges were proficient enough in prose literacy to understand materials such as textbooks, and their literacy improved very little during their time in college.

Increasing the diversity of people entering scientific careers is widely recognized as an important goal, yet literacy is likely to be lower for college students from some ethnic groups and those for whom English is not the primary language (Baer et al., 2006). Students with learning differences related to reading will likely have additional problems with comprehension. It is reasonable to assume that student success in biology may depend—at least in part—on the ability to read textbooks effectively, and that many biology students lack sufficient ability. Instructors may wish to select textbooks that are effective with students who are poor readers, but what makes a textbook readable? A number of indices have been developed to measure the readability of written materials in terms of their syntactic and semantic difficulty (Fry, 2002). Most of

these grade level scores are based on length of sentences and length of words. These indices are generally intended for use in evaluating materials for K-12 schools or for the general public. Making sentences shorter and simpler will result in a lower grade level score, but may not make college biology textbooks easier for high school seniors to understand (Johnson and Otto, 1982). This may be because the shorter sentences can make it harder for students to see the logical relationships between adjacent sentences (Armbruster et al., 1985). In a study of college business students, the use of more readable textbooks was correlated with greater student retention and higher grades (Spinks and Wells, 1993). Landrum et al. (2012) found a similar pattern with psychology students.

In addition to word and sentence length, unfamiliar vocabulary can be a challenge for readers. College textbooks can differ greatly in logodiversity, a measure of how many technical terms are introduced and how often they are used (Burton, 2011). Science contains so many technical terms that scientists in different fields often have difficulty communicating. If students are to learn science, they must have technical language translated for them (Montgomery, 2004). Some mastery of technical vocabulary is essential for becoming biologically literate, but there is no widespread agreement on which words are critical at the introductory level. Some researchers have expressed concern about the number of technical terms and volume of information included in recent textbooks (Blystone, 1987; Lord, 2007). A balance should be found so that students are introduced to enough vocabulary to allow them to

Table 1. Calculations for three measures of readability. For each, the index is intended to correspond with the number of years of schooling required to comprehend the writing.

The Flesch–Kincaid Grade Level (FKGL) was calculated as:

$$0.39 \left(\frac{\text{total words}}{\text{total sentences}} \right) + 11.8 \left(\frac{\text{total syllables}}{\text{total words}} \right) - 15.59$$

The Coleman-Liau Index (CLI) was calculated as $0.0588L - 0.296S - 15.8$, where L is the average number of letters per 100 words and S is the average number of sentences per 100 words.

The Automated Readability Index (ARI) was calculated as:

$$4.71 \left(\frac{\text{characters}}{\text{word}} \right) + 0.5 \left(\frac{\text{words}}{\text{sentence}} \right) - 21.43$$

communicate effectively, but not so much that they are overwhelmed.

The purpose of this experiment was to examine factors that might influence the effectiveness of college biology textbooks. The study compared comprehension of students who read textbook excerpts that differed from the original in one of two ways: logodiversity or grade level index. It also examined students' compliance with assigned readings and whether reading the textbook before class improved their performance.

MATERIALS AND METHODS

Students' comprehension of readings was analyzed by presenting students in an introductory majors biology course with one of three versions of a reading in biology. One version consisted of the original wording from a ubiquitous textbook. Another version was altered to reduce the grade level score by using shorter words and sentences. The third was altered to reduce logodiversity by replacing technical terms with less specialized vocabulary. Students then completed a brief quiz based on the readings. This was repeated for a total of four topics spread over a semester.

Readings

On four occasions, students received a brief (approximately one-page) reading on the topic to be covered in class that day. They then answered a series of questions. The topics were presented in this order: population dynamics, basic enzyme properties, the light-dependent phase of photosynthesis, and Mendelian inheritance. These topics were chosen mostly to allow the sessions to be spaced at roughly equal intervals (approximately session per month) throughout the course. All four original readings were selected from Campbell's *Biology: Concepts & Connections* (Campbell et al., 2006). This textbook was chosen because of its popularity and because it uses a large number of technical terms, has a relatively complex sentence structure, and uses a rich non-technical vocabulary. Sections were edited to remove references to illustrations and arranged so they covered the topic of interest, but sentences were left intact for the readings termed *original*.

Two other versions were created from each original reading. In one version, sections were edited to remove some of the technical vocabulary. These were termed *low logodiversity*. For example, "F1" was replaced by "first generation." Sentence structure was changed only to preserve meaning when the number of technical words was reduced. The decisions regarding word substitution were subjective.

In another version, sentence structure and words were changed to make the reading difficulty of the section more appropriate for students with lower reading ability. These were termed *low grade level*. Technical vocabulary was usually left intact, though a shorter technical term was sometimes substituted for a longer one. The decisions regarding sentence structure were subjective, but the effect of the changes was evaluated with readability indices. The readability indices used were the Flesch–Kincaid Grade Level (FKGL), the Coleman-Liau Index (CLI) and the Automated Readability Index (ARI). All of these indices provide a number that is meant to correspond to the level of education needed to comprehend the reading (Table 1). In these measures, a first-year college student generally is assumed to be able to comprehend readings with scores of about 13 or lower.

Because the weighting of sentence length versus word length in determining the readability level varies from index to index, the three indices tend to give slightly different scores for identical readings, but the rank of the scores was consistent for each set. The original version had the highest score (meaning it would be the most challenging to read; Table 2), the version with reduced logodiversity tended to score approximately one grade level lower, and the version edited to reduce the grade level readability scores tended to be an additional grade lower (meaning it should be understandable to a person with two fewer years of education than those required to read the original).

Subjects

The students in this study were all enrolled in three of the six sections of the introductory biology course for science and nursing majors at Alverno College in the spring semester of 2011 (approved by

Table 2. Readability indices for the three versions of each of the readings. The index is assumed to correspond to the level of education needed to understand the passage. FKGL = The Flesch-Kincaid Grade Level, CLI = Coleman-Liau Index, ARI = Automated Readability Index.

Subject	Version	FKGL	ARI	CLI	Average
Population Dynamics	Low Grade Level	10.75	11.05	13.83	11.88
	Low Logodiversity	12.00	12.96	14.42	13.13
	Original	13.38	14.09	15.64	14.37
Enzymes	Low Grade Level	8.05	8.60	11.49	9.38
	Low Logodiversity	9.44	10.37	11.79	10.53
	Original	10.27	11.26	12.57	11.37
Photosynthesis	Low Grade Level	9.42	9.28	12.38	10.36
	Low Logodiversity	10.53	10.70	12.44	11.23
	Original	11.58	11.82	13.51	12.30
Inheritance	Low Grade Level	7.18	7.27	9.89	8.11
	Low Logodiversity	9.51	10.47	11.18	10.39
	Original	10.78	11.61	11.92	11.43

the Alverno Institutional Review Board, IRB-011M-10). Two sections were taught by the author, the other by another faculty member in the biology department. There is no reason to believe that the students in the three sections used in this study differed in important ways from those in the other sections, but because sections were not compared with each other, this factor would not be expected to influence the outcomes of the experiment. Students typically take this course in the second semester of their first year, and must complete a course in introductory physical science as a prerequisite. All Alverno College undergraduates are female. In spring of 2011, 58% of the total undergraduate student body identified as Caucasian American, 17% identified as African American, 14% identified as Hispanic American, 5% identified as Asian American, and 4% identified as non-US residents or reported multiple ethnicities. Of the full-time undergraduate students, 88% were awarded some type of financial aid (Source: Alverno Institute). In order to preserve anonymity, demographic information was not collected from students in this study.

Testing

Testing occurred immediately before the specific topics were covered in class. Students did not know in advance what topics would be part of the study. At the beginning of class, the instructor read a brief script about the study, informing students that they could opt out of it with no penalty and all responses (including their willingness to participate) would be anonymous. Each student was given one reading (approximately one page long), one question sheet, and one answer form. The three versions of the reading were distributed randomly and had been marked A, B, or C to identify the version. The letters were used randomly each time. For example, the original was labeled C one time and A another. All students received the same quiz. Students were provided with time in class (approximately 20 minutes) to complete the reading and answer the

questions. Students were instructed to answer the questions without looking at their textbook or the reading they had just completed. Instructors observed no attempts at non-compliance with this. Testing was done for all sections at the same point in the course—the first day the topic would be covered—but not the same calendar day because the sections met on different days of the week. There was no evidence of increased reading compliance or increased scores to suggest that students had been alerted to prepare for the testing by their peers.

Students answered the questions using Immediate Feedback Assessment Technique® forms (IF-AT® forms, Epstein Educational Enterprises, Cincinnati, Ohio). These forms use scratch-off squares similar to those used on many lottery tickets. A student scratches off the square corresponding to the response she believes is correct. If it is correct, she will see a star revealed in the square; if not, she can review the question and possible answers to make another selection until she has found the correct answer. The student, therefore, had instant feedback on her performance. She could mark the correct answers on her question sheet and use this information for future study. This method also informed the researcher how many attempts the student needed to get the correct answer when given four choices. Students had used IF-AT® forms previously in review activities.

All students completed the reading and quiz as a learning experience. The first question asked the student whether she were willing to have her anonymous answer form used in the study. Only one student on one quiz requested that her answers not be used in the study.

The second question asked which reading selection she had received that day (A, B, or C). The third asked whether she had read the assigned relevant chapter in her own textbook (*Biology: A Guide to the Natural World* by Krogh) before coming to class. For the first three questions, students were

told to ignore whether their scratch-off revealed a star.

The remaining six questions tested comprehension of the subject; five were based on the in-class reading. One question tested vocabulary recall, one tested factual recall, another required the student to choose a correct summary of the concept, another required the student to apply the concept, and an extension question required the student to reason beyond the facts provided (e.g., to predict what would happen to the proportion of recessive genes over many generations). Naturally, there was overlap in the questions. For example, a vocabulary question was also a test of simple recall.

A control question asked about information that was in the assigned chapter on the topic, but that could not be extrapolated from the information in the in-class reading. The order of the question types was scrambled so that, for example, the simple recall question was a different number on each of the four quizzes in the study.

Analysis

The IF-AT[®] forms allow multiple possible points for each question. A question that was answered correctly on the first try (only one box scratched off) was scored as 5 points. A correct answer on the second try was scored as 3 points. A correct answer on the third try received 1 point. If all boxes were scratched off, no points were awarded.

The word “total” is used below to reflect the point total on the five questions that could be answered correctly using the information in the one-page reading provided in class. The score from the control question was used in other analyses, but not included in the total.

ANOVA tests were used to determine whether student performances on the quizzes were influenced by the type of reading they had done (original, low technical vocabulary, or low grade level index). One-tailed independent T-tests were used to compare students who reported completing the assigned reading with those who reported either that they had not or were not sure. All statistical analyses were performed using Microsoft[®] Excel[®] 2007.

RESULTS

In general, a reduction in logodiversity resulted in significantly improved scores for one topic, but not others. Compliance with pre-class reading assignments was low, and did not measurably influence student performance on the quizzes.

The three versions of the population ecology reading, the first of the four, did not result in any differences in student scores (Fig. 1, $P = 0.8$). Performance was strong overall (average = 23.32 of 25 possible, with a low score of 15). About half the students reported not having completed the assigned reading before class (26 reporting having read it, 27 reported not reading it, and 3 were unsure). There

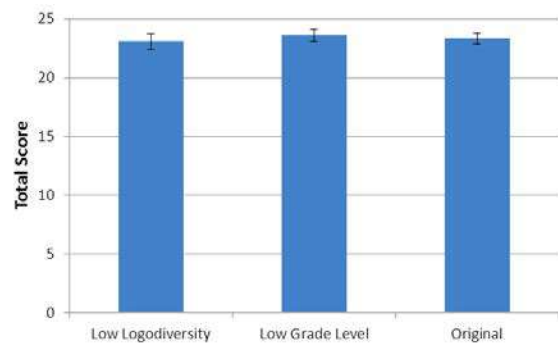


Fig. 1. Mean (+/- standard error) scores for students on a population ecology quiz with a maximum possible score of 25. Quizzes were given immediately after reading selections that differed in terms of grade level reading index or logodiversity index. Sample size = 19, 19, and 18. ANOVA, $P = 0.8$.

was no significant difference in performance between those who had done the reading before class and those who had not (unpaired T-test, 1-tailed, $P = 0.089$).

By contrast, the type of reading selection had a significant effect on student performance on the enzyme quiz ($P = 0.03$, Fig. 2). Those who read the version with a low logodiversity performed better on the quiz than those who read the other selections. Those who read the original tended to fare the worst. The overall performance on this quiz was the lowest of the four (average = 16.23, with a low score of 7). Students who had completed the assigned reading did no better than those who had not (unpaired T-test, 1-tailed, $P = 0.28$, $N = 52$).

Student performance on the photosynthesis quiz was not influenced by the reading selection type (Fig. 3, $P = 0.88$). Performance was moderate overall (average = 18.81 of 25 possible, with a low score of 9). Of the 52 students taking this quiz, only 15 reported having read the assigned chapter before attending class. These students did not perform significantly better than their peers (unpaired T-test, 1-tailed, $P = 0.404$).

The results of the quiz on Mendelian genetics were a bit different from the other quizzes in that

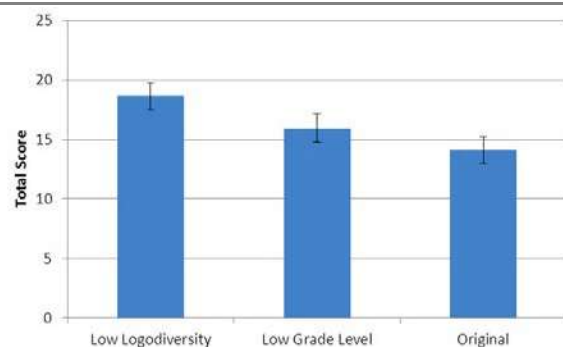


Fig. 2. Mean (+/- standard error) scores for students on an enzyme quiz with a maximum possible score of 25. Quizzes were given immediately after reading selections that differed in terms of grade level reading index or logodiversity index. Sample size = 17, 17, and 18. ANOVA, $P = 0.03$.

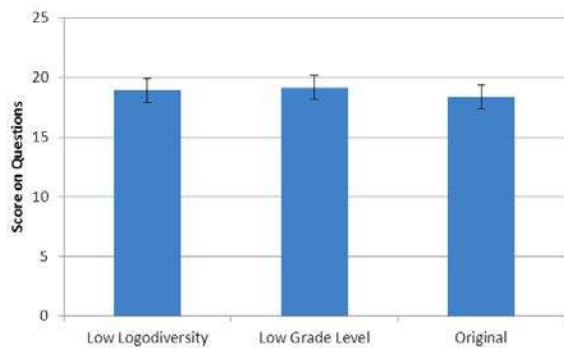


Fig. 3. Mean (+/- standard error) scores for students on a photosynthesis quiz with a maximum possible score of 25. Quizzes were given immediately after reading selections that differed in terms of grade level reading index or logodiversity index. Sample size = 14, 14, and 15. ANOVA, $P = 0.08$.

students who read the low logodiversity selection tended to perform less well than their peers, but the difference was not significant (ANOVA, $P = 0.067$, Fig. 4). Overall, performance on this quiz was slightly lower than that of the photosynthesis quiz, though still higher than performance on the enzyme quiz (average = 17.7, low score = 8, $N = 48$). The number of students completing the pre-class reading assignment was so low that a comparison between the students who had done the reading and those who had not (5 vs. 42) would not be valid.

Compliance with course reading assignments was low at the beginning of the semester and declined sharply throughout the semester (Fig. 5). Less than half of the students were completing the readings near the start of the semester, and scarcely more than 10% were reading the assigned chapter by the tenth week of the semester. However, completing the assigned reading did not lead to better performance on any of the questions, including the control questions.

Overall, students performed best on the question in each quiz that asked them to summarize the reading selection, but there was variation (Table 3). They also generally performed well on simple recall. As would be expected, they tended to perform poorly

on the control questions.

DISCUSSION

Many college students may find themselves unprepared to read their college science textbooks effectively (Baer et al., 2006; Williamson, 2008). The density of the information is probably one source of difficulty (Smith et al., 2010), but the writing itself may make the task more difficult by using technical vocabulary, complex wording, or words that are not part of the students' working vocabulary. In this study, reducing the technical vocabulary of passages from a college biology textbook increased student reading comprehension of the topic to a limited degree. For the topic with which students had the most difficulty (enzymes), reduction in technical vocabulary, general vocabulary, and sentence length may have allowed students to focus on more difficult

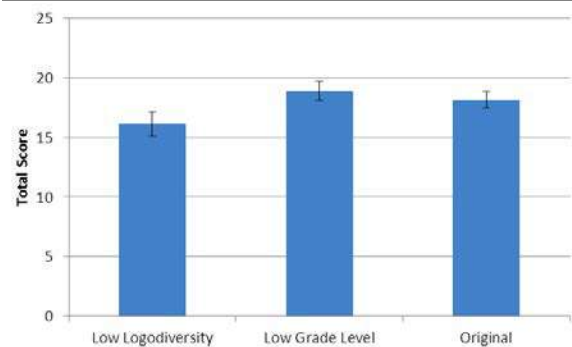


Fig. 4. Mean (+/- standard error) scores for students on a transmission genetics quiz with a maximum possible score of 25. Quizzes were given immediately after reading selections that differed in terms of grade level reading index or logodiversity index. Sample size = 14, 16, and 17. ANOVA, $P = 0.067$.

concepts. For the other topics, there was no significant difference in the performance of the students who read different versions of the passages. If students found this concept fairly easy to understand, they may have been able to tolerate writing with higher logodiversity and longer words and sentences.

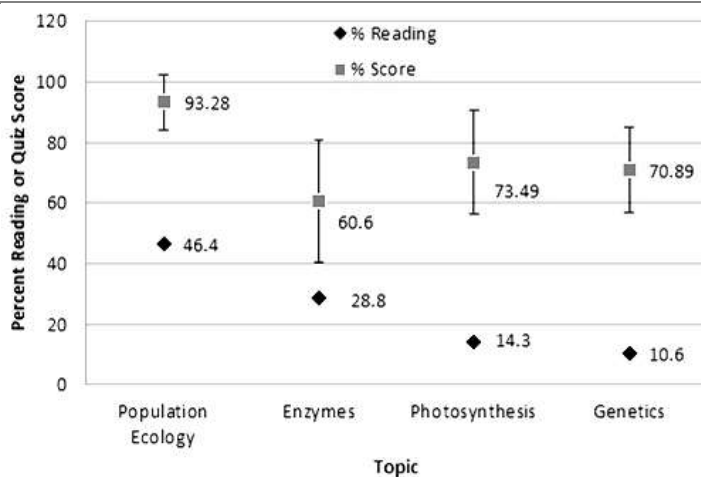


Fig. 5. Percent of students who reported having completed the assigned reading before coming to class and average percent score (+/- standard deviation) on the quiz for each topic for all students. Topics are arranged in chronological order.

Table 3. Scores on different types of questions.

Topic	Recall	Vocabulary	Summary	Extension	Application	Control
Population	4.89	4.82	4.68	4.45	4.48	3.41
Enzymes	2.27	3.90	3.08	4.15	2.83	3.08
Photosynthesis	4.51	2.86	4.56	2.14	4.30	2.77
Genetics	4.00	2.55	4.32	4.11	2.74	2.94
Mean	3.92	3.53	4.16	3.71	3.59	3.05

Whether students can comprehend a reading may be a function of the interaction between content difficulty and the level of the writing itself. Wright and Spiegel (1984) found that high school teachers' predictions of readability were more accurate than the Fry readability index at predicting student comprehension of biology textbook readings.

Apparently, teachers considered the difficulty of the subject matter, rating a reading on gene structure less readable than an introduction to ecology, even though the readings had equal scores on the Fry scale. In the current study, students performed very well on the ecology quiz and the version of the reading made no difference in their performance. They had more difficulty with genetics. There was a trend toward the students who received the low logodiversity reading performing worse than their peers, but it was not significant. The lack of Punnett squares and other diagrams in the in-class reading may have made the concepts so difficult to understand that the level of the writing was inconsequential. Illustrations can be critical in helping students learn biological concepts (Butcher and Kintsch, 2004; Rybarczyk, 2011).

There may be other reasons the reduction in logodiversity and reading level did not help the students on three of the topics. Perhaps the changes in the selections made some concepts more difficult to understand, but not in ways that the indices measured. Another possibility is that the reductions in reading level were not sufficient to make a difference. Students with significant challenges - such as those with poor academic preparation, learning differences, and those for whom English is not a primary language - may have benefitted from a greater reduction in the complexity of the readings.

Throughout this study, students who completed the reading before class were outnumbered by those who did not. By the end of the study almost no students were still doing the "required" reading. Other research has also found that students tend to complete very little of the assigned textbook reading (Bonner and Holliday, 2006; Brost and Bradley, 2006). Students may be using their textbooks as review tools, sources of diagrams, or as resources for discussions and homework, but not reading entire chapters to prepare for class. This attitude may persist into early college years. It is worth asking whether students would be more likely to read textbooks that had simpler prose. Landrum et al. (2012) found that college psychology students preferred textbooks that were more readable, that students were more likely to

actually read these books, and that those doing the reading performed better. Brost and Bradley (2006) found that the difficulty of a reading may be secondary to faculty behavior; if students believe that reading before class will not help them--because readings will be summarized or ignored in class--reading compliance is likely to be low.

When readers are new to a discipline, they lack not only content knowledge, but also cognitive frameworks for identifying key concepts and making sense of the information presented. They may also lack intrinsic motivation to expend the effort needed to learn from complex text (Jetton and Alexander, 2000). Faculty may not be considering these factors in their textbook selection. As Crow (2004) and Dutch (2005) point out, the more engaging books are not the books that instructors tend to choose for majors-only courses. Selecting textbooks with appropriate complexity of prose and other factors that influence student learning might improve reading compliance and effectiveness.

In this study, doing the pre-class reading did not appear to have been particularly helpful to students. One could argue that the influence of the in-class reading was so strong that it swamped any differences between students who had completed the pre-class reading and those who had not, but this lack of pre-class reading advantage was also found on the control question—the one that could not be answered from information in the in-class reading. While this was only one question per topic, the pattern was consistent through all four topics. Perhaps students in this study were reading the chapters superficially without really comprehending the concepts. Lord (2007) suggests that reading before lecture can result in more misconceptions, or in the ability to repeat information without understanding it. This could lead to students overestimating their understanding of what they read. Norris, Phillips and Korpan (2003) found that university students tended to rate media reports of scientific discoveries as easy to read, even when they failed to understand key features of the articles. Students in their study seemed to believe that if they could understand the words, they understood the article. In actuality, the students were unable to perform higher order tasks that were critical to comprehension of the readings, but failed to recognize this.

Some research suggests that instructors may be able to increase their students' effectiveness at reading by using questions to probe understanding.

Smith et al. (2010) found that a questioning strategy improved student comprehension of a passage on physiology. Posing questions that require higher level thinking may increase student understanding (Lord, 2007; Pestel, 1997). Reading quizzes can hold students accountable for learning from the assigned text. Course management systems can provide quizzes without using class time or faculty grading effort. Students can be allowed to access questions before they read, which can assist them to focus on key ideas. Questions can rely on higher order processes because students can be given more time and scaffolding than in a brief quiz at the start of class. Many quiz programs provide answer-specific feedback options, allowing the instructor to explain why the answer is incorrect, give hints about avoiding common misconceptions, or explain in more detail the implications of a correct answer.

Asking questions may be as useful as answering them. Henderson and Rosenthal (2006) suggest having students ask the instructor questions between reading and attending class. Instructors may not be able to imagine how students think about a topic, and this method would provide insight on student understanding and misconceptions. Teaching students how to ask good questions involving analysis, evaluation, and prediction may help students use the textbook effectively. Marbach-Ad and Sokolove (2000) found that students in active learning courses can be taught to ask higher level questions by being introduced to criteria for evaluating questions. They suggest having students prepare questions in advance to avoid low quality, last minute questions. Requiring online submissions by a deadline would encourage advance preparation of questions.

Understanding our students' experience in reading textbooks can improve instruction. Attention to the reading level of materials, teaching effective reading strategies, and holding students accountable for completing readings can improve student compliance with reading assignments and may improve their comprehension of what they read.

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Nora Virus Transmission in *Drosophila melanogaster*: An Investigation to Teach Viral Infection and Prophylaxis to Biology Students

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Abstract: Proper hand hygiene accompanied with environmental surface disinfection provides a comprehensive approach to control and prevent respiratory and gastrointestinal illness in schools, hospitals, work environments, and the home. The persistent non-pathogenic Nora virus common in *Drosophila melanogaster* provides a horizontally transmitted virus that students can research and design an experiment testing prophylaxis techniques for viral infection and pathogenic diseases. Students use inquiry-based methods to perform an experiment, analyze data, and draw conclusions on viral inactivation from disinfectant use on Nora virus in *D. melanogaster*.

Key words: viral infection, prophylaxis, transmission, *Drosophila*, disinfection, Nora virus

INTRODUCTION

Inquiry based investigations are necessary to stimulate learning, understanding, and excitement of the scientific process in laboratory based courses. To engage students, selecting topics that are current and relevant is essential. One topic that is seemingly timeless and relevant to the student of any age is missing work or school due to preventable illness. Absenteeism from school and work associated with respiratory and gastrointestinal illness is costly and imposes a burden on education and family financial resources. Respiratory and gastrointestinal illness results from direct or indirect contact transmission of pathogenic viruses, bacteria, and fungi. Examples of these infectious respiratory viruses are respiratory syncytial virus (RSV), rhinovirus, and influenza, including the much-publicized H1N1 strain, avian, and swine influenzas (Goldmann, 2000; Centers for Disease Control and Prevention [CDC], 2012a). Viruses causing gastroenteritis include norovirus, rotavirus, and adenovirus, with norovirus and rotavirus comprising the majority of United States infections responsible for up to 70,000 hospitalizations each year (CDC, 2012b; CDC, 2012c).

Hand hygiene in the form of hand washing with soap and water or hand rubbing with hand sanitizer is a well-documented prophylaxis for limiting indirect contact transmission of bacterial and viral infections, including both respiratory and gastrointestinal infections (Curtis & Cairncross, 2003; Rabie & Curtis, 2006; Sandora et al., 2008). One study found that 37.8% of rhinovirus remained viable after 1 hour on contaminated finger pads, and almost 16% after 3 hours (Ansari et al., 1991). Rabie & Curtis (2006) found that hand washing reduces respiratory infection

by 16%, and Ryan et al. (2001) reported a 45% reduction in respiratory illness in outpatient visits as a result of proper hand washing implementation. Furthermore, the risk of diarrheal disease is reduced by almost 50% by washing hands with soap and water (Curtis & Cairncross, 2003).

A less publicized way to control infection is fomite disinfection, as environmental surfaces become contaminated with pathogens by contact with nasopharyngeal secretions and contaminated hands. Fomites are inanimate objects, such as toilet seats or toys that can become contaminated. Rotavirus dried from fecal suspension remains viable for several days on fomites, and is readily transferrable from inanimate surfaces to hands and hands to surfaces (Ansari et al., 1988; Sattar et al., 1994). Rhinovirus and RSV are transmissible from contaminated environmental surfaces between multiple people (Gwaltney & Hendley, 1982; Sattar et al., 1993). In light of this, measures taken in preventing and controlling the spread of respiratory and gastrointestinal illness should include both proper hand hygiene and disinfection of environmental surfaces.

Using the topic of preventable viral disease, this inquiry-based investigation introduces biology classrooms to virology, molecular genetics, and the importance of hand hygiene and surface disinfection in the control and prevention of pathological disease. The students investigate pathogens, pathogen transmission, disinfectants and disinfection methods, and modern genetic laboratory techniques. The research question that the students are being asked to investigate is “What types of surface decontaminants are effective in preventing viral transmission and spread?” To test this question, we describe a novel

laboratory investigation using *Drosophila melanogaster* infected with non-pathogenic Nora virus. Nora virus is a picorna-like virus, which is seemingly endemic in both natural and laboratory populations (Habayeb et al., 2006). Because most laboratory and wild-caught stocks, as well as some commercially available stocks, are infected with Nora virus, any *D. melanogaster* stock can be tested for Nora virus infection utilizing the RT-PCR methodology outlined in this experiment. In addition, once stocks have been identified as Nora virus positive, they can be maintained indefinitely in the laboratory by transferring the stocks on a regular basis. These features negate the need for a collaborator with an infected stock to carry out experiments. *D. melanogaster* infected with Nora virus is ideal for student use because the virus is nonpathogenic to humans and *D. melanogaster* is a well-established laboratory model. To begin the inquiry process, the students first conduct a literature review to learn virus characteristics, pathogen transmission, viral disinfection, and disease control and prevention. They determine the surface decontaminant they want to test, and develop hypotheses on the efficacy of the experimental versus control surface decontaminant. The students design and perform the experiment, which includes handling Nora virus infected *D. melanogaster*, decontamination with the surface decontaminant they have selected, RNA extraction, RT-PCR for presence or reduction of Nora virus, quantitation of results, and data analysis including statistical analysis. They critically analyze their results and present them in the

structure of a peer-reviewed journal article or constructed as a conference poster to be displayed in the school to promote hand hygiene and surface disinfection in the prevention and control of respiratory and gastrointestinal diseases. Once infected fly stocks are on hand, the experiment can be conducted in a relatively short timeframe, requiring approximately 3 weeks to achieve results. Furthermore, non-infected fly stocks could be used to demonstrate the absence of Nora virus infection as an additional control, but were not used in this study.

MATERIALS & METHODS

Drosophila melanogaster rearing and culture

Nora virus (NV) infected flies (a gift from Dr. Dan Hultmark, Umeå, Sweden) were reared in 8 oz plastic bottles (Fisher Scientific, catalog #AS-117) at 25°C with diurnal light on standard molasses, torula yeast, and cornmeal media. For the experiment, the bottom of the bottles were cut off, filled with media, allowed to set, bottoms taped to the tops, and plugged with BuzzPlugs (Fisher, catalog #AS-277). In each of six bottles for the parental (P) generation, 50 NV infected males and 50 NV infected females were added. Bottles 1-3 served as the control group with either no rinsing (P flies) or eggs rinsed with *Drosophila* Ringer's solution (3mM CaCl₂•2H₂O; 182mM KCl; 46mM NaCl; 10mM Tris base; and pH adjusted to 7.2 with 1N HCl) and bottles 4-6 served as the experimental group that would later be rinsed with household bleach. The flies mated for 96 hours, with eggs removed after 24 hours for sampling and washing (Figure 1). Twenty eggs from bottles 1-3 were collected, briefly rinsed in *Drosophila* Ringer's

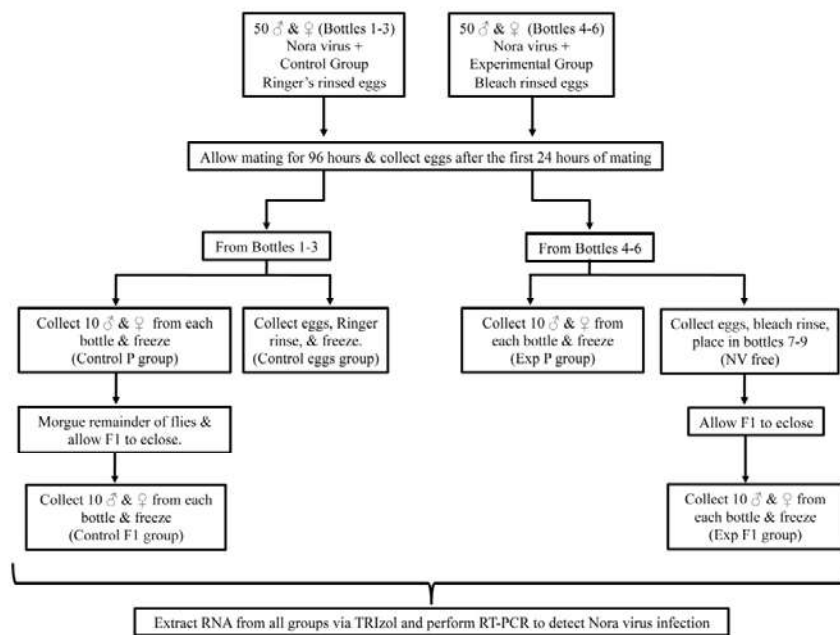


Fig. 1. Flow chart demonstrating the experiment set-up. The Ringer's wash serves as the control group, whereas the bleach wash serves as the experimental group. All groups collected including Control eggs, Control P, Control F1, Experimental (Exp) P, and Exp F1, had the RNA extracted by TRIzol and used for RT-PCR analysis.

solution in a cell strainer (Fisher, catalog #08-771-2), transferred to separate 1.5 mL sterile microcentrifuge tubes (Fisher, catalog #02-681-5) with *Drosophila* Ringer's solution, and frozen for RNA extraction. This procedure was repeated with the experimental bottles, except 15 eggs from bottles 4-6 were *briefly* rinsed, but not dechorionated, in a 10% sodium hypochlorite solution (household bleach) and placed on clean food in 3 new bottles (7-9), becoming the experimental NV free egg populations. At the end of the 96-hour mating period, 10 males and 10 females from Bottles 1-6 were placed in a separate 1.5 mL sterile microcentrifuge tubes and frozen for RNA extraction. These flies represented the control (1-3) or experimental (4-6) P groups. The remaining eggs in bottles 1-3 were allowed to emerge as adults and represented the control F1 flies. Ten adult males and ten adult females were collected from each control F1 flies bottle (1-3) after emergence and frozen for RNA extraction. A flowchart depicting the experiment setup is provided (Figure 1). The F1 experimental flies are explained in the next section.

D. melanogaster egg washing with bleach

The adult flies in the 3 experimental P bottles (4-6) were anesthetized using FlyNap (Carolina Biological Supply, catalog #173010). The tape was removed from the bottles, the bottom of the bottle placed on the stage of a dissecting microscope, and tweezers used to collect eggs from the surface of the media. A total of 15 eggs from each bottle were collected and placed in a cell strainer in a Petri dish containing *Drosophila* Ringer's solution. The eggs were washed 3 times. The first wash was with household bleach diluted with distilled water to a 10% bleach solution, lasting approximately 10 seconds. This wash is not long enough to remove the chorion of the egg, but long enough to penetrate the pits in the chorion where the virus may reside. The second and third washes were with fresh *Drosophila* Ringer's solution, lasting approximately 10 seconds each, to remove residual bleach. The washed eggs were placed on the surface of the clean food bottles (7-9) with tweezers and the tops of the bottles were taped back on. The washed egg bottles (7-9) were referred to as the experimental F1 flies. They were allowed to mature to adulthood and frozen for RNA extraction. The experiment setup is once again depicted in Figure 1.

RNA extraction and RT-PCR

P generation flies (bottles 1-6), control (bottles 1-3) rinsed with *Drosophila* Ringer's, control F1 flies (bottles 1-3), and experimental F1 flies (bottles 7-9), were frozen for RNA extraction and tested for the presence of Nora virus. RNA extraction was performed using TRIzol[®] per manufacturer's instructions (Invitrogen, catalog #15596-026) and concentration determined using the Nanodrop spectrophotometer. One hundred nanograms of RNA from each sample collected was analyzed for the

presence of Nora virus via RT-PCR using Nora virus specific primers ordered from Invitrogen (Forward 5'-TGGTAGTACGCAGGTTGTGGGAAA-3'; Reverse 5'-AAGTGGCATGCTTGGCTTCTCAAC-3') and a Promega Access Quick RT-PCR kit (catalog #A1250) according to manufacturer's instructions. Reactions were carried out under the following conditions: 45°C for 45 min, 94°C for 2 min, (94°C for 30 s, 55°C for 30 s, 68°C for 1 min)_{30 cycles}, 68°C for 10 min, and hold at 4°C. Five microliters of the RT-PCR products were mixed with 3 ul of 6X loading dye (Promega, catalog #G1881) and electrophoresed on a 0.8% agarose gel at 50V for 2 hours. A positive reaction yielded a product at approximately 800 bp. The relative density of the bands was quantitated by using the free program, ImageJ (<http://rsb.info.nih.gov/ij/index.html>; Abramoff et al., 2004). The results were tested for significance using a two-tailed Students *t*-test with unequal variance and $\alpha=0.05$.

RESULTS

All samples collected were tested for the presence or absence of Nora virus infection. The control (bottles 1-3) and experimental (bottles 4-6) P generation produced a positive reaction for Nora virus with a product at approximately 800 bp (Figure 2; Lanes 4-9). In addition, the control eggs removed from bottles 1-3 that were washed only in *Drosophila* Ringer's solution also tested positive for Nora virus (Figure 2; Lanes 10-12), as did the control F1 flies (Figure 2; Lanes 13-15). The intensity of the Nora virus product appeared less in the control eggs and F1 compared to the Control P flies (Figure 2; Lanes 7-12 versus Lanes 4-6), but upon statistical analysis, there is no statistical significance (Figure 3). The only statistically significant change in Nora virus expression was in the experimental F1 flies that were washed for 10 seconds in 10% bleach. These flies did not produce an 800 bp product (Figure 2; Lanes 16-18) and were found to be significantly reduced compared to all other samples tested (Figure 3).

DISCUSSION

The hypothesis for the study presented was if Nora virus is transmitted on the surface of the *D. melanogaster* eggs, it can be removed by a surface decontamination solution, such as 10% bleach, but not by a control solution (*Drosophila* Ringer's). Based on our results, it appears that washing *D. melanogaster* eggs in 10% bleach successfully disinfects the eggs, inactivating or removing Nora virus from the chorion, and eliminating viral infection in the resulting adults (Figures 2 & 3). Our procedure appears to be a successful treatment to eliminate Nora virus infection in *D. melanogaster* populations. Furthermore, these results support that Nora virus is horizontally transferred and the result of fecal-oral transmission from contaminated food

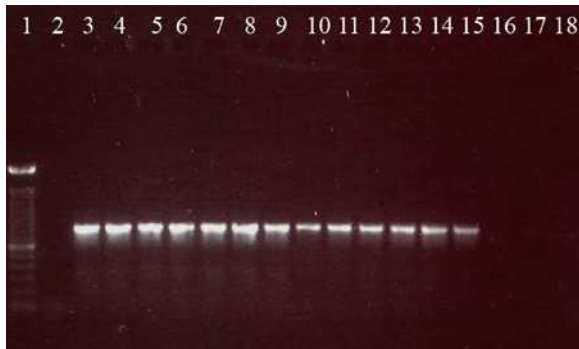


Fig. 2. Confirmation of efficacy of rinsing with 10% bleach on transmission of Nora virus via RT-PCR. Lane 1 = 100 bp Ladder; Lane 2 = Negative (water) control; Lane 3 = Positive (Nora virus RNA) control; Lane 4-6 = Control P; Lanes 7-9 = Experimental P; Lanes 10-12 = Control eggs; Lanes 13-15 = Control F1; Lanes 16-18 = Experimental F1. The product seen in Lanes 3-15 is approximately 800 bp, which is the expected size for the Nora virus product.

(Habayeb et al., 2009). This was deduced due to the fact that eggs rinsed in bleach gave rise to F1 progeny that did not test positive for Nora virus. If vertical transmission was demonstrated, the F1 progeny would have tested positive for Nora virus because the virus would have been transmitted from mother to offspring inside the egg, not on its surface. Interestingly, the control eggs tested positive for Nora virus after washing with *Drosophila* Ringer's solution, suggesting while the flies are laying eggs they are also shedding virus. This would provide an efficient way to transmit the virus to newly hatched larva as they would likely start eating the contaminated food in close proximity to where their egg was laid. Also, the intensity of the *Drosophila* Ringer's washed control eggs and adult control F1 flies Nora virus product appears to be less than that of the P flies (Figure 2, Lanes 10-15 versus Lanes 1-6), even though there is no significant difference when quantitated (Figure 3). This suggests that

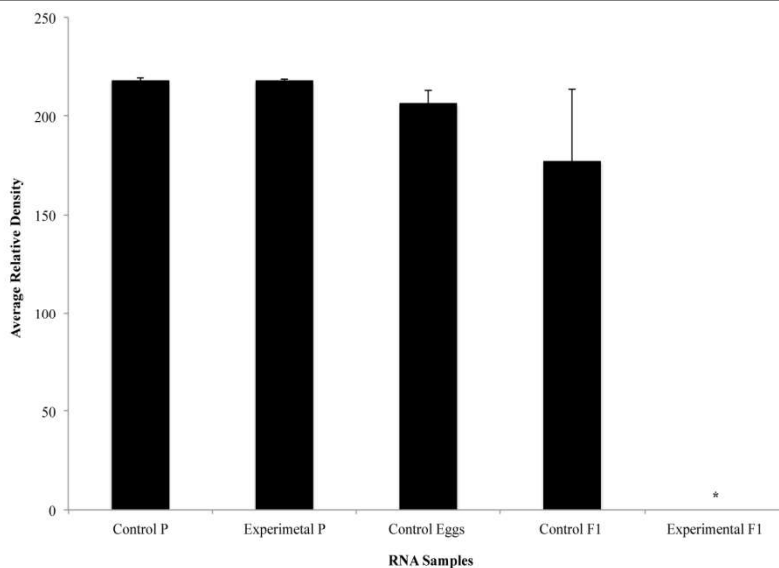


Fig. 3. Average relative density of the Nora virus RT-PCR products as analyzed by the ImageJ software. Nora virus infection was significantly diminished when infected eggs were briefly washed with 10% bleach and allowed to mature (Experimental F1) as compared to all other groups tested ($p \leq 0.05$; this comparison is represented by *). $n = 3$ for each sample, error bars are standard deviation, and the test statistic used was a two-way Student's t-test for unequal variances with $\alpha = 0.05$.

washing the eggs with *Drosophila* Ringer's may reduce viral titer levels, but does not inactivate or eliminate viral infection. These results correlate with research suggesting that water alone is not sufficient for proper hand hygiene or a reduction in viral infectivity (Sattar et al., 1994). The fact that the *Drosophila* Ringer's washed eggs contain enough virus to register a positive product using RT-PCR and the viral infection in the resultant adults should demonstrate to the students the concept of viral infection and the small amount of virus needed to induce infection. This extreme infectivity should also reinforce the idea that proper hand washing is necessary to prevent viral infections.

The results of the experimental F1 generation demonstrate that a 10% bleach solution is an effective disinfectant for Nora virus (Figures 2 & 3). Inhibiting Nora virus infection was as simple as rinsing the egg surfaces with disinfectant. Students should easily correlate this to the importance of disinfecting environmental surfaces to reduce pathogen spread.

This experiment could be modified to include washing *D. melanogaster* eggs with different disinfectant solutions, in different concentrations, and utilizing various exposure times to gauge the efficacy of different products and procedures. Students could be given different disinfectants, for example ethanol, citric acid, ammonia, or phenol based commercial products, and predicated on literature review, propose and test hypotheses for expected efficacy with regard to disinfectant type, exposure time and virus characteristics. Furthermore, there are many other persistent non-human pathogenic *D. melanogaster* viruses that could be tested. In addition to Nora virus, persistent viruses found in natural, laboratory, and commercial fruit fly populations include Sigma virus, and *Drosophila* viruses A, C, P and X, each with their own genome structure, family and transmission mode. This modification would provide

students with additional exposure to viral infection, possible virulence, and viral characteristics, which could tie into educational units on infectious disease, genetics and molecular biotechnology.

The described experiment exposes students to concepts of disease agents, disease transmission, prophylaxis measures, and molecular genetics. It could also be used to introduce students to the use of *D. melanogaster* as a model organism. Furthermore, based on their research, students could develop, promote, and implement plans to help reduce the spread of respiratory and gastrointestinal illness in their school through proper hand hygiene and environmental surface disinfection. This experiment provides students a practical investigative opportunity to apply the scientific method, reinforcing concepts introduced in lecture, and providing an opportunity for scientific research, which could ignite a spark of interest in scientific investigation unknown to them previously.

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New Methods for an Undergraduate Journal Club

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Abstract: Journal clubs have been used to advance students' scientific skills beyond basic knowledge and comprehension, but students often view the traditional format of analyzing reported data and experimental design as laborious and intimidating. As such, the traditional approach can diminish student engagement and enthusiasm for the value of scientific research and literature. In order to overcome this hurdle, we developed a novel journal club format that engages students in discussions of research literature while fostering attitudes of excitement and enthusiasm towards science. The semester begins with a broad discussion of a provocative, mysterious or even controversial central topic. During the course of the semester, students develop a research model about the topic utilizing a wide range of reference materials. Each session consists of developing, evaluating and refining hypotheses, engaging in group discussions, and determining potential directions of investigation. Herein we present (a) the details of this format including an example topic, (b) a discussion of student feedback and (c) observations following the conclusion of the inaugural undergraduate journal club.

Key words: Critical thinking; literature; science education; teaching methods; undergraduate Learning

INTRODUCTION

A review of pedagogical literature over the past decade reveals an abundance of novel classroom and laboratory methods focused on critical thinking (Allen & Tanner, 2003; Breakwell, 2003; Brown, 2010; Chaplin, 2003; Choe & Drennan, 2000; Kolkhorst et al., 2001). The fundamental aspects of critical thinking include the ability to extract key information from literature, debate the evidence, and independently design protocols (Bailin, 2001; Crowe, Dirks, & Wenderoth, 2008). The integration of research literature into classroom activities has been shown as an effective strategy for the development of critical thinking across multiple science disciplines (Breakwell, 2003; Brickman, 2012; Chisman, 1997; Choe & Drennan, 2000; Hoskins et al., 2007; Janick-Buckner, 1997; Krontiris-Litowitz, 2013; Muench, 1999). However, a common concern is that research literature's advanced language may confuse or frustrate novice students and ultimately prevent them from appreciating the applicability beyond traditional textbooks. To address these concerns, science educators often attempt to relate scientific information to real-world situations by utilizing various media sources familiar to a wide-range of students (Brickman, 2012; Brown, 2010; Krontiris-Litowitz, 2013). Some truly novel methods introduce research literature in a particular sequence in order to illustrate the inception and evolution of the scientific process (Hoskins et al., 2007).

Recognizing the potential for research-based literature to help our students improve their critical thinking skills, we decided to develop an undergraduate journal club. However, we wanted to take a unique approach with the objective of creating

a relaxed atmosphere that would stimulate scientific curiosity and wonder outside of the academic curriculum. Our objective was to appeal to our student's imagination and curiosity thus intriguing them to explore science beyond the conventional context. Once this was accomplished we could help them develop their critical thinking skills in a way that was not viewed as laborious or intimidating.

METHODS

The following journal club format was implemented at Lincoln Memorial University, a rural four year university in Tennessee, during a sixteen week fall semester. Meetings officially started in October and ended in December holding a total of five sessions. This journal club was extracurricular and no academic credit was offered or rewarded. Participation was open to all enrolled undergraduates from any academic discipline. Email solicitations and fliers providing an overview of the club, scheduled meeting times, and contact information were used to recruit participants. The club met for approximately one hour over the course of three months for a total of five meetings. Prior to the first meeting, a consent to participate form detailing the objective of the study, methods of assessment, and assurance of privacy for collecting and reporting data were given to all students. Students who declined to consent were allowed to attend and participate in the meetings with the understanding that no data would be collected or reported from that student.

Journal Club Format

The overall format for the journal club consists of (a) generating interest through a discussion about a provocative topic, (b) developing questions and

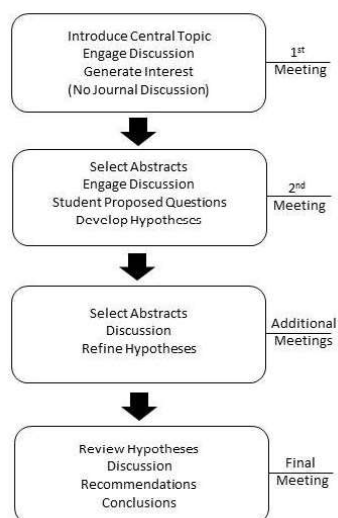


Fig. 1. Review of the journal club format summarizing the activities at each successive meeting.

hypotheses utilizing instructor selected abstracts, (c) further evaluating and refining hypotheses based on student selected abstracts and (d) making a conclusion about the hypotheses and model based on the body of information collected during the semester (Figure 1). In order to illustrate the methodology and format of this approach, the specific topic covered during our inaugural semester is discussed.

The first meeting began with students completing the journal club expectations questionnaire followed by a discussion about unexplained experiences. Students next watched “DMT: The Spirit Molecule”(Schultz, 2010) a documentary on N,N-dimethyltryptamine (DMT) followed with a discussion on the visual experiences reported in the documentary. The study of psychedelic compounds is unique as they often combine established biochemical findings that are challenged by spiritual interpretations from users. Following the documentary, the instructor revealed that the objective of the semester long journal club was to take a scientific approach to investigate claims

advanced in the documentary. Specifically, the club was tasked with developing a scientific model by which to investigate the presence of a spiritual or alternate realm of existence accessible by DMT. The group then composed a list of key terms from the documentary and used them to define the journal club topic as well as propose questions that would be used to direct the semester’s investigative path. At the meeting’s conclusion, the instructor introduced popplet.com, a website developed by Notion Inc.®, which allows users to map and organize information based on conceptual relationships.

Prior to the second meeting, the instructor selected a series of research abstracts related to the terminology list generated during the previous meeting and posted these on Popplet.com illustrating their possible relationships to the central topic. The group then discussed these abstracts at the second meeting, developing a series of working hypotheses. Based on the presented abstracts, the group selected one article to analyze in depth at the beginning of the next (third) meeting. In addition, each student was instructed to continue finding abstracts that would contribute to the ongoing discussion and potentially narrow the investigative focus.

At the beginning of the third meeting, students discussed the article in its entirety selected from the previous meeting. The discussion included analysis of the author(s) hypotheses, methods design and results. The investigation continued as students presented additional abstracts and defended how their findings contributed to the discussion and the developing series of hypotheses. Following the student presentations, the group discussed how the new information impacted the current hypotheses. The group decided which resources failed to contribute to, or misdirected, the investigative path. The group utilized the accepted resources to assess, update and add (if necessary) hypotheses to the working list. This format was repeated for the fourth meeting.

The final meeting consisted reviewing the

Table 1. Questionnaire results from the student expectation survey.

<p>“I expect Journal Club to be a forum for topics outside the normal science topics discussed. I would like to see topics that can be studied in animals instead of focusing solely on humans. I would like to further develop my skills at reading and comprehending primary research and review articles quickly and accurately. “</p> <p>“Have a wonderful time about learning new scientific concepts. Mainly help prepare and improve for other research in the near future. Discussion of research I believe is one of the best ways to become more knowledgeable. This club should expand the ideas of researching and the best approach. “</p> <p>“My expectations for a journal club are that the participants should be ready to discuss the articles in an open manner. Openness is a must. Most likely, any topic should be fair game. Skills that should developed are researching skills, relational skills, and also improvements in critical thinking.”</p> <p>“Relaxed atmosphere; interested topic; refined researching skills. Should have variety of students involved with wide-range topics and have 1 to 2 meetings every month on a specified day(s) to let students schedule appropriately. “</p> <p>“I expect journal club to provide skills in researching topics and discussing articles to their importance. When reading an article, I want to be able to distinguish between information that is important to the articles topic and filler information that doesn’t pose any importance. I don’t want to get caught up in scientific jargon or concepts that misdirect my attention....no mainstream articles that lose attention easily.”</p> <p>“I expect that we will examine scholarly journal articles as well as individual accounts. I would like to look at clinical research”</p>

Table 2. Results of activities conducted during the first meeting of the undergraduate journal club.

Central Topic: Is there an alternative spiritual realm of existence?

Sub-topic: Do psychedelics, particularly DMT, allow access to this realm?

Key Terms

Ego, ego death, hallucinations, pineal gland, sensory processing, serotonin, tryptophan, visual cortex

Student Generated Questions

Are they referring to an afterlife?

Are drugs causing hallucinations or accessing “special” senses?

What exactly is ego death?

What is the neurobiology of ego?

Does inhibition of ego allow us to see an alternate or “true reality?”

Is ego development an evolutionary survival mechanism?

Is ego a form of visual filtering?

Does DMT inhibit visual filtering?

collective list of gathered resources, questions and hypotheses to determine if a general consensus could be reached. This discussion was facilitated by using the conceptual map generated during the semester on Popplet.com. The meeting concluded with the distribution and completion of an evaluation form prompting the students to discuss their experiences with the new journal club format.

RESULTS

The initial enrollment for the journal club was 6 students of junior and senior status primarily representing basic and health science majors. All 6 students consented to the collection of information and participation in the study. The responses to the initial expectation survey revealed that students expected to talk about research in a manner that was (a) concise and efficient, (b) open and relaxed and (c) beyond the realm of what was typically encountered in their courses (Table 1). Following the revelation of the central topic a list of terms was generated followed by a series of questions from the students based on any of the listed terms. A majority of the generated questions focused on ego and ego death from which hypotheses would be generated (Table 2). As a result of the terminology list, three abstracts were selected that the group discussed. Based on a summary of all three abstracts, students generated a

series of hypotheses and selected one article to analyze in its entirety (Table 3). Subsequent meetings resulted in student-selected abstracts, a complete article and resources that were used to evaluate, delete, modify, and add additional hypotheses. During the final meeting, the group determined that they were unable to arrive at a satisfactory research model because the resources deviated from the initial findings and were ultimately inconclusive and contradictory. The results of the exit questionnaire were overwhelmingly positive and expressed a general appreciation for the unique topic, group discussions and relaxed environment (Table 4).

DISCUSSION

Our objective was to develop research skills and foster attitudes of excitement and enthusiasm for science. The response from student participants was overwhelmingly positive with an appreciation for the uniqueness of the subject matter, group discussions, and relaxed environment. Since our intention was to frame all discussions in a scientific narrative, we had some trepidation about the efficacy of working with an unconventional topic. Initially we were unsure of how the students would respond and once the topic of spiritual or alternate existence was revealed the initial reaction could best be described as confusion and bewilderment. However, once the group started

Table 3. Sample of the activities conducted during the second meeting of the undergraduate journal club.

Central Topic: Is there an alternative spiritual realm of existence?

Sub-topic: Do psychedelics, particularly DMT, allow access to this realm?

SELECTED ABSTRACTS

ANQUIANO-RODRIQUEZ ET AL., 2007

REUS AND KIEFER, 1989.

*MCDANNALD AND SCHOENBAUM, 2009.

Student Generated Hypotheses

DMT induced visual experiences result from inhibition of ego.

There is decreased serotonin receptor expression in visual cortex during development, allowing development of ego.

DMT increases and stimulates serotonin receptors in the visual cortex.

Egocentric navigation may serve as a model for ego development.

*Indicates article selected for complete review

Table 4. Selected questionnaire results from the exit survey.

“My expectations for journal club were met because I found out more about a very interesting topic. I realize the objective of the club this semester was to develop a scientific model to test for the existence of a spiritual realm and we did not achieve this; however, I feel that we eliminated some potential paths of research because they led nowhere. We made progress by eliminating options.”

“The journal club enlisted interesting topics that taught how to look up articles on a topic that might not have significant number of published works. The club also helped teach through experience how to dissect an article into helpful bits of information. Journal club supplied an entertaining way to practice science.”

“My expectations for journal club were exceeded. I have found the principles taught and utilized in journal club very helpful when reading abstracts for classes’ research papers. Before, I would try to muddle through the whole paper. [The instructor] has demonstrated a better, more efficient way to cull through a lot of abstracts in a short amount of time so that less time is wasted on reading material that I’m not going to end up using.”

“This club is new, and we have had more and more students attend throughout the school semester. I am pleased that it’s progressing. I like going through abstracts instead of reading entire articles. If we read the entire article, we wouldn’t have gotten far in the club at all investigating the role of DM T. I did not think the popplet site was helpful to us. But, I thought it was cool that we reached a point in the club that was a dead end for DMT. It shows us how real research is and how to adapt and change gears.”

“They were quite successful. The only thing that I wish we had more of is time or in some cases just an idea on what exactly we want to find. I love the research aspect and wish I knew better was of gathering information. I think that having others finding topics on the subject and then everyone discussing the importance of the information towards the study was a great learning experience.”

utilizing scientific resources (e.g., research abstracts) as a lens by which to view the topic, the atmosphere relaxed and dialogue quickly ensued. Ultimately the students were receptive to this approach as evidenced by their positive evaluations of the experience.

The deliberate focus on abstracts was an important feature of this journal club format. This approach allowed students to rapidly locate and identify information relevant to the topic while permitting a wider variety of topics to be discussed when compared to the traditional journal club format. Responses on the exit survey indicated that students liked this tactic and perceived it as a valuable way to collect information as well as an efficient use of their time. We did stress to students the limitations of relying on abstracts. Thus, over the course of four meetings, excluding the final fifth meeting, students reviewed two complete journal articles to allow more in depth analysis of experimental design and results.

Developing a specific research model from the gathered resources proved to be a difficult task given the limited meeting time. Moreover, some students expressed frustration when attempting to incorporate subsequent findings into the developing model. At times, some students declared that they believed the investigative process had reached a dead end. As an instructor, there was great temptation to assist with the research. For example, subjects of illusory perceptions may have provided a more direct approach. However, it was critical to allow students to guide their own investigation. Surprisingly, the failure to reach a consensus at the semester’s end was viewed by the students as a positive experience, coming to the realization that this can (and does) happen in “real world” research. The use of popplet.com, an interactive conceptual mapping program, was implemented as a means for students to visualize how all selected material and information links with the main topic. Despite this objective,

students found the site difficult to navigate and were hesitant to engage the website. Future sessions should include a detailed tutorial on using such interactive web sites.

We conclude that this unique journal club approach can produce an appealing and exciting atmosphere that may help students develop their critical thinking skills. The unique format allows students, instead of the instructor, to direct the path of investigation regardless of where that path may lead. The format presented is not restricted to the sciences and can easily be modified for any discipline. Ultimately this approach can be used with novice or advanced students to engage their interests through the use of research-based resources.

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ACUBE 57TH MEETING ABSTRACT SUPPLEMENT

Association of College and University Educators 57th Annual Meeting

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KEYNOTE ADDRESS

Interactive Lectures: Concepts and Competencies

Dee Silverthorn, *University of Texas*

Calls for reform to science education have been issued for decades with little response from the university community until recently. Now, with publication of the *Vision and Change* report and increasing use of technology for webcasting, podcasting, and lecture capture, instructors are beginning to re-examine how they teach. Can massive open online courses (MOOCs) replace warm bodies in the classroom? How do we convince the tech-savvy Millennials in our courses that coming to class is going to benefit them? In this talk we will examine several strategies for creating interactive lectures that focus on key concepts in biology and that also teach non-content competencies such as teamwork and the ability to recognize gaps in understanding.



TALKS, WORKSHOPS, AND ROUND-TABLE DISCUSSIONS

Captivating the Attention of Cell Biology Students

Anjali Gray, *Lourdes University*

In addition to the required textbook for a cell biology course, a recent bestseller was used to show students the importance and application of cell biology in real life.

Exploring Relationships Between Students' Conceptions of the Nature of Science, Evolution, and Global Climate Change

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

It is overwhelmingly acknowledged by the scientific community that evolution and global climate change (GCC) are undeniably supported by physical evidence. And yet, both topics remain politically contentious in the United States. Students' conceptions of the nature of science (NOS) may be key

factors in determining attitudes towards evolution and GCC. With this hypothesis in mind, we asked: Do changes in NOS understanding correlate with changes in attitudes towards evolution or GCC? Are correlations similar for evolution and GCC? What demographic factors influence these correlations? Are other factors from the literature important? We administered surveys to a large sample of students in a mixed-majors biology course at a medium-sized, private university in the northeastern US.

Students were surveyed both at the beginning and end of the course. The surveys included previously validated tools to measure acceptance of evolution and NOS conceptions, questions on GCC opinions from national polls, and items related to demographic factors thought to influence acceptance of evolution or GCC. Correlation tests and ANOVA/ANCOVA were used to look for significant relationships and interaction effects in the data. The data support the hypothesis that NOS conceptions correlate with positive attitudes towards evolution and GCC.

Undergraduate Ratings of Instructional Behaviors Informs Graduate Teaching Assistant Professional Development

Katharina Kendall, *University of Tennessee*, Matthew Niemiller, *Yale University*, Dylan Dittrich-Reed, *University of Tennessee*, Elisabeth Schussler, *University of Tennessee*

Introductory biology courses rely heavily on graduate teaching assistant (GTA) instruction in sub-sections (laboratories and discussions) associated with large lecture sections. These introductory courses are important gateway courses for student retention, attitude, and learning in the sciences, and the

instruction undergraduates receive from GTAs can impact all of these aspects. Therefore, this study explored instructional behaviors of GTAs teaching introductory biology laboratory sections to determine which behaviors are most important for teaching effectiveness. In Spring 2012, 1159 undergraduates in freshman-level biology courses rated their GTA on 21 instructional behaviors previously identified as important for student learning, the GTA's teaching effectiveness, the amount the student learned, and expected grade in the laboratory course. Using linear mixed models we found that instructional behaviors related to teaching techniques and interpersonal rapport best predict teaching effectiveness of GTAs, from the undergraduate perspective, suggesting these aspects should be the focus of professional development.

Improving Learning Outcomes from Introductory Courses through Semester-long Community Involvement Projects

Barbara Hass-Jacobus and Luke Jacobus, *Indiana University-Purdue University Columbus*

Teaching and applying knowledge utilizes more integrative thinking than memorization. Community involvement projects that require students to apply classroom knowledge in the real world can improve achievement of course objectives and program-level learning outcomes. We will discuss specific semester-long service learning projects in particular, and methods for assessing long-term learning.

Teaching Sensors and Automation to Enhance the Biology Lab Experience

Matthew Kropf, Nicolette Fruehan, and Danielle Erdley, *University of Pittsburgh*

New electronics technologies have enabled sophisticated digital measurement and control automation in biological science. With pervasive growth in open-sourced hardware and software platforms such as Arduino microprocessors, Processing programming language, and Raspberry PI computers, implementing custom automated measurements and control has become an inexpensive and straightforward option for the college laboratory. These technologies have eliminated the need of specialized equipment in order to achieve high accuracy control and measurements in biology experiments. A multi-disciplinary approach to learning integrates engineering technologies with biological education. This results in students with confidence and abilities in the application of supporting technologies. Furthermore, teaching the basic skills involved with open source

hardware programming provide students with a greater ability to apply these technologies to field biology, sustainability projects, and their careers. This presentation will review the curriculum, teaching method, and technology tools implemented in a multi-disciplinary course on Sensors and Automation.

A Case Study: Biology Research as a Capstone Experience

Stephen Daggett, *Avila University*

Since 1996, the Department of Biology at Avila University has required undergraduates to complete a minimum two semester research project as part of their senior capstone experience. The course has undergone several modifications since that time. Avila is primarily a teaching institution where twelve contact hours a semester is the minimum required teaching load for faculty. This presents several challenges, including time blocks to work in the laboratory and field, faculty compensation, and student motivation to devote 10-12 hours a week on average for a one-credit hour experience. This presentation will look at the evolution of the course, solutions to previous challenges, and concerns about the future.

Introducing Drawing Into a Powerpoint Lecture-Based Microbiology Course

Laurieann Klockow, *Marquette University*

Students introduced to microbiology often have trouble visualizing complex processes such as the host immune response and genetic drift/shift in the context of viral evolution. Furthermore, actively engaging students in a large lecture course (250+ students) without a team of teaching assistants is a daunting task for the new professor. To address these concerns, I introduced drawing into my Powerpoint lectures in two microbiology courses that I teach. The first course, BISC 3115, is a three credit introductory microbiology course for undergraduates. The student population consists of ~50% sophomore nursing students and ~50% junior/senior biomedical science majors. The second course, BISC 7410, is a four credit basic microbiology course taught to first year dental students and physician assistant students. I provided students with bare bones Powerpoint point lectures slides prior to lecture. During lecture I used a tablet PC to draw out structures and pathways to flesh out the Powerpoint slides. Students then copied these drawings into their notes rather than passively viewing Powerpoint images. I assessed the impact of using the tablet PC in the classroom by asking the students in the professional-level course, BISC 7410, to voluntarily complete an online survey. I also analyzed comments from students on end-of-semester evaluations in the undergraduate course, BISC 3115, to gather qualitative data. The survey consisted of five questions based on a Likert scale to assess the impact of drawing on student learning,

retention, and engagement. 70% of the respondents thought that the use of the tablet PC in lecture enhanced their learning of microbiology quite a bit or a lot. I will discuss how I incorporated drawing into my Powerpoint lectures, the benefits of this activity to the professor and students, sources of good examples of drawings, and student impressions of this teaching strategy.

Teaching Evolution

Kristin Jenkins, *University of Wisconsin-Madison*

Evolution is one of the Five Big Ideas in biology as identified in the Vision and Change report but it is also a challenging topic to teach. Not only are many important aspects of evolution cognitively difficult for students to grasp, but a plethora of misconceptions have been identified around key evolutionary concepts. On top of this, creationists have made evolution a social issue which can cause tension in the classroom for many students. This session will focus on identifying some key misconceptions and approaches to address them, as well as sharing a variety of freely available, high quality resources for teaching evolution at a variety of levels from Understanding Evolution, HHMI's Biointeractive and other groups. Specifically, we will use tree thinking as a valuable way to understand common ancestry and explore the genotype to phenotype approach to help students build a complete picture of evolutionary processes. In addition, we will touch on ways to defuse classroom tension. Kristin Jenkins is the director of BioQUEST and the director of Future Faculty Programs at the University of Wisconsin, Madison. She works with the UW Crow Institute for the Study of Evolution to provide quality evolution education resources to high school and college faculty.

Teaching Osmolarity, Tonicity, and IV Fluid

Dee Silverthorn, *University of Texas Austin*

Understanding osmolarity and tonicity is essential for health professionals faced with decisions about administering appropriate IV solutions. Student confusion is compounded by erroneous or misleading information that is widely disseminated on the web, in introductory biology textbooks, and even in continuing education material for nurses. In this workshop we will review the two concepts and show how they can be taught to students using clinical scenarios. Some of the problems we will discuss require students to use quantitative skills and apply the principle of mass balance. Other problems, though seemingly simpler, require conceptual understanding to answer correctly.

The Challenges of Career Advising for Biomedical Students

Khadijah Makky, *Marquette University*

Science students who are planning to attend professional schools (Medical, Dental schools) after

graduation are well served in Biomedical Sciences or Biology departments. The requirements are clear, the curriculum is planned and they are provided with a plethora of informational sessions for competitive and successful applications. In contradistinction to these professional school bound students, there is a growing number of students who are looking for careers in *alternative* healthcare fields. Helping these students to set up a plan for after graduation is more challenging! Some of the difficulties include a lack of well---known career paths, difficulty in finding training opportunities and internships, and the novelty of some of these alternative health related specialties in general. What can be done to help these scholars navigate the current climate of healthcare related specialties? How can we help guide them in pursuing a career in genetic counseling for example, or how to become a healthcare administrator after graduation? What are the ways we can help them enter this job market as strong candidates?

Student Engagement Through the Use of Biological Fieldwork

Antonios Pappantoniou, *Housatonic Community College*

One measure of student engagement is the willingness of students to become involved in extracurricular activities. In a collaborative effort between Housatonic Community College and the Connecticut Audubon Society, an extracurricular summer fieldwork experience has been underway since summer 2010. This experience has a dual purpose: 1. Introduce a group of community college students to fieldwork and 2. Have students collect and analyze data from aquatic organisms. This presentation will discuss components of this research experience. Opportunities such as this offer students an experience collecting biological data with real world applications. Since summer 2010 a total of 11 students have volunteered for this program with 7 of these students going on to four-year institutions to major in biology. Three of these students have graduated with degrees in biology.

Tales of a First Year Department Chair

Paul Pickhardt, *Lakeland College*

For most tenure track biology professors at smaller or more teaching focused institutions their primary responsibilities are classroom and laboratory teaching. So what happens to that primary responsibility when they find themselves taking on the position of department or division chairperson? In this presentation, issues associated with teaching while taking on administrative tasks will be presented and reflected upon. Ideally, the presentation will stimulate discussion on how the author could improve upon areas of concern and aid future biological administrators if and when they take on the role of departmental chairperson.

Lab Activity: Sperm number decreases after vaginal ejaculation

Dianne M. Jedlicka, *Devry University, School of the Art Institute of Chicago*, Victoria Lu, *Columbia College Chicago*

For decades, Biology and Health instructors have told students that the majority of sperm are made nonviable by the rigorous acidic environment of the vagina. By modifying a population life table lab tabulation, we now have a good illustrative data collecting lab that can successfully show what happens to a sperm cohort (an ejaculate) along its journey. Included in this presentation will be the procedure for the lab, explanation of a one hundred di (dice) cohort, and what happens on each roll of the di. Data sheets and calculations are needed to complete this exercise and examples will be presented at this ACUBE meeting.

Assessment of a Cell Basis of Anatomy and Physiology Course on the Success of Nursing Students in Microbiology

Janet L. Cooper, *Rockhurst University*

Initial assessment work showed that in general, nursing students do not score as high as Biology majors in a Microbiology course. This is especially true when examining units related to cellular structure and metabolism. One potential reason for this poorer performance may be the lack of preparation in cellular biochemistry. To address this issue, the department redesigned the existing course series for nursing students to include a 1 credit course in the Cell Basis of Anatomy and Physiology, taken concurrently with the Anatomy and Physiology I course. This course included an introduction to topics in cellular biochemistry. The redesigned course structure did not add any additional hours to the nursing curriculum. To determine if this course helped nursing students perform better in subsequent courses, student performance was evaluated in Microbiology classes before and after the implementation of the Cell Basis course. Students were evaluated based on their performance in individual units and in their overall performance (final grade average) in the course. Nursing students overall did better in the course after the implementation of the Cell Basis course, based on their final grades in the course. When examining units in Microbiology, it was also found that nursing students did better in areas related to cellular structure and biochemistry following the implementation of the Cell Basis course. While only the unit on prokaryotic structure showed a statistical difference, better scores were observed in the areas of growth and metabolism.

Connecting Genetics, Nutrition and Cellular respiration: A Case study in MCADD

Kimberly Vogt, *Marian University*

Cellular respiration is one of the topics introductory students struggle with most frequently. Students are introduced to medium chain fatty acid oxidation disorder by ways of a newspaper article. By examining this genetic disorder, students begin to understand the steps involved in respiration and the consequences if these are steps do not proceed as usual. An additional component of this case study asks students to explore how key players in the health field balance costs and benefits of diagnostic tests.

How Often Do College Students Use YouTube Videos to Learn Biology and Chemistry Concepts?

Abour Cherif, *Devry University*, Margaret Martyn, *Harold Washington College*, Julia Siuda, *The Illinois Institute of Art*, Charles Cannon, *Columbia College Chicago*, Samar Ayes, *Harold Washington College*, Farahnaz Movahedzadeh, *Harold Washington College*

In this presentation we describe a study we conducted with 385 (144 + 241) students from two and four year colleges. We asked them to provide their own perspectives on how often they use YouTube videos in learning biology and chemistry at the undergraduate level, and how they see their usefulness in helping them understand learned topics. In this study we will share the results and discuss the implications of the findings on students, instructors, curriculum, and academic leaders. In short, being aware of how students themselves use and perceive the effectiveness of YouTube videos in learning the subject matter is a necessary first step. It can help instructors decide how to integrate YouTube videos into the curriculum when designing their courses, selecting learning materials, and selecting teaching strategies to achieve higher rates of success of the intended learning objectives and outcomes in their classes. The goal is to find workable pedagogical options that can lead to an increased rate of student success measured in terms of higher student satisfaction, and better academic performance and long term retention of their comprehension of learned concepts.

Galápagos Mystery: A Scientific Process Case Study

Conrad Toepfer, *Brescia University*

Participants of this workshop will have a chance to work through an extensive case study (over 100 pages of data and notes) used to illustrate the scientific process. I use the case study in 2-3 class periods after discussing the nature of science with freshmen biology majors. Students are given preliminary data showing a dramatic decline in marine iguana populations concurrent with a

population explosion in Galápagos finches. Students, working in groups, are required to develop reasonable hypotheses which may result in the receipt of data to interpret (if that study had been done in reality). As students progress through the case study, they typically eliminate multiple hypotheses and begin to build an explanation for the observed data. Their use of deductive and inductive reasoning is emphasized through the entire case. The case is open-ended so is slightly different each time it is used. It does, however, usually allow discussions of how experimental methods and data presentation may alter interpretation of results, how scientists piece together data from disparate sources and compensate for missing information, and how the elimination of alternative hypotheses is just as important as the right answer. After we work through the case study, I will point out where specific issues can be addressed and discuss how students respond to the case. My intent is to make the case study and teaching notes freely available on the members-only section of the ACUBE website.

Addressing Student Misconceptions about Human-Driven Natural Selection in Introductory Biology Courses

Conrad Toepfer, *Brescia University*, Carol Maillet, *Brescia University*, Sibyl Bucheli, *Sam Houston State University*, Brooke Dubansky, *Tarleton State University*

As a mechanism of evolution, natural selection is a core concept in introductory biology courses, as well as evolution courses. Students at all levels of study, however, tend to carry the misconception that humans are isolated from the effects of natural selection, and do not often recognize anthropogenic influences on the environment as natural; rather they categorize these interactions as components of artificial selection. In this workshop, we will be presenting a teachable tidbit we developed at a National Academies Summer Institute. This teachable unit and its correlated assessments are designed to address these misconceptions at the introductory biology level. Following a short lecture that uses anthropogenic examples of natural selection (i.e., Warfarin resistance in rodent populations and/or antibiotic resistance in MRSA), students (or you, as a workshop participant) will utilize a strip-sequence activity designed to reinforce the logical framework and prerequisite conditions for natural selection to occur (e.g., pre-existing variation in natural populations, selection pressures, differential reproductive fitness, etc.), which were covered in a previous class session. Formative assessments such as clicker questions and think-pair-share activities will encourage student reflection and discussion about how pesticide resistance and/or antibiotic resistance meet the requirements of natural selection. The use of anthropogenic examples of natural

selection emphasizes that natural selection can be human-driven, and illustrates that natural selection can impact human health. Additional class discussions should emphasize the differences between natural and artificial selection.

Teaching and Assessing Higher-Level Thinking in Biology

Rebecca S. Burton, *Alverno College*

We will be discussing outcomes, criteria, assessment, rubrics and feedback as part of an integrated system to help students analyze, evaluate, and predict--skills that they can transfer to other disciplines.

Approaching biology as a framework for learning beyond content allows us to identify thinking skills that are critical across the curriculum. Departmental outcomes focus efforts on the most important aspects of learning. Authentic assessment puts the student in the role of a biologist. Criteria define the key aspects of effective performance. Well-designed rubrics allow for efficient feedback on complex higher-level tasks. Share your ideas and get concrete examples.

Challenges of Assessment Within and Between Programs

Christina Wills, Laura Salem, and Mindy Walker, *Rockhurst University*

We will be on leading a roundtable about the challenges of assessment (within and between programs). This will include a list of challenges that have been faced at Rockhurst assessing the Biology Program, the Honors Program, and the General Education – Science requirement (across biology, chemistry, geology, and physics), and some of the solutions that we have developed. Participants will be asked to discuss the formulation and assessment of learning objectives at the program level. We hope to foster an open discussion about the difficulties other faculty have faced and the unique approaches they have developed to solve assessment issues.

Redesigning sperm and egg

Dianne M. Jedlicka, *Devry University, Columbia College of Chicago, The School of the Art Institute of Chicago*, Abour Cherif, *Devry University*, Ateegh Al-Arabi, *Devry University*, Kris Horn, *DeVry University*, Farah Movahedzadeh, *University of Illinois at Chicago*

After employing our idea of “Redesigning the Human Body Systems” for a few years, an interesting twist at the synthesis level of knowledge jumped out. What if, after studying the Human Reproductive System, the students were asked to redesign only the egg and the sperm?! We gave the design role to the students and allowed their creativity, still using basic physical laws, to start up. This question allowed for additional thought by the student and initiates higher cognitive and creative thought processes. Three different Biology classes were presented with this assignment. Creative and scientifically based answers illustrate how the

students’ interpret the instructor’s lectures, text reading, and figures from the text. There was one student who was hesitant in this project due to possible religious conflicts. This presentation will highlight student ideas and possible instructor applications.

Survey Results: Addressing Critical Challenges to the Teaching of Anatomy and Physiology

Abour H. Cherif, Kris M. Horn, and Matthew J. Bruder, *Devry University*

This survey of anatomy and physiology professors examines some of the most critical challenges in teaching anatomy and physiology to college students. This survey looks at some of the best ways to overcome these critical challenges. In addition, this survey examines some of the most critical challenges in learning anatomy and physiology for college students and some of the best ways to help students overcome these critical challenges. This survey also examines the relevance of other disciplines that are routinely taught with anatomy and physiology.

You’re Only in Peru Once: Organizing a Field Trip to the Amazon

Mindy Walker, *Rockhurst University*

Providing students the chance to participate in field work in turn provides them with an invaluable opportunity to explore biology and learn about themselves and their strengths and limitations. Further, field trips abroad can provide not only lessons in ecology and biodiversity, but also in language, research, ethics, socioeconomics, and service. It is difficult to envision an experience that better educates and engages students than the opportunity afforded by field trips abroad to approach complex, real-life problems through experiential-, and service-learning. Herein I will present our experiences with planning and implementing a field trip abroad, as well as provide information about the field station at our field trip destination in the Peruvian Amazon.

The Science Case Network: Supporting Faculty Implementing Case Studies and Problem-based Learning

Karen Klyczek, *University of Wisconsin – River Falls* Pat Marsteller, *Emory University*

This session will provide a brief update on the activities of the Science Case Network (SCN), an NSF-funded project to support an active community of science educators, learners, researchers and developers interested in furthering the use of case studies and problem-based learning (PBL) in undergraduate biology education. The web site, www.sciencecasenet.org, connects users to the case studies and PBL projects in the network, groups of educators focused on particular issues in biology education, collaborators for research and development projects around cases, and ideas for classroom implementation.

POSTERS

Scientific Consensus and Social Controversy: Exploring Relationships Between Students' Conceptions of the Nature of Science, Biological Evolution, and Global Climate Change

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

It is overwhelmingly acknowledged by the scientific community that evolution and global climate change (GCC) are undeniably supported by physical evidence. And yet, both topics remain very politically contentious in the United States. Efforts to mitigate the disconnects between the scientific community and the general public on these issues are imperative to science education. Such undertakings need to examine students' conceptions of the nature of science (NOS), including how evidence is treated, how theories are constructed, and how scientific consensus is reached, as these may be key factors in attitudes towards evolution and GCC. *If students have a more thorough understanding of the processes of science, how consensus is built, and better tools to discern scientific versus nonscientific arguments, they may become more likely to accept strongly supported scientific ideas.* This study explored this hypothesis guided by the following questions: Do changes in NOS understanding correlate with changes in views on evolution or GCC? If there are correlations, are they similar for evolution and GCC? What demographic factors affect these correlations? To what extent do the proposed factors affecting evolution and GCC acceptance actually affect respondents views in a large sample size?

Assessment of Highway Traffic and Rail-Road Impact on Campus Environment: A Case of Martin University, Indianapolis, Indiana

Valerie Collier, Nancy Munson, and Mamta Singh, *Martin University*

People in the United States have been exposed to unhealthy levels of noise level, and it has become greater since 1974 (Williams & Wilkins, 2007). The studies have shown that noise pollution can be harmful, which can cause hearing interferences, not able to communicate with other people or have to speak louder because of the trains or highway, activates the nervous hormonal response, mental health, and not able to perform task. According to Stansfeld & Matheson (2001), noise is a feature of the environment which includes noise from transportation. Noise tends to disturb people's sleep while in the lab, however; it generally does not interfere with field studies which adaptation occurs. Road traffic exposures are associated with psychological symptoms. The rationale of this study is to reach out to health officials, local government, and federal legislation to support the issue of noise pollution, and the laws that can be change to make it better; especially in low income areas.

Design and Implementation of an Automated Plant Growth System

Danielle Erdley, Nicolette Fruehan and Matthew Kropf, *University of Pittsburgh at Bradford*
New electronics technologies have enabled sophisticated digital measurement and control automation in biological science. With pervasive growth in open-sourced hardware and software platforms such as Arduino microprocessors, Processing programming language, and Raspberry PI computers, implementing custom automated measurements and control has become an inexpensive and straightforward option for the college laboratory. These technologies have eliminated the need of specialized equipment in order to achieve high accuracy control and measurements in biology experiments. A multi-disciplinary approach to learning integrates engineering technologies with biological education. This results in students with confidence and abilities in the application of supporting technologies. Furthermore, teaching the basic skills involved with open source hardware programming provide students with a greater ability to apply these technologies to field biology, sustainability projects, and their careers.

'Evo in the News': A Pedagogical Tool to Enhance Students' Perceptions of the Relevance of Evolutionary Biology

Lynn M Infanti and Jason R. Wiles, *Syracuse University*

This investigation evaluated the effects of the use of *Evo in the News* on attitudes toward biological evolution among undergraduate students in a mixed-majors introductory biology course at a medium-sized, private research university in the American Northeast. In addition, this study looked at the initial attitudes of the students and their knowledge of evolution before beginning an introductory biology course. Initial attitudes and the gains in positive attitudes and knowledge were measured using the Evolutionary Attitudes and Literacy Survey (EALS). We used a quasi-experimental design with pre-test/post-test comparison between a control group and an experimental group. The control and experimental groups differed in that throughout the course of the semester, the treatment group was assigned pre-laboratory work using *Evo in the News* while the control group was assigned similar, traditional pre-lab activities. Post-course, the experimental group showed significant gains in their attitudes regarding the relevance of evolution. Additional findings included a significant correlation between positive attitudes toward evolution and knowledge of evolution. Also, significant correlations were found between both positive

attitudes toward and knowledge of evolution and the students' level of achievement in the course.

Freshwater Ecosystem Health – Why is it Important?

Mauriya Majada, Nancy Munson and Mamta Singh, *Martin University*

Pogue's Run Greenway is located south rural street to Brookside Park in Indianapolis, Indiana. Pogue's Run is made of 14.34 acres of wetlands and 8.11 acres of open water systems. It is designed to create varied wetland plant community types and promote sheet flow of water as it passes through the site. Structure and function of a wetland depends on its ecosystem health. Ecosystem health can measure in terms of both physical and chemical parameters. They play an important role in survival of aquatic life and balancing the ecosystem. Three sampling locations were selected based on landscape differences (shade, sunny, low flow and high flow) along the sampling stretch of Pogue's Run wetland. Three samples were collected from each site. The objective was to compare the difference in water quality parameters of the three sites. Methods: Vernier, LabQuest[®]2 was used to collect field data. Parameters measured were specific conductivity ($\mu\text{S}/\text{cm}$), air temperature ($^{\circ}\text{C}$), water temperature ($^{\circ}\text{C}$), pH, and dissolved oxygen (mg/L). Latitude and longitude using a portable GPS system connected to the calibration meter was used. Results: On average, dissolved oxygen was 5.5 mg/L , and specific conductivity was 505 $\mu\text{S}/\text{cm}$ indicate this area is moderately impacted. Conclusions: The above results are based on the preliminary filed data collection. Additional monthly and sessional data collections are recommended for the comparison of upstream and downstream sites.

The Effects of Individual Components of Acid Mine Drainage Remediation on *Elodea densa* Viability

Paige Mundy and Irene M Wolf, *Saint Francis University*

Acid mine drainage (AMD) is a known source of abiotic stress. After a mine has closed the water tables rise allowing contaminated ground waters to discharge into the environment. These contaminated waters are often acidic and contain elevated concentrations of metals and metalloids. The goal of the experiment is to study the effects of individual components of AMD on plant viability, determining which component is the most harmful, and which stress pathway is affected most in the plant. This information may be useful in determining new remediation methods catered to aquatic plant viability. The harmful components being focused on are acidity and arsenic exposure. To achieve this, *Elodea densa* plants were submerged in water adjusted to varying levels of pH (2-7) or arsenic (0, 0.05mM, 0.5mM and 1.0mM). DNA degradation

was observed by PCR amplification of the gene RuBisCo, and quantified using densitometry analysis. Degradation appeared in all samples subjected to pH 6 or lower after two days. Currently we are quantifying protein expression of HSP70 in the elodea exposed to acidic environments and arsenic, as well as measuring all viability utilizing a fluorescent assay. Methods & Equipment: Vernier/LabQuest 2 with GPS locations, Sound Level Meters (dB), Logger's Lite software, Lab Top computers, USB cords, and Tape Measure were used for data collection. Three Martin University students along with three professors agreed upon selection of data collection points. Three data collection sites were selected using Google Earth and the sites were: Front of Martin University light pole-Martin University Aerospace Education (AEL) lab; between the doors and parking lot of school; and the back of the school. The sites were selected so that both highway and rail road data were captured. Data were collected from 9:00 a.m. to 4:00 p.m. on Monday, Wednesday, and Friday from July 3, 2013-July 19th 2013 from three locations. The data were collected every 30 min., in increments of 10 minutes and were imported to spreadsheet which reflected time, sound reading in decibel (db). Results: The result from the present study suggests that on average sound level is below 80 db which is below the required standard recommended for building a sound barrier. However, the present study is based on limited resources and time, therefore, the continuous data collection during the extended hours is recommended for future research.

Environmental and Socio-Economic Studies of the Impact of Freeway (I-70) and Rail-Road on a University Campus and its Neighborhood in Indianapolis, Indiana.

Sophia Nelson, Mamta Singh, Nancy Munson, Tia-Lyn Gary and LaTosha Williams, *Martin University*

Air pollution has both acute and chronic effects on human health affecting a number of different systems and organs. Short- and long-term exposures have also been linked with premature mortality and reduced life expectancy (Kampa & Castanas, 2008). Pope's (2000) study on chronic exposure suggests relatively broad susceptibility to cumulative effects of long-term repeated exposure to fine particulate pollution, resulting in substantive estimates of population average loss of life expectancy in highly polluted environments. Kampa and Castanas (2008) state hazardous chemicals escape to the environment by a number of natural and/or anthropogenic activities and may cause adverse effects on human health and the environment. Increased combustion of fossil fuels in the last century is responsible for the progressive change in the atmospheric composition (Kampa & Castanas, 2008). Kunzli, Kaiser, & Medina et al. (2000) and Samoli, Peng, & Ramsay et al. (2008)

also clearly state a strong relationship between air quality and human health impact.

The present study will assess a level of highway traffic noise and railroad noise impact on Martin University and its surrounding neighborhood using both primary and secondary data sources. Martin University is located right across highway I-70. Everyone on and near campus are aware of how I-70 is impacting the campus. If you are in the campus garden performing some activity with university students or K-12 students, you can experience that the campus environment is affected by highway traffic flow on the adjacent freeway, I-70. The situation gets worse when the highway traffic noise is combined with rail road traffic. In this research paper, the two questions are addressed: What are the impacts of I-70 and railroad traffic on Martin University campus? How are traffic noise and air quality affecting Martindale-Brightwood community and Martin University campus? Seventeen questions survey were administered. Participants were Martin University students, staff, and faculty. Responses were anonymous and fifty responses were analyzed. Excel Spread sheet was used for data analysis. The results indicated that 90% respondents were African American, 88% respondents were the age of 25 plus, 38% indicated that they use a car as one of the means of transportation to school, 98% indicated that they do not have any kind of employment and 98% indicated that they have good health condition. The results suggested that traffic and I-70 do not have any impact on health of Martin university community. However, in-depth research in combination with a mixed method research design will be conducted to get more reliable data regarding the environmental studies of Marti University Campus and Martindale-Brightwood area.

This project utilized resources from the open source software community to enhance control capabilities in the biology lab facilitating undergraduate research. Using inexpensive Arduino microprocessors and readily available open source software, automated environmental controls for plant growth systems were implemented. The design utilizes sensors for automated lighting and watering controls, allowing consistent treatment of the plant specimens under study. The technology is also capable of integrating humidity, temperature, and light intensity measurements to provide quantitative data throughout the period of study. This project demonstrates the ability to measure and control biological experiment variables through innovative integration of technologies.

Effects of Acid Mine Drainage on Hsp70 Protein Expression of *Elodea densa* at Remediation Ponds

Travis Schofield and Irene M. Wolf, *St. Francis University*

This experiment investigates plants' response to ecosystems affected by acid mine drainage (AMD). Acid mine drainage increases acidity and adds numerous other factors that serve as stressors to organisms inhabiting freshwater systems, such as increasing iron levels. *Elodea densa* was used as a model in these experiments and was placed in the ponds of a remediation site. In order to explore the effects of such stressors, protein analyses were undergone (specifically targeting Hsp70 and actin) on samples of *Elodea densa* that were cast into organized environments that simulated the toxicity of acid mine drainage in aquatic ecosystems to varying degrees. It was hypothesized that the levels of Hsp70 would increase in correlation with the level of toxicity of the waters in which the samples of *Elodea densa* were cast. A trend would potentially be applicable to indigenous species.

Increased HSP70 Expression in *Typha latifolia* in Decreasing Concentrations of Acid Mine Drainage

Matthew Williams, and Irene M. Wolf, *St. Francis University*

Acid Mine Drainage (AMD) is a major concern for many freshwater ecosystems. Due to high levels of iron deposits and other factors, many species of organisms are adversely affected. In order to combat the adverse effects of AMD, a process of remediation is commonly used (1997). In this experiment, a comparison of heat shock protein 70 (HSP70) in four ponds at a remediation site and a control pond on Saint Francis University's campus is examined. We hypothesized that the expression of HSP 70 will decrease as the level of contamination decreases. Previous research performed by Thomas McWilliams showed that the opposite happened, and the purpose of this research was to see if this trend continued after a year. Protein samples were extracted and were analyzed using a western blot. Our results indicate that the trend from last year remains; as the level of contamination decreases, HSP70 expression increases.

Enabling Undergraduates to Comprehend and Analyze Primary Research

Katharyn J. Affeldt, *University of Wisconsin-Madison*

Reading, and more importantly, understanding, primary research articles can be difficult and frustrating for undergraduates due to field-specific jargon, unfamiliar techniques, and extremely condensed information. Multiple strategies were employed in the course Critical Analyses in Microbiology to provide students with the skills to understand and analyze primary literature. Among these were pre-class assignments designed to focus students' reading on key areas of the papers. In addition, students were given the option to add corrections to their assignments during class to increase engagement and understanding. A brief

mini-lecture provided background information, but the majority of the class time was spent on activities and discussions that dug deeper into the paper and reinforced major concepts. Through active learning and a low—pressure environment, students reported increased facility in several specific skills related to understanding primary research literature.

A Literature Review on the Possible Uses of Course Web Sites

Andrea Bierema and Renee' S. Schwartz, *Western Michigan University*

The possible uses of course web sites extend far beyond just a place to post PowerPoint lecture notes, but what are some examples on how to make better use of a course web site? Several college biology educators have found creative ways to use their course web sites and have provided these examples in the primary literature. These include providing several different types of supplemental material, sometimes to the extent that they replaced the textbook. Supplemental material may include graphics, glossaries and readings that are more directed toward course objectives than general resources, interactive modules that may include animations, simulations and quizzes, and brief podcasts that are focused on common misconceptions. Course web sites can also be a location for discussion among students. Many of the articles provided details on what they did, what worked and what students enjoyed or suggested for improvement. We examined these articles and summarized their insights on how to make better use of the course web site.

Facilitating Successful Collaborative Research in Undergraduate Animal Behavior Courses

Rebecca Burton, *Alverno College*

This poster addresses benefits and challenges of having students test their own hypotheses in independent groups. It offers ideas and resources for facilitating efficient, effective, and legal projects. A web site connected to the poster supplies several templates for resources such as research proposals, group work contracts, and report criteria.

New Methods for an Interactive Undergraduate Journal Club

Jordan Clark, Adam Rollins, and Philip Smith, *Lincoln Memorial University*

Journal clubs have long been utilized to advance student's scientific skills beyond basic knowledge and comprehension by engaging them in the process of critically evaluating and discussing research literature. In order to encourage consistent participation, many institutions offer journal clubs for elective credit or as specific course requirements. However, creating a well-attended extracurricular journal club for which no additional academic credit is offered requires a delicate and creative approach. Undergraduate students (already facing a demanding

course load) often view the traditional format of analyzing reported data and experiment design as too laborious and intimidating with little perceived benefit. As such the traditional approach can diminish overall student engagement and enthusiasm for the wonders of scientific research. To overcome this perception we have been developing a new journal club format that engages students in discussions of research literature while fostering attitudes of excitement and enthusiasm toward science. To these means the group spends the semester exploring the literature related to a provocative, even controversial topic that encourages both scientific and philosophical debate. The semester begins with a broad discussion of the topic (perceptions, media coverage) and with each progressive session advances from general readings to reports and ultimately the primary literature. An interactive website is utilized that allows students to upload and link articles, videos, comments and/or questions related to the topic. This new format has received positive student reception, but low attendance. The poster will present the details of this new journal club format including (a) an example topic, (b) student feedback, (c) our observations and (d) how we are using this crucial insight with respect to student expectations to further refine our methods to produce a successful and engaging extracurricular undergraduate journal club.

Teaching from the Primary Literature: An Overview of a Molecular Cell Biology Course Taught Using the C.R.E.A.T.E Method

Melissa A. F. Daggett, *Missouri Western State University*

The extensive use of primary literature in undergraduate courses can be an excellent mechanism to demonstrate and reinforce the style and format of scientific communication and process skills to students. This poster presents an overview of materials developed and used to teach BIO 410 Molecular Cell Biology using the C.R.E.A.T.E Method. The C.R.E.A.T.E (Consider, Read, Elucidate hypotheses, Analyze and interpret data, Think of the next Experiment) method uses intensive analysis primary literature in the undergraduate classroom (<http://www.teachcreate.org/>). Examples of the papers, assignments, assessments and corresponding laboratory activities used in the course will be presented and discussed.

PULSE: Organizing to Catalyze Change in Undergraduate Biology Education

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

The Partnership for Undergraduate Life Sciences Education (PULSE) is a collaborative effort of the HHMI, NIGMS, and NSF to help catalyze institutional change in undergraduate STEM education. Through a national call of departmental

leaders, PULSE selected 40 Vision and Change Leadership Fellows from a pool of 350 applicants. The Vision and Change Leadership Fellows, which include departmental leaders from all institution types, were given an eleven-month charge to develop strategies that had the potential to catalyze national implementation of the recommendations from the Vision and Change report (2009) across the full spectrum of post-secondary educational institutions. The Fellows originally formed four working groups, which then rearranged and coalesced around emerging products during the course of their work over the 10 months. In this poster we highlight the challenges, goals, and broad activities of the Vision & Change Fellows.

Halobacterium Species NRC-1 as a Model for Independent Student Projects

Nighat P Kokan, *Cardinal Stritch University*

Halobacterium species NRC-1 is an archaeon that is an extreme halophile, facultative anaerobe, and a phototroph that can be easily grown in lab without strict safety protocols. Our students have utilized this organism as a model for independent projects in a regular microbiology laboratory course (BL203) at Cardinal Stritch University, Milwaukee, Wisconsin. Groups of students investigate a biological question and carry out the project over a period of 7-8 weeks. Being part of an independent project gives the students a sense of excitement and compels them to learn more than they would in a standard laboratory. The projects culminate in the form of a poster relating to the biological question under investigation. I will provide details of the implementation and examples of student projects carried out using this microbe.

Weaving a Thread: A Cross-Curricular Approach

Carol M. Maillet and Conrad S. Toepfer, *Brescia University*

Responding to national initiatives for changes in undergraduate science education, as well as our own observations, we have implemented a project that: 1) provides students with a multi-faceted exposure to complex biological systems, 2) gives student additional practice in evaluating and synthesizing information from multiple sources, 3) gives students opportunities to collaborate in intradisciplinary teams, and 4) provides students with additional exposure to quantitative analysis and practice with large data sets. The thread topic (for example, cancer) with a focus question, is identified and is woven through classes both semesters. Each semester culminates in a symposium in which synopses of information from all classes are presented, followed by small group discussion led by upper-division biology students. Each biology student then writes a short paper in which he/she synthesizes and reflects on the information (fall semester) or applies the

information to a novel, but related, problem (spring semester). Assessments are done at multiple points and include analyses of the papers, pre-post analyses and self-assessment of learning. Activities within each class vary, but include case studies, concept mapping, team-based learning, etc. Preliminary results after the second year of completion indicate an increased sophistication of responses and fewer misconceptions in spring compared to fall. We also established a baseline that both shows higher scores from upper division students (3-4.5 on a 5-point scale) compared to lower division students (1-2 on the same scale) and accommodates improvement among the higher scoring groups. Students' self-assessments report an increased understanding of both the focus topic and the value of multiple points of view. However, when surveyed after exposure to the thread, students noted deficiencies in their own capacities of logical thinking and expression. We anticipate that exposure to the thread over four years of undergraduate education will enable students to make connections among disparate pieces of information, concepts and questions (V&C document). Overall, our procedures and assessment tools appear to be appropriate for the project and we look forward to extending participation in the thread project to other areas of the Natural Sciences as well as Mathematics and Behavioral Sciences.

Blending Lecture and Lab in one Setting to Maximize Learning

Devonna Sue Morra, *Saint Francis University*

Having taught marine biology for the last 17 years at Saint Francis University and frequently getting frustrated during lectures about my inability to draw pictures into my students' minds about animal physiology or ocean cycles, I have convinced administration to allow me to teach lecture and lab in the same room starting this fall semester. The administration finally agreed to this idea when they studied the number of lecture halls and laboratory rooms needed to meet the needs of all members of the science faculty. A new science complex was built from 2012-2013 with my lab room integrated with a lecture room. I have committed to teaching my classes, both lecture and labs, in this single room. Science faculty moved into the new building August, 2013. I will be teaching not only marine biology in this lab/lecture room, but also animal care, animal nutrition, and freshwater aquatic biology. Other professors will utilize the room for animal behavior and invertebrate zoology. While designing the new facility, all faculty members were involved in the discussions of what we needed to effectively teach. For students to really understand how sea urchin tube feet allow an urchin to climb the aquarium wall, they need to watch a live sea urchin climb. By integrating the space, students can now do exactly that. We can discuss sea urchin anatomy and physiology utilizing

textbook materials on a smart board at the front of the room and then move to the aquarium section and observe live sea urchins. I frequently allow students to hold the live urchins so that they can actually feel the tube feet moving. The tables in the front of the room will serve as both note taking space and exploration of animals, etc. The aquarium spaces will serve for animal care along with research space. Both safety and IACUC requirements can be accommodated by the room. During my poster session, I will share how my space was developed and also the sessions that I'm developing to deliver my spring marine biology class as a combined unit utilizing students exploring marine concepts throughout the class.

Can 'Supplemental Instruction' Increase the Success of Students in a One Semester Human A & P Course

Thomas Rachow, *Missouri Western State University*
Supplemental Instruction was developed by Dr. Deanna Martin at the University of Missouri-Kansas City in 1973. It is an academic support program that targets historically challenging courses. It is open to all students. It consists of non-remedial sessions led by trained student leaders who help participants review notes, discuss readings, develop organizational tools and prepare for examinations. S.I. has been used in BIO250, a one semester human anatomy and physiology course primarily for aspiring nursing and physical therapy assistant students at Missouri Western State University for two semesters. Data comparing the performance on lecture exams of S.I. participants and non-participants typically showed a +0.5-0.9 grade point difference between students who attended S.I. sessions and those that didn't. End of S.I. surveys generally found that students felt they benefitted from the sessions. About 69% of the students (102 of 148) attended at least one session during the fall 2012 semester; 25 students attended 3-5 sessions; 19 students attended 5-10 sessions.

Peer Led Team Learning in Introductory Biology: Effects on Critical Thinking Skills and Student Achievement

Julia J. Snyder and Jason Wiles, *Syracuse University*
Peer-Led Team Learning (PLTL) is a pedagogical approach to small group instruction which can supplement other traditional components of undergraduate courses. In the PLTL model, students work in small groups of six to eight students led by an undergraduate peer who has previously taken and

been successful in the course. Peer leaders are trained in learning theory, pedagogical methods, and the conceptual content of the course in preparation for working collaboratively with the course instructor to facilitate small group problem-solving sessions. Many studies have documented the effectiveness of the PLTL model. Research has focused primarily on the academic benefits to the students who have participated in the PLTL workshops. Studies have shown improvement in students' performance, attitudes, retention in the course, conceptual reasoning, and critical thinking skills, yet little attention has been given to the academic benefits for the peer leaders.

This study evaluated the effects of the Peer-Led Team Learning (PLTL) instructional model on undergraduate, biology peer leaders' critical thinking skills. As the role of the peer leader involves several factors associated with various aspects of higher-level critical thinking, we hypothesized that participating as a PLTL peer leader should promote gains in critical thinking skills.

Critical thinking was assessed using the California Critical Thinking Skills Test (CCTST) Herein, we present results and statistical analyses of data obtained via a controlled, quasi-experimental pretest/posttest protocol designed to measure critical thinking gains in PLTL/non-PLTL groups of undergraduates who were qualified and interested in such experiences. Potential implications of this study are also discussed.

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

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

HungerU is a mobile exhibit that travels to college campuses across the United States with the aim of educating college students, academia and anyone who eats about the role advanced agriculture plays in putting food on our tables. Using a controlled, quasi-experimental, pre/post approach, we surveyed students enrolled in an introductory biology course regarding their attitudes and understandings of agriculture and related science concepts before and after the HungerU exhibit and used both quantitative and qualitative methods to measure and describe the impacts this informal education experience had on their knowledge and perspectives on food sourcing as well as their intentions for getting involved with hunger prevention efforts.

Conference Photos



ACUBE/2013 Registration



First Poster Session



"Meet With Pre-Professional Advisors"



Presentation



Wrap-up Dinner



ACUBE Carlock Award Winners

Bioscene: Journal of College Biology Teaching

Submission Guidelines

I. Submissions to *Bioscene*

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

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

II. Preparation of Articles, Innovations and Perspectives

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

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

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

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

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

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

Single Author:

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

Two Authors:

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

Multiple Authors:

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

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

(1) Articles-

(a) Single author:

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

(b) Multi-authored:

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

(2) Books-

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

(3) Book chapters-

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

(4) Web sites-

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

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

D. Tables

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

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

E. Figures

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

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

III. Letters to the Editor

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

IV. Other Submissions

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

V. Manuscript Submissions

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

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

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

VI. Editorial Review and Acceptance

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

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

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

VII. Revision Checklist

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

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

VIII. Editorial Policy and Copyright

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