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Cover image: Photograph of a young iguana is courtesy of Dr Doris Audet. The photo was taken in the Guanacaste province of Costa Rica in Spring 2005 using a Canon EOS Rebel.

CONTENTS

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ARTICLES

Using History and Philosophy as the Capstone to a Biology Major

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Abstract: Capstone experiences have high educational impact with a number of approaches for biology. In most capstones, students produce a major project, typically as an undergraduate research experience, with a primary goal to integrate students' learning. At Augustana, our senior biology capstone uses history and philosophy to frame students' reflections and to integrate their biological education within our liberal arts and sciences curriculum. In a flipped classroom approach, students write a response to the assigned reading before class, when the paper is discussed through student-led seminars. Assigned papers consider the philosophy and historical development of biology focusing on its three conceptual pillars: function, development, and evolution, allowing students to examine how biologists arrived at their current understanding of life. Assessment of ten years of course offerings indicates students' ability to write and speak are being successfully developed, but that thinking shows no significant learning gains between the midterm and final exams. Student quantitative and qualitative ratings of the course indicate that it is a valuable learning experience, despite its heavy workload and difficult nature.

Keywords: high impact educational practice, senior year, writing, speaking, critical thinking, functional biology, developmental biology, evolutionary biology, student learning outcomes

INTRODUCTION

High impact educational practices are teaching strategies in which "students invest time and energy over an extended period that has unusually positive effects on student engagement in educationally purposeful behaviour" (Brownell and Swaner, 2010). Capstone experiences are considered to be a high impact educational practice because of their ability to engage students and integrate their learning (Hauhart and Grahe, 2015). Rather than disconnected individual educational experiences (courses) a capstone experience should enable students to understand the connections between the courses and leave the program with an integrated, robust knowledge structure of their discipline and integrate that discipline into a broader understanding of the world - it is not just about biology, it is about embedding biology into the lived experiences of people (Smith, 1998). Research has shown that attending to students' engagement enhances their learning outcomes (Carini et al., 2006). Capstone courses engage students typically through projects, senior theses, or an undergraduate research experience (Hauhart and Grahe, 2015). What makes these engaging is students' sense of ownership and enfranchisement with their own learning - it becomes something they control in their own learning. Capstone courses can also provide an educationally purposeful activity by providing students with a forum to integrate their major and their entire undergraduate education (Kinzie, 2013). Typically, students go through the undergraduate curriculum ticking off their course requirements from a checklist without understanding the integration implicit in their general education requirements and how they relate to their major (Smith, 1998). By linking students' learning to their prior educational experiences, students are able to construct a more robust knowledge structure. In addition, facilitating the integration of students' learning with their own lived experience will increase their educational engagement by linking their personal to their academic lives making their learning relevant and significant. Capstone courses are one way to weave the different threads of students' undergraduate education and life into a coherent tapestry of learning and experience (Kuh, 2008).

A number of approaches exist for developing capstone courses (Davis, 2011). Some provide students with a service learning experience (Kerrigan and Carpenter, 2013). Others give students an undergraduate research experience (Wenk and Rueschmann, 2013). Still, others are designed to integrate the entire undergraduate program or simply integrate the different parts of students' major (Usher et al., 2010; Griffin and Burns-Ardolino, 2013; Redman, 2013; Stubbs et al., 2013). Many are part of the general (core) curriculum of the institution but most are housed within students' major (Kinzie, 2013). In addition, most capstone courses seem to be focused on skill development rather than on content mastery (Obringer and Kent, 1998; Haave, 2015b; Aguanno et al., 2015).

In the early 1990s, the Augustana Faculty of the University of Alberta revised their educational

curriculum making it a requirement that all majors either complete an undergraduate research experience or complete a course that enables students to critically reflect on their discipline's theoretical and historical development. Due to a lack of lab facilities, our biology major chose to develop and implement a course on the history and philosophy of biology. This task fell to me. During my 1996 sabbatical, I researched and developed History and Theory of Biology, a senior capstone course for the Augustana biology major. The course's learning goals were the development of students' writing, speaking, and thinking skills tied to a critical reflection of the historical development of our current understanding of life processes with an emphasis on evolution, genetics, and development (Haave, 2012). In this paper, I reflect on the efficacy of the course over the 10-year period 1998-2009 using students' marks and evaluations as the evidence for my analysis.

METHODS

Course description

The course under consideration is a senior (fourth-year) capstone course for the biology major of the Augustana Faculty at the University of Alberta: AUBIO 411 - History and Theory of Biology. The course content focuses on the historical development of evolutionary, developmental, and functional biology as the three primary conceptual foundations of biology (Haave, 2012). The goals of the course are to actively engage students in their reflection on Biology as a discipline by having students consider how and why biology is currently investigated. These goals lead to questions such as: What are the assumptions inherent in our approaches to biological investigation? Why am I training to be a biologist? How does my biological education inform me as a person and/or citizen? How will my biology education affect me to action?

Embedded in the course are the development of students' thinking and communication skills via a writing dossier in which students reflect and respond to the assigned course readings. In addition, students' speaking and research skills are developed through the requirement to lead two class seminars for which seminar leaders need to do some additional research on the paper assigned for that particular day. Thus, students are held responsible for the assigned readings by engaging them prior to class through a writing dossier and in-class through seminars in a manner consistent with active learning and flipping the classroom (Linton et al., 2014; Abeysekera and Dawson, 2015).

The period of assessment is the first year the course was offered (1998) until the year before my teaching duties were decreased due to an increase in my administrative load (2009). All students must complete this course to graduate with a major in biology from the Augustana Faculty. The student composition was typically students in their senior year but did contain a few junior students or those who returned for a fifth year. The pre-requisites for entry into the course were senior standing, and completion of six credits of freshman biology, six credits of sophomore genetics and biodiversity, and six credits of junior biology. Junior developmental biology was strongly recommended.

The course content was divided into four parts: I - an introduction to the philosophy of science; II - an introduction to the problems of doing history; III - the conceptual development of biology with a focus on evolution, development, and genetics; IV – the social aspects of modern biology. The course was structured around the discussion of assigned readings from the philosophy and history of biology with students required to read approximately two papers per week.

In the style of the flipped classroom, students completed a two-page typewritten response to the reading for entry to each class in which the paper was discussed. These responses comprise their writing dossier of which a small sample (approximately five) was marked. In addition, students provided at midterm and end of term, an analysis of their own writing that addressed their writing structure and style. This self-critique was assessed.

Each student led a seminar twice per term. These student-led seminars were evaluated by the instructor and students. Instructor and student comments (made anonymous) were returned to students at midterm as formative feedback. As formative feedback, the student-led seminars were weighted 1:2 for pre- and post-midterm evaluations. Writing dossiers were similarly weighted.

Students also evaluated their peers' contribution to the class discussion which informed the instructor's evaluation of student participation. This peer evaluation of participation was critical to ensure that all contribute to a robust intellectual conversation to facilitate student learning and discourage social loafing (Seidel and Tanner, 2013).

Students' understanding of the conceptual development of biology was evaluated with a midterm and final exam which were comprised of three short essays (one to three paragraphs each) at midterm, and four to five short essays on the final exam. Students had a choice of questions to answer, within constraints, to ensure that each part of the course was addressed. In addition, on both the midterm and final exams there was one common question which all students answered to evaluate students' ability to integrate their learning in the course; they considered how biological concepts developed over time and were influenced by both intellectual and social factors. It is this final question that I used to assess students thinking in the following analysis.

Assessment of achieving course learning goals

The efficacy of the course was assessed by

Table 1. Questions soliciting comments from students on the Universal Student Ratings of Instruction (USRI) form

Pre-2005*	Post-2005
• What aspects of the instructor's teaching did you find most valuable?	• What aspects of the course and/or instructor did you find most valuable?
• What aspects of the instructor's teaching did you find least valuable? What suggestions do you have for improvement?	• What aspects of the course and/or instructor did you find least valuable?
• Any additional comments that you would like to make.	• Please add any other comments that you would like to make about the course and/or instructor.

*In 2005 Augustana University College became a Faculty of the University of Alberta. This was accompanied by a change in the wording of some of the USRI questions

comparing midterm and end of term student results for their seminars (speaking skills), dossiers (writing skills), and integrative exam question (thinking skills). Student marks were analyzed using Students' paired t-tests to assess whether students' abilities improved between midterm and end of term. When the data did not pass a normality test, the Wilcoxon Signed Rank Test was used to determine statistical differences.

Students' assessment of their learning experience

Students' perception of their learning and the learning environment of the course were assessed by analyzing the end of term student evaluations considering both the Likert scale rating and student comments. Questions informing the analysis of students' perceptions of their learning and the course learning environment included: 1. workload, 2. difficulty, 3. clarity of the objectives, 4. achieving the objectives or increasing their knowledge, and 5. the quality of the learning experience. In 2005 Augustana University College became a Faculty of the University of Alberta. With this merger, some questions changed. For example, before 2005 the question asked whether students thought that the course was a positive learning experience whereas after 2005 students were asked whether the course was a very good learning experience. These two questions were analyzed separately due to differences in responses among the year cohorts.

Students' ratings of the course using a five-point Likert scale (1-5: strongly disagree, disagree, neutral, agree, and strongly agree) were first analyzed for significant differences among the year cohorts using the Kruskal-Wallis one-way ANOVA. When differences did not exist between the years, the 10 years of student evaluations were combined into one cohort and analyzed using Chi-square. Anonymous student comments written in response to three open-ended questions (Table 1) on the end of term course ratings (Universal Student Ratings of Instruction or USRI) were analyzed for common threads of perception towards students' own learning and their response to the character of the course as a learning environment. The total number of students completing the end of term evaluations over the ten-year span under study was 123-127 for each question: not all students responded to all questions.

RESULTS

The course offerings over the 10-year period consisted of relatively similar students with regard to student learning outcomes: The Kruskal-Wallis one-way ANOVA did not detect significant differences ($p > 0.05$) among the annual cohorts of students. Thus the student learning outcomes were treated as a single group (Chaplin and Hartung, 2012). Students' speaking and writing ability improved when comparing their pre and post-midterm seminar marks (Figure 1, Wilcoxon Signed Rank Test, $p \leq 0.001$) and writing dossiers (Figure 2, paired t-test, $p \leq 0.001$). However, student thinking as assessed by an integrative exam question did not change (Figure 3).

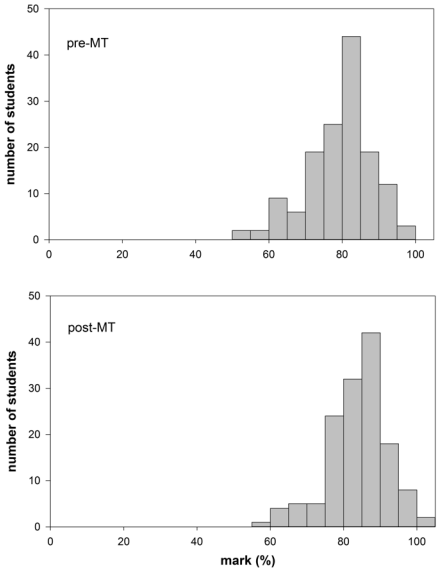

Fig. 1. Pre-midterm and post-midterm seminar percent mark distribution of combined student cohorts from 1998 to 2009. One-way analysis of variance did not detect significant differences among the individual year cohorts ($p > 0.05$). The decade of combined student marks was significantly different between the pre-midterm and post-midterm seminar mark (Wilcoxon Signed Rank Test, $p \leq 0.001$

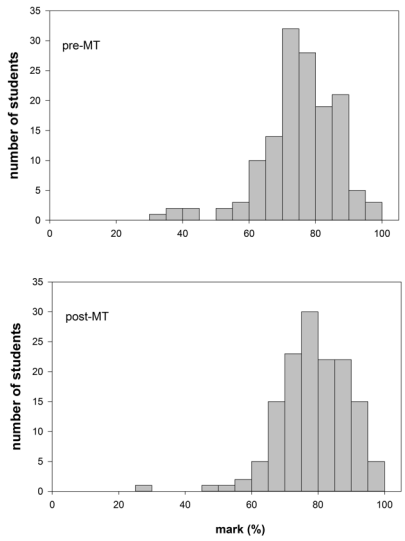

Fig. 2. Pre-midterm and post-midterm writing dossier percent mark distribution of combined student cohorts from 1998 to 2009. One-way analysis of variance did not detect significant differences among the individual year cohorts ($p > 0.05$). The decade of combined student marks was significantly different between the pre-midterm and post-midterm seminar mark (paired t-test, $p \leq 0.001$).

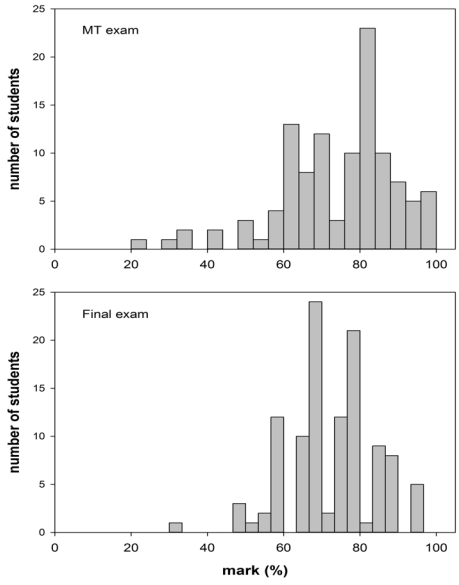

Fig. 3. Percent mark distribution for a midterm and final exam integrative question of combined student cohorts from 2000 to 2009. One-way analysis of variance did not detect significant differences among the individual year cohorts ($p > 0.05$). The decade of combined student marks was not significantly different between marks for the midterm (MT) and final exam question (two-tailed paired t-test $p > 0.05$).

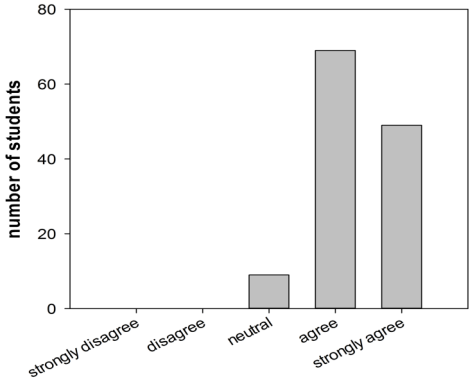

Fig. 4. Number of students (1998-2009) indicating that the course objectives were clear. Kruskal-Wallis one-way ANOVA did not detect significant differences among the year cohorts ($p > 0.05$). Chi-square analysis of all students (1998-2009) detected a significant difference ($p < 0.005$) among the choices of the entire 10-year cohort**.**

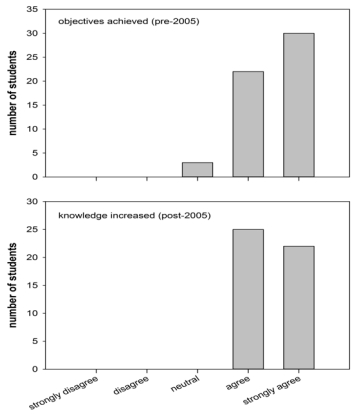

Fig. 5. Number of students reporting that either the course objectives were achieved (pre-2005) or that their knowledge of the subject matter increased (post-2005). Kruskal-Wallis one-way ANOVA did not find significant differences among the different year cohorts ($p > 0.05$). Chi-square analysis found significant differences ($p < 0.005$) among the choices when analyzed as two single cohorts pre-2005 and post-2005.

Kruskal-Wallis one-way ANOVA on ranks did not detect any significant differences ($P > 0.05$) among the year cohorts of students' rating for four of five course parameters. When analyzed as a combined single group Chi-square analysis detected significant differences ($P < 0.005$) with 86-100% of students agreeing that the objectives were clear (Figure 4), the objectives were achieved, that students increased their knowledge (Figure 5), and that the course is more difficult (Figure 6) and has a greater workload (Figure 7) than other courses. The Kruskal-Wallis one-way ANOVA on ranks did detect differences among the student cohorts rating the course as a learning experience (Figure 8). To tease this apart the cohorts were split into two analyzable groups based on the wording of the question which changed as a result of Augustana becoming a Faculty of the

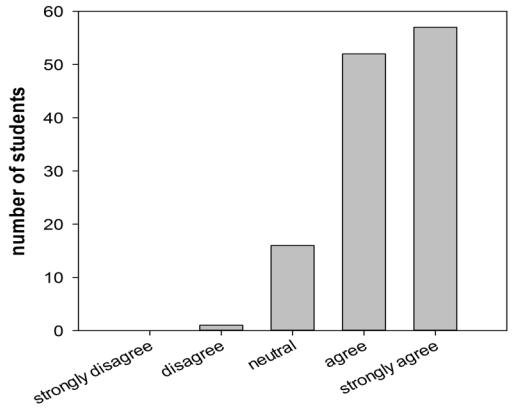

Fig. 6. Number of students (1998-2009) indicating that the difficulty of the course is greater than others they have taken. Kruskal-Wallis one-way ANOVA test did not detect significant differences among the different year cohorts ($p > 0.05$). Chi-square detected significant differences ($p < 0.005$) among the responses of the entire 10-year cohort.

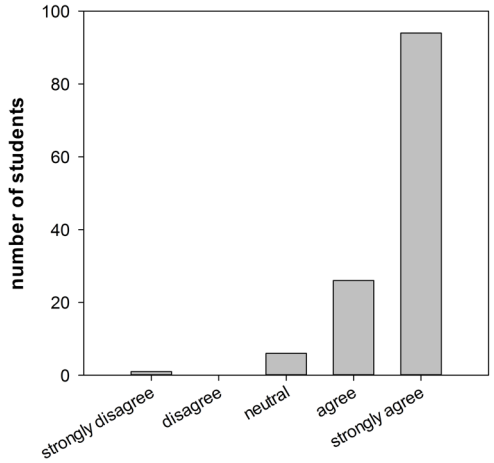

Fig. 7. Number of students (1998-2009) agreeing that the course had a greater workload than others they had completed. Kruskal-Wallis one-way ANOVA test did not detect differences among year cohorts ($p > 0.05$). Chi-square detected significant differences ($p < 0.005$) among the responses of the entire 10-year cohort.

University of Alberta in 2005. Dunn's Multiple Comparison test found that the 2007 and 2008 cohorts had significantly ($p < 0.05$) more students than other year cohorts disagreeing with the statement that the course was a very positive learning experience. However, most students still thought that the course was a positive learning experience.

The student written comments support their ordinal results. Student comments indicate that the course was very difficult with a high workload but that it was valuable and eye-opening (mind-opening in the words of one student). The student comments and ordinal data are somewhat contradictory; on the one hand, students complained about the workload and difficulty with some students commenting that the two-page response per reading, typically twice a week, was difficult. On the other hand, some students commented that preparing for class by writing a two-page response to the assigned reading was necessary to participate in the ensuing class discussions. Following are some sample student-written comments from the USRIs that indicate the tension between the value of the course and its difficulty and workload:

- But it's a good workload since all students are well prepared for exams.
- Reading & summaries are a LOT of work, but are necessary to understand the objective of the course.
- The Reading and Summaries [were valuable]. Though time consuming they forced me to read and get the work done.
- Summaries kept me on top of my work which makes studying easier.
- Though I cursed having to write summaries, often enough, I think it is the only method to ensure that people have read the article and understood. And this is vital if discussion is to take place.
- The summary each class makes sense but at times it got overwhelming.
- I did not enjoy writing a review for every class but it was needed in order to understand topics.
- Some of the readings were such a chore! I realize their importance and value. I'm just complaining.
- This course had a huge workload but I can see the value in it.
- Overall very interesting course, except for the grueling workload.

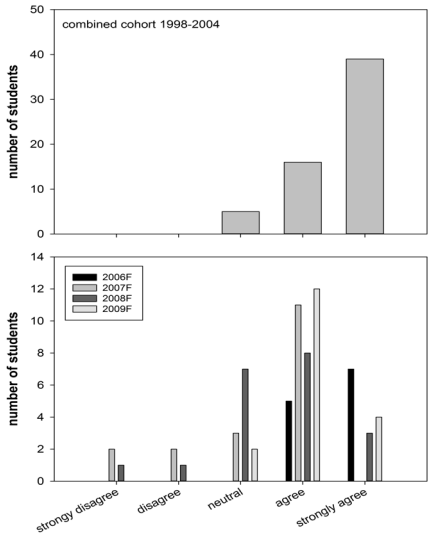

Fig. 8. Number of students rating the course as a positive learning experience. Kruskal-Wallis one-way ANOVA on ranks followed by Dunn's Multiple Comparison found the 2007 and 2008 cohorts to be significantly different ($p < 0.05$) among all student cohorts 1998-2009. There were no differences among the cohorts from 1998-2004. Chi-square analysis of the combined 1998-2004 group indicated that significantly more students agreed that it was a positive learning experience ($p < 0.005$).

DISCUSSION

The data indicate that students enrolled in Augustana's biology capstone course improved their speaking and writing skills but did not improve their ability to answer an integrative thinking question. Students indicated that the course met its stated objectives (pre-2005 question) and that their knowledge increased (post-2005 question) and that it was a good learning experience. However, the workload and difficulty of the course are high. A minority of students in the 2007 and 2008 cohorts disagreed that the course was a positive learning experience.

The results from the integrative exam question are clearly disappointing: I was expecting an increase in students' ability to integrate their learning and thus demonstrate improved thinking ability. Students typically perform poorer on the final relative to the midterm exam in the courses I teach (Haave, 2016) which may be due to the greater amount of material examined on a comprehensive final exam. However, students did not decrease their ability to answer an integrative thinking question as might be expected from trends in midterm versus final exam marks for my courses. On the other hand, the difficulty of assessing students' thinking ability has been identified (Bok, 2006) but can be approached using student self-reports (Tsui, 1999); students' comments and ratings of the course indicate their sense that their understanding and knowledge increased. The significant improvement in speaking ability appears to be mostly due to an increase in the mark of the bottom 25% of the students which is similar to results from other high impact practices (Brownell and Swaner, 2010) such as undergraduate research (Haave and Audet, 2013). Part of this effect may be due to the upper ceiling of possible marks.

My previous study found that most institutions require a capstone course of their biology majors but no other institution, except Augustana, uses history and philosophy to integrate students' biology program in their senior year (Haave, 2015b). Most biology capstone courses are structured around an undergraduate research experience. In contrast, a recent study reported that few capstone experiences in biochemistry and molecular biology are courses (Aguanno et al., 2015). Some have reported using history and philosophy to aid the doing of science by reframing the questions asked by biologists (Daggett, 2012; Kendig et al., 2012), as is done in the Augustana capstone. However, our course is the only one that uses history and philosophy to capstone a biology major but is not unique in its emphasis on developing students' communication and thinking skills in a seminar format, which integrates their learning from previous courses (Chaplin and Hartung, 2012). Students' self-assessments indicate that this approach is successful in engaging their reflection on biology as a discipline. Student comments and ratings indicate that the capstone course has a high impact on their learning as would be expected from a high impact practice (Kuh, 2008).

Although students identified the course workload and difficulty to be high as a result of the assigned readings and written responses, they understood their necessity for being able to engage in the intellectual class discussions. Something that I have learned over my many years teaching this course is that providing guiding questions, and better summarizing the discussion and reading before the end of class lessens the anxiety students have over peer-learning. Essentially, instructor-led closure at the end of each student-led discussion is necessary. I do not think that students' complaints about workload and difficulty are about the writing per se, but rather are indicating the effort required to think through the assigned readings with the writing being an exercise in thinking (Haave, 2015a).

Most capstone courses are disciplinary in nature with students writing comprehensive exams, papers, or engaging in field research (Kinzie, 2013). Field experiences seem to have the greatest impact on learning outcomes. Kinzie (2013) suggests that reflection goes hand-in-hand with integration and that instructors need to be purposeful in guiding students through the reflective process in order for students to integrate their educational experiences. The Augustana biology capstone course does this by providing students with a reading guide containing guiding questions. One conclusion (Kinzie, 2013) is that the ability to integrate needs to be scaffolded into degree programs. Expecting it in the final year, without proper preparation, is not the best way to achieve integration. I have been attempting to address this with the introduction of e-portfolios in my sophomore molecular cell biology course (Haave, 2016).

Similar to what has been reported for other capstone courses (Humphrey Brown and Benson, 2005), the Augustana biology major capstone is time-consuming to teach. Unlike other reported capstone courses, the Augustana biology capstone is not an undergraduate research experience. Rather, it is comprehensive in nature providing students with the opportunity to reflect on the discipline and integrate their previous learning experiences. Students find our capstone to be significantly different from other courses, and recognize the difficulty in synthesizing previous learning.

Some biologists have reported concern (Carter et al., 1990) that traditional approaches to teaching (lecture and content) are insufficient to teach students to think critically, problem solve, and to collaboratively work as a team; a concern shared by Augustana biologists. Thus, I designed our biology capstone course to have students think critically and work collaboratively through writing, seminar presentations, and discussions understanding that

biological problem solving would be considered and developed prior to this course in our curriculum (e.g. specifically our sophomore molecular cell biology course, but also in other junior courses centered around the completion of a research project).

A faculty survey (Carter et al., 1990) found that few faculty were concerned with providing a summary course, research experience, a consideration of the history and philosophy of biology, or ethical questions in biology. In contrast, surveyed students indicated a desire that their biology program considers values and ethics (Carter et al., 1990). The Augustana capstone does this when considering why falsifying data is treated much more harshly by the research community than plagiarizing. The course also considers the values inherent in the questions we ask as biologists and how we frame our interpretation of the results; namely determinism vs indeterminism, destiny vs free will, genetics vs environment and experience. Our biology capstone examines how our worldview can impact how we frame our questions and interpret our data. Augustana biology students considering graduate school are encouraged to enrol in our senior courses offering an undergraduate research experience.

Some of the questions that have been raised (Carter et al., 1990) are addressed by our capstone course at Augustana. Using the history and philosophy of biology as the focal point for the course makes it accessible for students interested in a variety of biological sub-disciplines. This approach enables the integration of the different sub-disciplines of biology to which students would have been introduced in their prior years of study and also enables a review of biology in a new context without simply re-teaching introductory biology. Integrating people, history, and context into biology capstone courses can make biology relevant to students (Chamany et al., 2008) and is the approach taken by Augustana's capstone course which considers the history and role of individuals in the development of modern biology. The history of biology is rich and thus needs to be limited in scope to be addressed in a single capstone course. The Augustana capstone uses the thread of the historical relationship between evolution, development, and inheritance as its content filter using key texts (see a sample reading list in the 2009 course syllabus: http://aug.ualberta.ca/B411F2009) which do a good job of integrating these topics.

One of the advantages of including a consideration of the philosophy of biology as it developed over the last couple of centuries is that it addresses different modes of inquiry such as the reductive and holistic approaches of molecular and field biology. To limit the scope of our capstone course, I chose not to include a study of current biological literature, instead focusing on secondary sources which consider biology's philosophy and history. Our program, however, is designed such that students must take a senior course in biology which does consider current biological research. However, there is not one particular course that does this: students have the opportunity to choose a senior course in biology that is within their area of interest (e.g. microbiology, biochemistry, developmental biology, conservation biology). Thus, our capstone course provides an opportunity for students to consider the theoretical assumptions of modern biology and to understand the historical constraints that have influenced current biological concepts and experimental approaches. But our capstone course does not further develop students' biological research skills. That is developed by a second senior course requirement in our degree program. The Augustana biology capstone course integrates their prior knowledge into a coherent structure but does not attend to all skills necessary for students to become adept biological researchers: a single capstone course cannot accomplish all of the goals of a biology major, choices must be made.

It has been suggested (Carter et al., 1990) that biology curricula need to better address the interdisciplinary nature of the world's present problems and not teach biology in a vacuum or be isolationist in its approach to educating students. Rather, there needs to be an acknowledgement of the courses being taken outside of the major and attempts made to integrate biology teaching with teaching in the humanities and social sciences. The Augustana biology capstone takes this suggestion to heart with its focus on the history and philosophy of biology.

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Undergraduate Biology Students' Attitudes towards the use of Curriculum-Based Reader's Theater in a Laboratory Setting

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Abstract: In the undergraduate biology laboratory, many freshmen are apathetic towards the content of the course. Curriculum based reader's theater (CRBT) is an instructional method that can increase interest the students in the content of the course while improving student communication, collaboration and understanding. This research is an examination of the student's attitudes about participating in a non-traditional teaching method such as CRBT in a biology laboratory setting. A reflection document was given to the students before and after their experience with the CRBT in the biology laboratory to determine the attitudes of the students about the experience with this novel instructional method. Qualitative methods were used to code and examine the student reflections along with three other data sources. Most of the students were initially positive about performing a reader's theater as a part of the biology lab, while 81 % of the students who had originally negative perceptions of the reader's theater, changed their perceptions from negative to positive after the reader's theater experience. The findings of this research indicate that students respond positively to the use of curriculum based reader's theater in a biology laboratory as an alternative instructional method.

Keywords: science, undergraduate biology, drama, reader's theater, instruction, alternative instructional methods, curriculum, student attitudes, student perception, communication, collaboration, content knowledge

After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well. –Albert Einstein

INTRODUCTION

In my experience as an undergraduate biology laboratory instructor, I faced a constant battle to motivate students. Freshmen tend to be unexcited about the subject matter, as indicated by their detached stares, blasé attitudes and inability to see how the course will apply to their major or career goals. Passivity can be reduced and performance increased in the classroom when students are actively involved in the instruction (Nash, 2013). Collaboration, communication, and arts integration are all classroom techniques that can actively engage students in the instruction. As Zemelman, Daneils & Hyde (2005) stated, students need "more cooperative, collaborative activity"; the classroom should be "an interdependent community" (p. 8). Group activities that convey the content and foster positive relationships among the students can aid in the formation of this type of community classroom atmosphere (Stepanek, 2000). The Howard Hughes Medical Institute (Jarmul & Olson, 1996) stated that biology curriculum must reach beyond the standard curriculum to promote critical thinking and collaborative experiences. The National Research Council (2003) recommended that science laboratories implement project-based curriculum and "provide opportunity for students to work cooperatively in groups" (p.75).

Collaboration and communication can be increased in the science laboratory by integrated a curriculum based reader's theater (CBRT) as form of the dramatic arts into the science curriculum. According to Flynn (2007), CBRT is an excellent way to directly involve students in the communication of the content of the course while giving them opportunity to build collaboration skills in groups. A curriculum based reader's theater (CRBT) incorporates the content of the course into a reader's theater script that the students perform during the class. When students act out the content information, their ability to remember and retain the information is improved over listening to or reading the content, this has been described as the "enactment effect" by Rinne, Gregory, Yarmolinskaya, & Hardiman (2011), and occurs when students "physically acting out material leads to improved recall relative to simply reading or hearing material" (p. 91). As a science educator, I became interested in uncovering the attitudes of students towards incorporating drama or storytelling into a biology laboratory setting as I was exposed to these instructional methods in graduate school. Research has supported incorporation of a CBRT into the biology laboratory classroom curriculum (Brooks & Nahmias, 2009; Dorian, 2009; Fels 1999; Flynn, 2007; Prescott, 2003). I wanted to know how my students, college freshmen, would respond to such a radical shift from the traditional lecture-based

methods of science teaching. The research question framing this study is: What are the attitudes of undergraduate students toward incorporating a curriculum based reader's theater (CRBT) into a biology laboratory setting?

Literature Review

Fels (1999) incorporated drama into an integrated science class for pre-service teachers. Academic performance is defined by Fels (1999) as "a theory of performance as learning". Fels went on to say "it is through performance that cognition or learning may be realized". Fels (1999) investigated how dramatic performance of a scientific concept could be a viable pedagogy. The findings of this study suggest that the incorporation of drama and storytelling into instruction improved students' understanding of the content knowledge, improved students" ability to communicate science content knowledge, and improved students' skills for collaboration.

Fels and Meyer (1997) created performance opportunities in their undergraduate elementary education physical science class. Through inquiry the students were allowed to experience science concepts and then find creative ways to express their knowledge. This teaching method established a foundation of knowledge based on experience and helped the students develop new questions about the science concepts (Fels & Meyer, 1997). As the students began to express their knowledge of the concept through performative methods such as reader's theater, poetry, plays, and other arts and drama, Fels and Meyer realized that the students' level of knowledge was consistently increasing because of their appropriate use of science terms and concepts that reflected the original concept. The students' foundational knowledge developed through inquiry combined with the design of their performances opened new questions and depths of knowledge for the students to pursue (Fels & Meyer, 1997).

Brooks and Nahmias (2009) studied the engagement and vocabulary retention of a group of seventh grade students in a life science class using CBRT. They chose a narrative style book to teach the science concepts required by their state standards. The teachers assigned groups of students to write reader's theater scripts based on the book. Brooks and Nahmais (2009) determined that their project was successful because the students mastered the learning objectives, scored strongly on the vocabulary assessments, and communicated the science concepts clearly in their reader's theater scripts.

Ødegaard (2003) stated that drama in the science classroom "helps to develop knowledge development through complex negotiations of meaning" (p. 81). Two methods of using drama for science instruction were investigated in the study. These methods were using drama to enact abstract concepts and allowing the students to role play about science issues within a global context. The Ødegaard (2003) ethnographic case study was done in a British school for students between the ages of twelve and sixteen years of age. Observations and interviews with the students and teachers revealed that the students benefitted from the use of drama within the classroom as part of the curriculum. Drama helped teachers and students improve expression of science concepts, collaborate as part of a scientific community, and invest themselves as active participants of the curriculum.

Research Setting

This research was conducted at a small private liberal arts university in Texas in an undergraduate biology laboratory where I (the researcher) was employed as the biology laboratory instructor. The freshman level biology course is specifically designed for students who are science majors, and whose ultimate career goals include graduate school, medicine, pharmacy, physical therapy and other related fields. The laboratory room holds approximately twenty-four students around laboratory tables that seat four people. The purpose of the laboratory class is to complement the lecture style biology class by giving students a chance to build science laboratory skills that coincide with the biology lecture class. This research was implemented midway through the 2nd semester of the course, so as the instructor, I had developed rapport and relationships with the students over a period of six months previous to the implementation of the research.

Participants

The majority of the 57 study participants were college freshmen majoring in science or pre-health degrees. The class was a mix of male and female students whose average age was 18 or 19. The participating students were included due to their enrollment in a freshmen level course of biology for science majors and known as major's biology. The major's biology class had a laboratory requirement, which consisted of three hours in a laboratory environment per week. There were four different sections of the course; each of them presented with the curriculum based reader's theater and student reflection forms in the same manner. The choice of these students was purposive due to ease of access, prolonged engagement, and persistent observation by the researcher (Lincoln & Guba, 1985; Spradley, 1980).

Methodology

Qualitative research was determined to be the best fit for this research study because of its naturalistic setting, the instructor as a participant observer, and the open-ended research question (Denzin, 2001, Erlandson, et al., 1993; Lincoln & Guba, 1985). Rallis and Rossman (2011) also suggest that when researching new types of instructional methods, a qualitative study is appropriate. Since I wanted to

specifically capture the students' attitudes towards the use of CRBT as a novel instructional method in a science laboratory, a qualitative survey with open ended questions allows students to express their attitudes in a personal manner, as opposed to a quantitative survey that has pre-set attitude choices. In addition, student attitudes can be conveyed by students through body language and vocal expression within a classroom, which I captured through observation.

METHODS

As I began reflecting on how to incorporate drama in to the biology laboratory, I chose a simple laboratory exercise over the content for designing a testable research question. In my previous experiences, the freshman biology students often struggled with the ability to create a testable research question to design a research experiment around. Traditionally, a lecture or PowerPoint would be presented to the students about how to design a testable research question along with potential examples of good and poor research questions. I chose to write a brief reader's theater about fictional students who had designed testable and untestable research questions. I included examples of testable research questions and untestable research questions. After the reader's theater, the students would then begin drafting their own research questions for a simple scientific method based experiment they would perform at home as an assignment for the class. I did not tell the students before the lab began that our instructional time would be changed, I wanted to get an authentic student attitude response when presented with the idea of the reader's theater, so they did not know prior to the class time that they would be performing a CRBT. As the students walked into class, I handed them the short anonymous survey consisting of two open ended questions at the beginning of class. I instructed them to only answer the first question, "How do you feel about your biology lab teacher incorporating drama or storytelling into a biology lab setting?" The students had several minutes to think about their answers and record their answers on the survey papers. I then explained to the students that instead of giving the students a short lecture or directions in a bulleted list about completing a laboratory experiment, which was the typical procedure for the lab, I would be asking for volunteers to read a script, called a reader's theater. Several students reluctantly volunteered to read the short reader's theater script. A portion of the reader's theater script is included here:
Setting: 4 students, Mark, Jane, Sher, Quintin are standing in the hall talking about a lab project given to them by their teacher, Mrs. Jones.
Mark (disgusted tone): Ughh, Mrs. Jones wants us to do a science fair project, that is so 5th grade.
Jane: It's not that bad, and Mrs. Jones will help us.
Sher: I just don't get why she didn't like my idea.
Jane: Why, what was it?
Quintin: She hated mine too!
Sher: I just thought it would be interesting to know which lipstick is best.
Mark: what the heck does that mean?
Sher: you don't get it because you don't wear lipstick.
Jane: Well, what do mean, best? Best color, best lasting, what?
Sher: I don't know, which is just the best!
Quintin: Well, she said I needed to rethink mine and it is way better than that.
Sher: that's rude.
Quintin: I don't mean yours is bad, listen. I want to see which golf ball goes farther when you hit it.
Mark: Dude, hit it with what? A driver, an iron, a putter, what?
Quintin: Dude, driver, duh.
Mark: But, what if you hit it different each time? And there are way too many golf balls to hit, you would be golfing all day.
Quintin (grinning): that's the point.

The content of the reader's theater incorporated four main concepts of scientific method through designing simple experiments, they were: simplicity, organization, potential for replication, and practicality. These four concepts were written into the reader's theater, and were also assessed by the grading rubric for the student's experiments.

After the reader's theater, as a class activity, we discussed the different character's research questions within the reader's theater and why some would or would not be testable. After the discussion, I then asked the students to answer the next question on their anonymous survey which was, "After listening to the reader's theater, how did your perspective on incorporating drama into science lab change?" Before and during the reader's theater I made notes and observations about the climate of the classroom based upon student voice level and body language. After the class period, I recorded my experiences in my researcher's journal.

RESULTS

Data Sources and Analysis

Observations

The first data source was the researcher's participant observation written in field notes during the reader's theater activity. These observations were memoed in the field notes according to the suggestions of Charmaz (2010) and Corbin & Strauss (1990). Since the research question addressed the attitude of the student, I made an effort to document the climate of the classroom, the vocal expressions of the students, and the body language of the students.

The field notes taken during the participant observation were analyzed for emergent themes

(Lincoln & Guba, 1985; Spradley, 1980; Strauss & Corbin, 1994). Open coding was used to determine what indicated a positive student reaction or a negative student reaction (Lincoln & Guba, 1985; Strauss & Corbin, 1994). I documented the sounds of the students' voices, body language and facial expressions, and the climate of the class environment as a whole. Laughing, smiling, and a relaxed posture indicated a positive attitude toward the reader's theater, while frowns, silence, and stiff postures indicated a negative attitude of the reader's theater. This method of descriptive observation was done according to Spradley (1980)'s recommendation of documenting three primary elements of social situations which are place, actors, and activities. Here is an excerpt from my reflexive journal based upon my field notes memoed during the reader's theater.

The air in my classroom was a bit tense and thick as I announced that I needed 4 volunteers to "read something". There was a low chorus of "no's" echoing across the room, the faces of the students were apprehensive. I took a deep breath and mentally steeled myself for utter rejection and scanned the room for interested faces. Some students were nervously looking down at their desks, hoping I would not look at them, a few were looking back at me with tentative smiles, and those were the students that I honed in on. "Any volunteers?" I asked. There were two "I will's" that spoke up, a girl and a boy. The students came to the front of the room, I handed them their scripts and said, "This is a reader's theater. Go ahead and begin." One of the girls rolled her eyes, another scanned her page and smiled. One boy was obviously nervous and read his page intently, the other glanced at his page and did a fist pump, ready to read his role. The students began speaking.

As the reader's theater progressed, the students began to relax, smile, laugh, and make comments; this indicated a student perception of acceptance and even enjoyment. The primary emergent theme that arose from the observation data was that the students' attitude toward the reader's theater activity was apprehensive at the beginning of the reader's theater, but by the end the students' attitude suggested enjoyment and ease.

Student Reflection Document

The second data source was the student questionnaire. The students were given a sheet of paper at the beginning of class with two questions. They were informed that this questionnaire was to be anonymous. The questionnaire asked students to write responses for two questions: "How do you feel about your biology lab teacher incorporating drama or storytelling into a biology lab setting?" and "After listening to the reader's theater, how did your perspective on incorporating drama into science lab change?" The students were required to answer the first question before the curriculum based reader's theater began. The students answered the second question after the CBRT activity. The student survey gave the students opportunity to anonymously write their attitude toward the reader's theater in the biology laboratory before and after their experience. This document was collected immediately after the students wrote their responses to the reader's theater activity. Fifty-seven students completed this form. The two questions were on the same piece of paper and the students anonymously answered each respective question before and after the reader's theater. The data analysis indicated a primarily positive theme and a negative theme as the comments were coded according their positive and negative wording, as is shown in Table 1.

The words and phrases the students used to describe their feelings about the use of drama in the biology lab were the primary focus of the data analysis. The recurrence of words was noted in the analysis considering the context of the word. There

Table 1. Survey questions and thematic responses

Question 1-How do you feel about your biology lab teacher incorporating drama or storytelling into a biology lab setting?
• *Positive response-If it explains the material in a more exciting and effective way, I think it is a great technique*
• *Negative response - I think things should be kept more scientific in a lab setting*
Question 2 – After listening to the reader's theater, how did your perspective on incorporating drama into science lab change?
• *Positive response – My perspective grew stronger, I think it was very effective*
• *Negative response – Theatrics are fine every once in a while, but I prefer a lecture to theatrics when it comes to science.*

were three words that could be considered either positive or negative depending on the context and the opinion of the reader. The word, "ok" was used twelve times, and the word "fine" was used seven times. These words were not considered as positive because they may indicate lack of interest or passivity toward the activity. The word "interesting" occurred twenty times among the fifty-seven student responses, the word "fun" occurred thirteen times, the word "better" occurred ten times. Some of the negative words and phrases included, "don't like it" and "inappropriate." These only occurred once each in the fifty-seven student reflection documents.

Before the reader's theater, the analysis of the student language indicated that positive language was dominant in 41 of the 57 (72%) student reflections and negative language was prevalent in 16 of the 57 (28%). Again, this is prior to the implementation of the reader's theater. This data is compelling as 72 % of the students were open to the incorporation of drama into the biology lab before the reader's theater occurred. After the students actually performed the reader's theater, the positive language in the student reflections increased. Fifty-four (54) of the 57 (95%) total student reflections were primarily positive. Of the sixteen originally negative reflections, 13 of those students changed (81%) their response from negative to positive after participating in the reader's theater. This indicates that of the original 16 negative responses, only 3 remained negative (5%) after the reader's theater. A summary of this data is compiled in the graph in Figure 1.

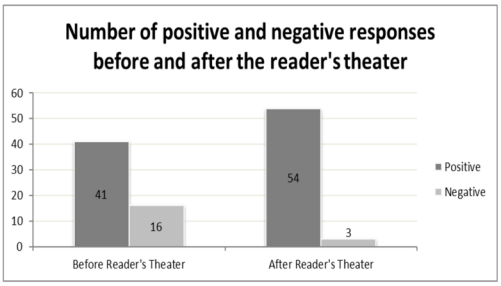

Fig. 1. Number of student positive and negative survey responses before and after the reader's theater

The Researcher's Reflexive Journal

The third source of data was a researcher's reflexive journal. The journal incorporated my own reflections about the experience with reader's theater in each of the lab sections and my reflections about the experience as a whole. The reflections were documented immediately after implementing the reader's theater in the laboratory.

Modified grounded theory (Glaser & Straus, 1967) was used to find emergent themes in the reflexive journal, the third source of data. The identified themes indicated disparity in my own attitude before and after the reader's theater activity, corresponding to that found in the documented participant observations. Before the reader's theater I had documented and observed apprehension and skepticism in the students. After the reader's theater, I observed a more relaxed, comfortable, genial atmosphere. I wrote,

Being a science person I would have never thought that art and science could mesh and be such a positive experience. These kids WANT this, they liked it, they need it. Apparently, they are desperate for something besides lecture and PowerPoint.

Trustworthiness

Lincoln and Guba's (1985) methods of triangulation of emergent themes from data sources were followed to ensure trustworthiness of the analysis. Emergent themes from the four sources of data were examined and compared for similar ideas. The common themes present in the three different data sources indicate a reliability of data, the credibility of the researcher, and the transferability of the data analysis, and the ability of another researcher to repeat and corroborate the researcher's claims. Purposive sampling, thick descriptive narrative, audit trail, and triangulation were done according to the qualitative research guidelines of Lincoln and Guba (1985), Erlandson, et al. (1993); Strauss & Corbin (1994) to ensure the trust worthiness and rigor of this research.

Discussion of Findings

Science teachers need to be aware and open to the idea that the incorporation of drama into a laboratory setting is an appropriate instructional strategy and appears to be supported by the students' positive viewpoints of such methods. One of my students wrote that incorporating drama in the science lab "would be a gratifying change"; another wrote, "it would be different and attention getting. It could also potentially relate the science to real world experiences", while another student wrote, "I will more likely remember the info from a more creative presentation of the material." The findings of this research indicate that students' attitudes towards new and different instructional methods, such as CRBT are primarily positive, and there seems to be a student need for a change from the traditional instructional methods in a college biology classroom and laboratory. This indicates that the freshmen participants were open minded towards alternative methods of teaching in a biology lab setting. The findings of this study are similar to the findings in the research of Fels and Meyer (1997), Ødegaard (2003), and Brooks and Nahmias (2009).

Assessment of Curriculum Based Reader's Theater Success as a Curricular Tool

In conjunction with the qualitative analysis of the student's viewpoints about the incorporation of the reader's theater into the biology laboratory, the

Table 2. Sample of assessment rubric for student designed scientific experiments

Concept	*Mastery of Concept*	*Knowledge of Concepts*	*Needs Improvement*	*Re-teaching needed*
Organized	Well thought out, implemented with precise procedure, data collected and displayed in an organized manner	Some evidence of organization, procedure, data collection and organization needs some refinement	Student did experiment on the fly with little planning or organization, data collected and displayed in haphazard way	No forethought about experiment, poor data collection and poor communication of data

students were required to design a simple experiment to perform at home and present in class as a graded assignment for the course. This assignment was graded by myself as the instructor of the laboratory and also independently by my laboratory assistant also with a degree in biological sciences to ensure reliability and consistency in the scoring of the grades for the assignment.

The rubric that was used to grade the student designed experiments included an evaluation each of the four concepts (Simplicity, Practicality, Organization, and Replication) presented in the reader's theater with a corresponding level of mastery. A "mastery of concept" level of evaluation means that the student had indeed mastered the concept, performed the skill in their investigation, and presented it appropriately. A "knowledge evident of concept" level of evaluation means that the student's knowledge of the concept was evident however, there is room for improvement to reach the mastery of the concept. A "needs improvement" level of evaluation indicated that the student made a good effort in the content area, but there were errors or room for improvement in order to reach mastery of the content area. A "re-teaching needed" level of evaluation indicates that the student was completely unable to show any understanding of the concept, did not make effort to understand, and needs significant intervention in order to achieve understanding. A sample of that rubric is included in Table 2.

The assessment data indicated 73% of the students mastered the four primary concepts illustrated in the reader's theater through designing, implementing and presenting a simple science experiment. Seven percent of the students showed knowledge of the concepts presented in the reader's theater within their experiment, but refinement was necessary. Twenty percent of the students showed some comprehension of the concepts from the reader's theater in their science experiments, but they needed to improve on one or more of the four basic components of scientific method. While zero percent of the students were rated as needing re-teaching of the concepts from the reader's theater. The assessment data is summarized in *Figure 2*.

DISCUSSION

The findings of this study indicate that incorporation of drama into a laboratory setting is an effective instructional strategy and appears to be supported by the students' positive viewpoints of such methods. One of my students wrote that incorporating drama in the science lab "would be a gratifying change"; another wrote, "it would be different and attention getting. It could also potentially relate the science to real world experiences", while another student wrote, "I will more likely remember the info from a more creative presentation of the material." The findings of this research indicate that students' attitudes towards new and different instructional methods, such as CRBT are primarily positive, and there seems to be a student need for a change from the traditional instructional methods in a college biology classroom and laboratory. This indicates that the freshmen participants were open minded towards alternative methods of teaching in a biology lab setting. The findings of this study are similar to the findings in the research of Fels and Meyer (1997), Ødegaard (2003), and Brooks and Nahmias (2009).

While this study primarily focuses on the student participant's responses to the CRBT, there is also value in the assessment of the student's ability to synthesize the information from the reader's theater and design, perform, and present an actual scientific experiment. The majority (80%) of the students in

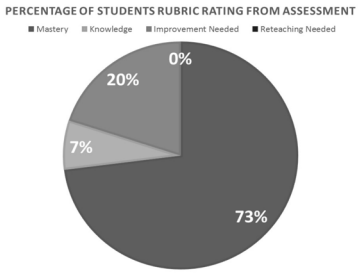

Fig. 2: Assessment results indicating student's ability to design and perform their scientific experiment

the biology laboratory were able to master or show knowledge of the concept illustrated by the reader's theater and were able to successfully design, implement, and present their own scientific research, and for many it was their first time to do so. Science teaching should be empowering students to design research, collect their data, and present their findings, this laboratory curriculum accomplished that goal.

Educational Implications

Science teachers need to realize that the time is right to exchange their traditional science teaching for alternative instructional strategies. According to the American Association for the Advancement of Science (AAAS) document *Vision and Change for Undergraduate Biology Education: A Call to Action* (Brewer & Smith, 2011), students are ready for professors to implement different instructional strategies in the biology laboratory that provide the students "more opportunities for creativity" (p. 30). *Beyond Bio 101* (Jarmul & Olson, 1991) states that future scientists need to be able to "write and speak clearly, work in groups, and act ethically" (p.27). A CBRT activity trains students to do all of the above as they participate in active and collaborative experience while learning to understand and communicate the content.

Conclusion

Max Planck (1968), father of quantum theory, proposed that pioneering scientists "must have a vivid intuitive imagination, for new ideas are not generated by deduction, but by an artistically creative imagination" (p. 109). The freshmen biology students in this study were not only ready and willing participants in the reader's theater, but were also receptive to the incorporation of the reader's theater into the laboratory environment as an alternative method of teaching. The findings of this study suggest students are ready for change in methods of science education. May they inspire the teachers to change as well.

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The Evolution of Student Engagement: Writing Improves Teaching in Introductory Biology Courses

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Abstract: In response to calls for pedagogical reforms in undergraduate biology courses to decrease student attrition rates and increase active learning, this article describes one faculty member's conversion from traditional teaching methods to more engaging forms of practice. Partially told as a narrative, this article illustrates a.) the way many faculty initially learn to teach by modeling the pedagogy from their own undergraduate programs; b.) the kind of support biology faculty may need to break out of traditional molds; c.) how writing can promote active learning; and d.) the impact of reformed pedagogy on student levels of engagement. The latter will be demonstrated through assessment results gathered from student surveys, reflective writing, and focus group interview. Ultimately, the study challenges misunderstandings some faculty might have regarding the value of writing in science classes and offers inspiration, urging critical reflection and persistence.

Key Words: traditional science pedagogy, high-impact practices, writing in the disciplines, student engagement, faculty development.

INTRODUCTION

Central to the study of evolutionary biology is the premise of adaptation for survival. However, some biology faculty have not recognized the changing environment in higher education and adjusted their teaching practices to be more suited to the needs of today's students. Traditional STEM teaching methods rely heavily on lectures, large classes, and multiple-choice exams. In some cases, the faculty member serves as the content expert and acts as a gatekeeper, "weeding-out" students deemed unfit to handle the course material. In this way, the burden of learning can rest heavily on the students' shoulders; the teacher may bear little responsibility for optimizing student success. Traditional pedagogical approaches promote a competitive culture that permeates STEM fields, signaling to "many potential students that they do not fit in…or are not welcome" (Baldwin, 2009, p. 11).

Science pedagogy literature identifies some of the potential harms associated with this culture. According to Hannauer and Bauerle (2102), perhaps most notable is students' failure to persist in college science classes at a national rate over 50%. Reasons for this range from lack of preparation to lack of engagement caused by perceptions of the courses as impersonal and irrelevant. With nearly one-third of undergraduates enrolled in a STEM major, with biological sciences the most popular field (Chen, 2013), steps should be taken to right the wrongs. Moreover, the increasing accountability pressure on colleges and universities for outcomes-based competency (Cowan, 2013; DOE, 2015) might mandate such reforms.

STEM fields are looked to for solutions to some of society's most pressing problems, but identifying these solutions "requires attracting and retaining new generations of creative and versatile scientists who are well prepared to participate in fast-paced, information-rich, collaborative forms of science" (Hanauer & Bauerle, 2012, par. 2). This new generation of scientists must be drawn from a "broad and diverse talent pool of students who are interested in science" (*ibid*). Therefore, concern over the STEM attrition crisis has led to the launch of numerous initiatives. Amongst plans for improving student retention rates is reform of the classroom experience. Programs increasingly look for strategies to better support and engage students in their learning. Not surprisingly, a frequent suggestion is for science faculty to include more writing in their courses. Writing appears on Kuh's (2008) list of high-impact practices, is identified by Bean (2001) as "the most intensive and demanding tool for eliciting sustained critical thought" (xiii), and can create more authentic and inviting occasions for learning (Bain, 2004, 62-63). Moreover, "the relationship between the amount of writing for a course and students' level of engagement…is stronger than the relationship between students' engagement and any other course characteristic" (Light, 2001, p. 55).

The arguments for writing in the sciences are grounded in the beliefs that writing is thinking

(Menary, 2007), that writing can deepen learning by activating priming, calibration, chunking, synthesis, reflection, elaboration, and metacognition (Brown, Roedgiger & McDaniel, 2014), and that writing can empower student success by giving students space to digest course material, raise questions, and formulate opinions in ways that honor student agency (Gottschalk & Hjortshoj, 2004). Nevertheless, writing can be slow to make its way into widespread accepted practice in science classrooms, or when it appears, it primarily is used as an assessment tool (e.g., short answer questions on an exam) (Kalman, Aulls, Rohar, & Godley, 2008).

However, this study presents a possible avenue for reform - by integrating writing more comprehensively into daily classroom practice. This approach can transform both student learning and faculty teaching experiences. Also, it neither requires special faculty training nor necessitates sacrificing content or standards. Because science faculty training can create a culture where writing-as-learning is not standard, this article will briefly discuss that acculturation process. It will then describe how that norm might be disrupted and the subsequent effect on students, using surveys and focus-group interviews.

Inherited Practice: How Science Faculty Learn to Teach

Many faculty are initially drawn to careers in science by inspiring K-12 teachers. Unfortunately, graduate programs in the natural sciences generally train research specialists, not *teachers* of biology. Therefore, many science faculty learn to teach through models of traditional pedagogy from their own undergraduate programs. These models suggest that to be "challenging," faculty have to be perceived as "hard," which often means many students earning Ds and Fs. There is an assumption that "competent" students will easily understand material and do well on exams. High standards and efforts to optimize student success are mutually exclusive (i.e., in order to have "winners," you have to have "losers"). While some faculty might try to make lectures memorable, "teaching" primarily means delivering all of the concepts itemized in the syllabus: a "checklist," the completion of which means students are ready for the next course in the program's sequence. Because such inherited pedagogical practices are the product of social reproduction (Bourdieu & Passerson, 1990), they are often unquestioned but can have dire effect on students. None of these beliefs or practices is necessarily spurred by malevolence; it is simply how things are done. However, in uncritically accepting the norm, even well-meaning biology faculty can become gatekeepers.

METHODS

Adding Writing and Changing Pedagogy

The following study features pedagogical experiments testing alternatives to traditional teaching practices. The endeavor is framed as narrative to capture the emergent way the reform evolved, and the authors hope that others might identify with the authors' concerns, benefit from their insights, and generalize from these particular endeavors to strengthen the experience of biology students across the board.

This study was started in 2014, in co-author and biology faculty member Land's 4th year after tenure at a mid-sized, comprehensive, private university. At this time, he happened to teach a summer school course that had very low enrollment (by biology standards), only 22 students. It was impossible to ignore the fact that this group was far more engaged in their learning than generally found in his larger classes. Thinking like a scientist, he wondered why and began imagining pedagogical experiments. However, he might never have tested any of his theories were it not for another serendipitous event. In the fall, he joined a science faculty learning community, sponsored by the campus Writing in the Disciplines Program, run by co-author Camfield. He was initially hesitant to join because the main requirement was to incorporate more writing into classes, questioning how he might do that with 80-100 students per class. However, in part because of his friendships with and respect for the members of the group, he decided to try. During monthly meetings with science faculty from geosciences, mathematics, and physics, they discussed strategies: ideas for lab notebooks, process-narration of mathematical problems, and capstone essays. However, Land's doubts continued to persist and took two forms: practical (e.g., Where was there room for more writing in introductory biology?) and cultural (e.g., How would adding writing impact the rest of the biology department, since there were multiple sections of the course?).

Nevertheless, he began to reflect. In upper division courses, students are often expected to compose research papers, grant proposals, and posters – even though students are never formally taught writing in courses beforehand. Contemplation of this dichotomy created a more focused question: When should programs incorporate writing into the curriculum? Perhaps the best time is during students' foundational experiences in introductory biology. Writing not only helps stimulate critical thinking but also helps students develop the organizational study skills that could help them navigate a major that has traditionally been a "weeder." It also signals that writing should be expected in all classes, including science courses.

In spring 2015, for two sections of introductory biology (one with large enrollment, one with small) Land added a major essay question on each of the three major midterm exams. The students were taken aback. Nothing was done to allay their misgiving; they were just expected to write. No surprise,

answers and their attitudes about writing were lackluster. He was also overloaded with grading. One might term this experiment a failure.

Even More Writing

Land recognized that the first hypothesis (that merely adding writing would automatically improve student learning) was incorrect. In the fall 2015 semester, he became more intentional, also keeping "field notes" about what he observed in his classrooms. At Camfield's suggestion, he became more transparent in his teaching, explaining to students that writing could be a means to improve their understanding of the course material. This effort involved implementing short daily "writing wraps" at the end of each class where students summarized two main points from the lecture (Angelo & Cross, 1993). His intention was to give them practice so they would do better on the exam. Soon he came to realize that the wraps did much more, but first he had to push through student recalcitrance. Initially they resisted writing wraps; the responses he received were either blank or incomprehensible. He explained that failure to complete a writing wrap could be due to poor attention skills or a lack of preparation for class. In class discussions, he asked the students to reflect on the reasons why they were struggling. In dedicating this time, he simultaneously signaled the importance of this activity and helped students practice metacognition. They persevered. After a couple of weeks, students were anticipating the wraps at the end of class and there was improvement in their quality. From a workload perspective, it is important to note that he did not read every student's wrap, but he did collect all of them and scan the responses to derive general impressions. He also encouraged students to use writing wraps outside of class as a study tool.

At the same time, he became more mindful about how he was constructing essay exam questions and became much more careful about providing instructions for how students should compose an answer. As his questions became more focused and manageable, he also talked with students about thesis writing, supporting paragraphs, and concluding with a "wow effect." Essay responses on the first midterm were better than the previous year's. He believed there was a direct link between the wraps and this improvement, but he knew it could be even better. So, instead of summaries, he started having students write thesis statements that captured the day's class. This encouraged students to actively engage during the class and to spot relationships between concepts. Students rose to the challenge, and attitudes about writing were improving. They had almost 100% participation (even though the wraps were still not mandatory) and used this format for another 2-3 weeks in the semester.

He then had students peer review one another's thesis statements for the rest of the semester, arguing that two students might not have the same statement and that it was valuable to see what others surmised. He gave students about 5-7 minutes at the end of each class to analyze things like relevance, breadth, and depth. Students were encouraged to be critical, to disagree, and to not just rubber-stamp their peers' papers as "good," but to also avoid being overly harsh or unfair.

To be clear, the intention of adding writing to the class was not to make them master writers by the end of the semester but rather to help them more actively engage in their learning and to change their attitudes about writing in science classes, recognizing it as an excellent study tool for digesting course material. Land argued that clear writing was indicative of clear, logical thought processes and muddled writing was often reflective of illogical or unorganized thinking. In this way, he hoped to move students from seeing memorization and regurgitation as the main learning tasks of the class. Moreover, he no longer took it for granted that students knew how to study for the class and kept up a steady stream of general tips and strategies.

Along the way he became more understanding of students' frustrations and responsive to their expressed concerns that the exam time limits forced them to rush on their essays and do less-than their best work. Therefore, he began offering the opportunity for them to revise their midterm essays for a small number of points. At the end of the semester, students also had to reflect on their own development as writers by assembling a writing portfolio of their 3 essays, the 3 (optional) revisions, and a survey of their attitudes about writing.

RESULTS

Impact on Students

Because the authors of this article did not set out with the intention of studying the impact of these pedagogical interventions on student *performance* in biology class, it is difficult to make claims in this area. As published elsewhere (Camfield, McFall & Land, 2015), we knew that students in smaller classes out-performed their counterparts in larger classes on exams and in labs. Moreover, student writing in the wraps and on the exams seemed to improve over the course of the semester, from stream-of-consciousness associative writing to more focused arguments. We also have published elsewhere on the importance of positive student *dispositions,* particularly self-efficacy, as a proxy for subsequent skill development (Camfield, 2016) and on the degree to which student *attitudes* are more malleable in the short-term than their abilities and, therefore, are worthy of assessment (Camfield, 2015). For the purposes of this study, understanding student degrees of engagement with their learning best demonstrates the impact of the changes in the faculty's attitude and pedagogical strategy. Evidence was gathered from students using

three instruments: a comprehensive survey, the writing portfolio learning reflections, and a summative focus group interview.

The survey

The survey was distributed as a write-in questionnaire at the end of the semester to all students enrolled in both sections of the introductory biology class. Students were given class time to complete the surveys, Land was not present as they were being completed, and students were assured of anonymity. Results pertaining to student attitudes about their levels of engagement with the course (i.e., senses of relevance, enjoyment, empowerment), about their perceptions of the faculty member's engagement with their learning needs, and about their own learning were illuminating, indicating extremely positive attitudes about the course and the instructor. Interestingly, responses from the larger class seemed even more favorable than those from the smaller class, even though grades were higher in the smaller class. More significantly, the vast majority of students believed they could best demonstrate their learning through writing, not multiple choice questions. Given that this was a specific pedagogical innovation being tested in the classes, understanding more about student attitudes about writing further reveals the impact of the course.

Writing portfolio reflection.

At the end of the semester, students were asked to gather their exam essays and optional rewrites into a writing portfolio for which they were required to compose a reflective statement. In addition to narrative responses, students were asked to evaluate their attitudes about writing (Fig. 1) and about themselves as writers (Fig. 2) based on a Likert scale. As with the previous survey, responses here were positive.

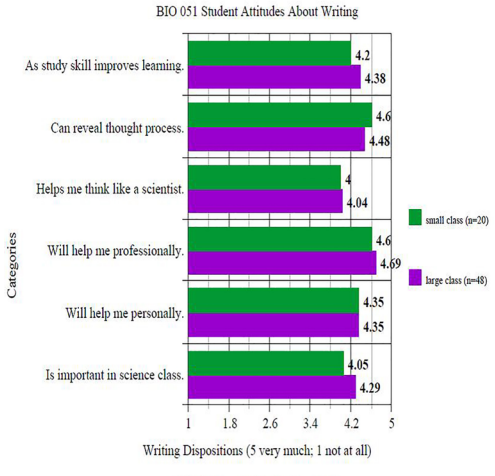

Fig. 1. Student attitudes about writing.

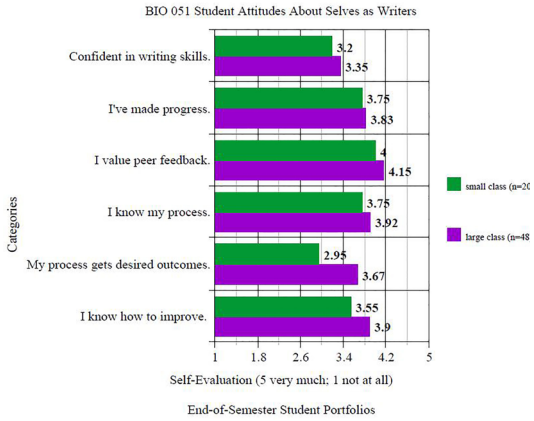

Fig. 2. Student attitudes about themselves as writers. Student attitudes about themselves as writers were a bit more modest, but still informative.

Most salient is the fact that all students recognized they can benefit professionally from writing well. Also gratifying was the fact that all students reported strongly valuing feedback from their peers, indicating they recognized how writing wrap peer reviews improved their communication of key ideas. Further, positive attitudes about peer review signaled student readiness for participation in collaborative forms of doing science.

Focus Group Interview

What closed-ended surveys miss is the nuanced and organic quality of face-to-face conversation. In order to illuminate and understand students' lived experience of the classes, on the day the surveys were distributed, students were offered the opportunity to sign up for a focus group interview conducted by Camfield and a graduate student assistant. The interview was pitched as an opportunity for students to add detail to or raise issues not captured by survey items. Participation was voluntary, their identities would not be shared with the instructor, and their only compensation was a pizza lunch. The small group, composed of students who all had Land for the entire year (both fall and spring), met for an hour. Conversation was subsequently transcribed verbatim and coded for themes pertaining to engagement.

Some of these themes that related to liking the course simply confirmed what the survey had previously revealed. Other more complex motifs emerged. For these, the students' own words will be used to capture their depth of meaning. Students extolled Land's lecture style; they referred to his "stories" that made concepts memorable and called lectures "more like conversations." His "interactive" approach "forced you to think on your feet" which "gave more motivation to learn biology." Many associated this with being in the smaller class and compared Land's teaching style favorably against their high school experiences.

The writing wraps were seen as "extending the conversation" beyond the lecture and allowed students to identify Land's "code words" that signaled a concept was likely to appear on an upcoming exam. The wraps helped "brainstorm for the essay in advance." One student observed that "biology is a lot of facts and to be able to put them all together [through writing] really helped me understand biology in general." Writing on the exams provided "a way of taking smaller concepts and making connections [so that] you were almost re-learning it while you were writing the essay." Essays allowed them to "defend their ideas" and "explain their thought process" in ways closed-ended multiple choice questions did not.

However, many did not start the semester with such a positive attitude about writing. Initially some thought it was "tedious" and doubted they could "encompass everything down into one idea." One student confessed she "didn't understand the purpose of it at the beginning" but came to see the wraps "helped you come up with ideas for the essays." When asked if Land should have better explained the purpose of the wraps, other students chimed in that he did do that effectively: "He said you should be able to summarize the things you learn simply, to show that you actually understand it." Indeed, they appreciated his recommendation that they write wraps in all of their classes because "it's important to be able to see the connections." Many then described links between their biology and chemistry classes.

The focus group also fleshed out the ways they believed writing would benefit them professionally. One particularly memorable response came from a student who connected his father's professional struggle as a dentist whose first language is not English to his own future work as a dentist, recognizing the need to communicate with colleagues "clearly and memorably." Another was well-aware that while she would "not have to write a thirty-minute essay in [her] professional career," she would have to "organize her thoughts" and "make sure concepts are clear in her head." The "process of writing" was important.

They valued peer feedback because it gave learners a "safe space to test out ideas" and to "see if others could follow the [author's] thought processes." Students lauded Land's direction to just "find something the author could add, even if it's not something that is wrong." It seemed particularly liberating to be able to offer suggestions as "just a thought."

Interestingly, several students were surprised to learn Land's reputation according to students in other sections of introductory biology: "In lab, everyone asked me 'who's your lecture professor,' and I said 'Land,' and they said 'I'm so sorry for you; he's so hard.'" Yet, the students in the focus group did not believe they were deserving of sympathy. They recognized: "He wants you to understand…to learn better. You realize actually he's helping you figure things out for yourself rather than him just giving you the answer." One said: "A lot of people are afraid of his teaching style and the writing, but I think it's actually really effective and more professors should do it." They believe he has "adjusted" his techniques, becoming not easy, but "what he does makes more sense." Students also recognized in making his PowerPoint slides available before class, in providing sample test questions, and in allowing rewrites of the exam essays, he was setting them up to be successful.

Others favorably compared their experiences in Land's class to the experiences of their friends in other sections of biology. One revealed his sense of empowerment when he reported:

"I was studying with some people who don't have Dr. Land and they were just going through the material trying to memorize terms. They were trying to convince me that I didn't need to interact deeply with the material at all, just to memorize surface stuff. It was actually very irritating because I was like, 'No, it is important that you understand because…you might actually discover something.'" They were inspired by Land's "passion" and "intensity," and this extended outside of the classroom. They believed "you have to make life a field trip," not "like high school where you're just regurgitating for a test." Affectionately, they confessed: "Because Land is such a character, he doesn't make you feel weird for wanting to know more or for wanting to ask more questions or to do outside-of-class thinking." In their peers from other classes they "don't see that as much." Land has entered their hearts and minds to the extent that for some he has become an ally, an inner voice: "Sometimes you can be eating or walking to class and you suddenly say something weird biologically-related. Inside you'd be like 'Land would be proud,' even though I might sound weird right now, at least someone gets it."

Such rich, thick description of the student experience partially demonstrates the power of engaged pedagogy, but what about its impact on the teacher?

Impact on Faculty

Looking back, Land realizes the degree to which he had become somewhat dissatisfied with his teaching, how far he had drifted from the impulse that initially impelled him to become a biology teacher. Ironically, while he feared the grading load associated with added writing, he underestimated that the corresponding exhilaration would offset the extra labor. The experience is one that demonstrates the reciprocal nature of gratification. As Land became more inspired, his students became more engaged, which in turn triggered his creativity and commitment – a beneficent cycle.

DISCUSSION

Readers may take note of three salient aspects of this narrative. First, throughout this process Land drew on his training as a scientist: He began experimenting with new teaching approaches, developed hypotheses, tested his ideas, kept field notes, recursively tweaked experiments to elicit different results, and developed a new theory that informed his pedagogy. Thus, even though it initially felt alien for him to include writing in his curriculum, he tapped into a methodology with which he was very familiar. Through the iterative process, Land came to realize he had the expertise to include writing-as-a-learning-tool and doing so did not necessitate sacrifice of essential course content. "Teaching like a scientist" also provided his students a model for their own inquiry, improving their perceptions of their learning, experiences in lab, and overall attitudes about the role of writing in studying and thinking. In these ways, "teaching like a scientist" can enhance the teacher-scholar model that has been adopted by many liberal arts colleges nationwide.

Secondly, some faculty fail to persist if a pedagogical innovation fails the first time it is tried. Land stuck with it and discovered that the antidote to bad writing on the mid-term essays (year one) was *more* writing (wraps with peer review, year two), not *no* writing. Therefore, sometimes pedagogical solutions may feel counter-intuitive but are worth exploring. The strong relationships he forged with key faculty development administrators also helped activate changes in his perspective and sustain his persistence. Additionally, intentional efforts to change one aspect of a course can trigger other efforts toward improvement (i.e., you cannot just "fix" one thing). Conversely, those things that are barriers to student learning success may also be barriers to faculty gratification.

Thirdly, the inherited practice that colors some faculty members' attitudes about student success – that in order for there to be winners, there must be losers – must be critically examined. Readers should note that Land changed nothing in his curriculum; he simply made efforts to ensure all students received instructions on how to study effectively. There is a saying that a rising tide lifts all boats. When applied to undergraduate biology classes, we can say more engaged teaching empowers all students, and instructors can be lifted along with the tide.

Land's departmental colleagues have become interested by what he is doing. "Engagement contagion" spreads – although more slowly than expected. It took almost two years for some to get curious; now another colleague will be implementing periodic writing wraps in her upper division genetics course. This will provide an opportunity to compare the retention of material, depth of thought, and quality of writing between students who had writing in their introductory classes and those who did not have those experiences. The authors of this article also move forward with increased commitment to optimize student success and intend to continue experimenting. Up next will be piloting writing intensive sections of introductory biology courses for "at risk" students with enrollment caps of 20 students and with take-home essay exams that allow students ample time to express their thoughts. As we determine the best ways to sustain our model, we move forward with optimism.

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ACUBE 60TH MEETING ABSTRACT SUPPLEMENT

Association of College and University Educators

60th Annual Meeting October 21-22, 2017

Hosted By

Cardinal Stritch University

Keynote Speaker: Annie Prud'homme-Généreux

Quest for a Meaningful 21st Century Education

What would you do if you had the opportunity to create a teaching-focused university from scratch? How would you structure the degree? What would you prioritize? A decade ago, I embarked on a journey to create Canada's newest university: Quest University Canada. Hired a year prior to opening, the five founding faculty wrestled with what it means to educate someone in the 21st century. We questioned conventions and wisdoms about higher education, researched the latest findings about learning and the brain, and reflected on our modern world and what an educated citizen ought to know to be successful contributing members of society. Similar discussions are happening throughout most university campuses across North America, but we had an advantage: a blank slate upon which to act on these discussions. We were afforded the freedom to design a liberal arts program that we thought would achieve our goals and to build an entire university structure in support of it. The experiment has been on-going for nearly a decade, has garnered attention by topping the rankings of the National Survey of Student Engagement, and is serving as a sandbox for pedagogical experimentation that informs the decision of other institutions. What did we do with our blank slate? What did we prioritize and how did we set out to achieve them? What were the responses and the outcomes? What happens when these ideas that academics are discussing everywhere are given the opportunity to take form? In this keynote address, I will reflect on my experience at Quest and what it has taught me about education, learning, teaching, faculty, students, and the university system…

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PRESENTATION, ROUNDTABLE, AND WORKSHOP ABSTRACTS

PRESENTATIONS

Stereotype Threat in Introductory Biology

Natalia Taft and Cathy Mossman, *University of Wisconsin Parkside*

Stereotype threat can be defined as distress associated with the prospect of confirming a negative stereotype about a group to which one belongs. Previous work has shown that stereotype threat is associated with lower performance in science courses in several groups including underrepresented minority groups and first-generation college students. At UW Parkside there is a much higher proportion of first generation students (52.9% in the 2015-2016 academic year) than the national average. We also have a relatively high proportion of underrepresented minority (URM) students (over 20%). Our population, therefore, is potentially at risk for stereotype threat in large science courses like introductory biology. I chose to implement an experiment implementing a one-time, brief (15-minute) values-affirmation writing intervention and a control exercise in the first week of an introductory biology course. In this exercise, students in the experimental group select three values from a list of 13 values and write about why those values are important to them. Despite its simplicity, this values-affirmation writing exercise has been shown to positively affect performance in first-generation and underrepresented minority groups. This intervention was based on a study performed at the University of Wisconsin-Madison that demonstrated that a similar values affirmation intervention significantly improved course grades and retention for first-generation students. The current study was conducted in the fall of 2015 and spring of 2016 in four different sections with three separate instructors of BIOS 102: Organismal Biology. This course is an introductory course that is mandatory for prospective biology majors. In this study, students who had the opportunity to affirm their values in writing in the first week of classes showed a 7% better performance on their average exam scores for the semester. In contrast to previous work, all students benefitted, on average, from participating in the values affirmation compared to control, not just first generation students. This includes males and females, continuing and first-generation students, URM students and non-URM students. Although there was still an achievement gap between URM and non-URM students, URM students participating in the intervention had an 8.5% increase in exam performance overall compared with those in the control group. In contrast, there was not a significant gap between first generation and continuing-generation students. This suggests that stereotype threat can work differently at different college environments, and more work needs to be done to explore this issue on different types of campuses.

PLTL Enhances Retention in STEM Majors Among Women and First-Generation College Students

Jeremy D. Sloane, Julia J. Snyder, Ryan D. P. Dunk, Christina I. Winterton, and Jason R. Wiles, *Syracuse University*

Expanding diversity in Science, Mathematics, Engineering, and Technology (STEM) fields is important for reasons of equal representation as well as for the benefits to these fields that accompany diverse perspectives among participants. Additionally, the President's Council of Advisors on Science and Technology has called for a drastic increase in the number of STEM college graduates produced by the United States. In order to remain economically competitive, we must identify and adopt teaching methods that have been empirically validated by research to enhance achievement and persistence in STEM majors. In particular, efforts need to be made to support women and first-generation college students who are underrepresented in the STEM population. Peer-Led Team Learning (PLTL) is a pedagogical approach that appears to satisfy much of what PCAST deems necessary to improve student persistence in STEM—including providing role models and an opportunity to interact with peers and grow STEM identity—and as such may improve rates of recruitment into and retention in STEM majors. Herein, we present the results of a study that indicate that the gaps in retention rates between men and women as well as between first-generation and non-first-generation college students are both closed when students participate in the PLTL model. We recommend adoption of this model, or any similar active learning strategy, at all institutions in order to satisfy PCAST's call for a drastic increase in the number of STEM majors produced by our country and to increase diversity and equity in STEM fields.

Online Student Default Rates During Different Semesters: Rethinking Online Offerings

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

Online courses are already known to have higher default (missed exams or course abandonment) rates than face-to-face courses. I have analyzed several years of course default rates on an online version of our two-course sequence of Human Biology. The data reveal that online course defaults occur at a higher frequency during summer semesters than during Fall and Spring semesters. I will compare exam and course default rates and compare/contrast these differences with those occurring in face-to-face

classes. I will also discuss implications of the results in terms of curriculum, course scheduling, and student success.

A Multifactorial Analysis of the Acceptance of Evolution in College Students

Ryan DP Dunk, *Syracuse University*, Andrew J Petto and Benjamin C Campbell, *University of Wisconsin-Milwaukee*

Despite decades of reform to improve evolutionary understanding and acceptance, little change has occurred in the number of people who accept evolutionary explanations of life's diversity as compared to supernatural ones (Gallup 2014). This rejection of biology's overarching theme leads to an inability to correctly understand and an inability to reason appropriately regarding biological phenomena (Dobzhansky 1973). In addition, science denial by those responsible for setting policy leads to poor potential outcomes regarding future funding for biological sciences. It is for these reasons and more that a public literate in evolutionary biology is not only desirable, but necessary. There are a multitude of different factors that have been shown previously to affect acceptance of evolutionary biology: measures of epistemological sophistication (Sinatra et al., 2003; Deniz et al., 2008; John et al., 2008; Hawley et al., 2011), knowledge of evolution (Rutledge and Warden, 2000; Deniz et al., 2008; Carter and Wiles, 2014; Barone et al., 2014), higher education levels (Mazur, 2004; Heddy and Nadelson, 2013; Wiles, 2014), an understanding of the nature of science (Johnson and Peeples, 1987; Rutledge and Mitchell, 2002; Trani, 2004; Cavallo and McCall, 2008; Carter and Wiles, 2014), and strength of religious beliefs (Mazur, 2004; Trani ,2004; Nehm and Schonfeld, 2007; Moore et al., 2011; Heddy and Nadelson, 2013; Barone et al., 2014; Carter and Wiles, 2014).While all of these factors have been shown to be related to acceptance of evolution, very few studies include multiple factors (especially in the same model), and to our knowledge none exist that include all of them. This is the aim of our study. Specifically, we predict that, when analyzed together, greater epistemological sophistication, evolutionary content knowledge, higher education levels, and understanding of the nature of science will increase acceptance of evolution, while higher religiosity will decrease acceptance of evolution.

Biology for the Greater Good: Factors Related to Biology Career Aspirations of African American College Students

Alissa Hulstrand, *Northland College* and Ronald Ferguson, *Luther College*

Despite the frequency of reform initiatives within higher education regarding equity and access, African American students remain underrepresented in the sciences. The life sciences have not been immune to the dearth of future black scientists. The scope of this research was to examine potential factors that affect African American students' choice of a career in biology. To assess students' career priorities, we analyzed data from the Persistence Research in Science and Engineering (PRiSE) project, a study that surveyed 7505 college students. Among factors included in their choice of biology as a career, African American students reported that biology was most desirable as a career when there was an emphasis on science as a means of social justice and community support. As educators, institutions, and policy makers pursue strategies to confront continuing inequities, such findings could potentially shape how biology instruction may evolve to meet the needs and desires of future African American biologists.

Addressing, "How Does This Relate to my Degree?"

Fara Dyke and Sarah Powell, *Grantham University*

We have all had students confront us with this questions. As a result, we decided to address this issue through formal research. We will share our methods and results for helping students make career and content connections. Whether you teach face to face, blended or fully on-line you will find this interactive session useful. Take away fresh concepts to enhance your classroom and engage your students.

Changing Attitudes Toward Active Group-Based Learning and Increasing Performance in a Large Biology Course for Nursing Majors

Christopher Mayne, R. Charles Lawrence, and Michael Alfieri, *Viterbo University*

Current best practices in biology suggest increased use of active learning strategies as opposed to traditional lectures. Active learning-based approaches have led to increased student engagement and performance in numerous science courses, yet implementation of these techniques in foundational science courses for nursing majors has been more limited. This population is of particular interest since these students often have challenges recognizing the relevance of basic biology to their professional practice, leading to decreased engagement in the course. To meet this challenge, we implemented an active group-based learning technique in our first-year anatomy and physiology series for nursing majors. Our collaborative approach emphasizes a student-centered strategy using a learning cycle of exploration, concept invention, and application. We will discuss the initial reactions among the students to this approach and our continued efforts to improve acceptance, the educational experience, and student success. We will also present quantitative and qualitative data over four years focusing on student performance and changing attitudes toward active

group-based learning in introductory anatomy and physiology.

Graduate/Postdoc Teaching Experiences with CREATE at the University of Wisconsin
Lindsy Boateng, Aayushi Uberoi, and Chris Trimby, *University of Wisconsin-Madison*
The Teaching Fellows Program, administered by the Wisconsin Institute for Science Education and Community Engagement (WISCIENCE), facilitates the training and mentorship of graduate students and postdocs during their first independent teaching experiences. This program is based on the principles of Scientific Teaching, and Fellows are taught to incorporate active learning, aligned assessments and inclusive teaching practices to enhance the undergraduate science learning experiences on campus. Traditionally, Teaching Fellows accepted into the program have developed teaching materials and active learning strategies to use in a large freshman seminar course to expand on their teaching repertoire. However, in Fall 2013, a cohort of Teaching Fellows was encouraged to develop a new course on campus that utilized the CREATE method of teaching developed by Sally Hoskins and colleagues. Since the inception of this new course entitled "Secrets of Science" in Spring 2014, Teaching Fellows have been building on the basic CREATE method and incorporating their own improvements and adjustments based on course evaluation, assessments and instructor experiences. In this presentation, Lindsy Boateng and Aayushi Uberoi will share their personal experiences in teaching this course, how it is designed, and the new implementations they individually added to the course due to their co-involvement with the Delta program. They will present some findings on student feedback and learning gains that have been achieved in this uniquely evolving course, as well as some reflections on their own growth as educators.

Astrobiology as a Unit in Cell Biology
Janet L. Cooper, *Rockhurst University*
What is life? and how did life begin? are questions that surround biology that are not dealt with in a systematic way in most biology courses. Discussing the beginnings of life and the formation of a cell were integrated into the beginning of a Cell Biology lab. Topics covered included Cosmic Calendar, birth of the Universe, stellar evolution and the formation of the elements, formation of the solar system and the conditions on early earth, formation of simple organic molecules, assembly of macromolecules and the evolution of self-replicating collection of macromolecules. Discussions of defining life, what a first cell might have looked like, NASA's attempts to find life on other planets and life in extreme environments were also integrated into the unit. Challenges were finding lab activities and videos that would keep students interested and still provide a good basis for understanding as well as getting students to see the connections to the class as a whole. The most difficult topic for students to grasp was the evolution of self-replicating macromolecules.

ROUNDTABLE

UW--Milwaukee AAUP Chapter Presentation
Nicholas A Fleisher and Rachel Ida Buff, *University of Wisconsin Milwaukee AAUP*
We will discuss the founding of our chapter, UWM AAUP as a response to the crisis of public education in Wisconsin. Our chapter was founded with the AAUP national "One Faculty" campaign in mind: we represent faculty, staff and graduate students. Our work has included: defending tenure and academic freedom at the state level; working against austerity at our institution; networking with advocates for K-12 education; and working with student groups. Founded in crisis, our chapter is now working on institutionalization and on building and extending our membership base.

The New MCAT Format: First Years' Experience, Future Challenges and Preparing Students for an Excellent Performance
Khadijah Makky, Diane Novotny, and Laurie Goll, *Marquette University*
The AAMC launched the new MCAT test in 2015. The new test evoked anxiety among students and left educators and pre-health advisors wondering what they can do to adjust curricula, and/ or find different resources to help students succeed. The medical field is changing and the new MCAT is designed to help students learn the knowledge and skills to succeed in medical schools and as future doctors. The new MCAT does not only test students' foundational knowledge but also tests their skills in critical thinking, and in the natural, behavior, and social sciences. It was clear that many colleges and universities went to work immediately after the announcement to make the necessary changes in their students' preparations. In the College of Health Sciences at Marquette University we approached this new test with careful examination of the contents and the topics that would be covered. We made recommendations to the students and our professors. Although, a lot of work was done before the launch in 2015, most of the changes we implemented (in preparing the students) occurred after the data from the first wave of scores were reported. This roundtable discussion is designed for educators from different institutions to share their experience with the new MCAT, starting with the Marquette experience, what we have done, our students' challenges, and our future plan to enhance our students' scores.

Undergraduate Summer Research Program Components- What Works and What are the Challenges?

Laurieann Klockow and Autumn Swanson, *Marquette University*

The benefits of undergraduate research are many and well documented (1,2) and the Association of American Colleges and Universities designated undergraduate research as a high impact educational practice. As such, summer undergraduate research programs (URPs) have become common practice at many institutions. Although summer research provides the best opportunity for undergraduates to engage in a meaningful, immersive research experience, the question is how best to design that summer undergraduate research experience? At Marquette University, our biomedical sciences summer research program evolved from a loosely structured experience for a handful of students to a highly structured program that involves on average 35 students each year. In this roundtable discussion, I will present the program components for Marquette University's Biomedical Sciences Summer Research Program (MU SRP) and our assessment of what has worked well and what hasn't. I hope to elicit ideas and feedback from audience members of the types of activities they have implemented at their home institutions' summer research programs. Additional discussion points will include measures taken to sustain the research experience into the academic year, how to obtain financial support, as well as how to cater a summer research program to meet the needs and interests of a diverse student cohort who vary considerably in their motivation, expectations and desired benefits. This discussion will benefit both faculty looking to update/revise their department's summer research program, but also those who are just beginning the process of developing a departmental summer research program. 1)Russell S. H., Hancock M. P., McCullough J. (2007) The pipeline benefits of undergraduate research experiences. *Science.* 316 (5824), 548-549. 2) Seymour E., Hunter A. B., Laursen S. L, Deantoni T. (2004) Establishing the benefits of research experiences for undergraduates in the sciences: first findings from a three-year study. *Sci.Educ.* 88 (4), 493-534.

A Learning Philosophy Assignment Positively Impacts Students' Intellectual Development and Mastery of Course Content

Neil Haave and Tonya Simpson, Dept of Science, *University of Alberta*

Engaging students in metacognition can improve their learning outcomes (Ambrose et al., 2010, Girash, 2014). This study analyzed the effect of a learning philosophy assignment on students' intellectual development and mastery of freshman biology and sophomore biochemistry course content. All students were required to complete the Learning Environment Preferences (LEP) survey (Moore 1989) at the beginning and end of the term to determine if students' cognitive complexity was impacted by the assignment. The ability to master course content was assessed by comparing students' midterm and final exam marks. We found that the learning philosophy assignment rescued Bachelor of Science students in the freshman biology course from a decrease in cognitive complexity. Additionally, the guided metacognition rescued sophomore biochemistry students from performing poorer on the final relative to the midterm exam and promoted an increase in their cognitive complexity. These results suggest that a learning philosophy assignment may be an effective way of engaging students' in metacognition of their learning to improve their intellectual development and ability to master course material. References: Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). How do students become self-directed learners? In How Learning Works: Seven Research-Based Principles for Smart Teaching (pp. 188–216). San Francisco, CA: John Wiley & Sons, Inc.Girash, J. (2014). Metacognition and instruction. In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), Applying Science of Learning in Education: Infusing Psychological Science into the Curriculum (pp. 152–168). Society for the Teaching of Psychology.Moore, W. S. (1989). The learning environment preferences: Exploring the construct validity of an objective measure of the Perry Scheme of intellectual development. *Journal of College Student Development*, 30(6), 504–514.

Sharing and Stealing Ideas: Flipping the A&P Classroom

Tom Davis, *Loras College*

This interactive roundtable discussion will start with the session leader giving a few examples of flipping strategies that have worked in his Physiology course and in his Human Anatomy course including using rotating spokespersons in each group, Draw Dis and Draw Dat and peer group critique sessions. But just don't come to listen! Attendees will be asked to share their ideas and activities that increase student engagement and get students ready for class before they arrive.

Assessment Across the Liberal Arts - How Can Biology Contribute?

Christina Wills, Jessica Allen, Robert Vigliotti, Anne Austin-Pearce, Jennifer Oliver, Mark Pecaut, William Stancil, *Rockhurst University*

The Higher Learning Commission (HLC) currently designates general education (Core at Rockhurst University) as a program and requires program level assessment. Rockhurst's Core was designed prior to assessment requirements and focuses on the acquisition of a wide breadth of knowledge across the

liberal arts. Historically, Course Embedded Assessment (CEA) not program assessment has been used to assess specific areas (e.g. natural sciences) within the core. To bring Rockhurst into compliance with HLC standards while respecting the design and history of our core, we developed a pilot procedure to assess the core as a single entity rather than by individual area. Association of American Colleges and Universities (AAC&U) VALUE rubrics on critical thinking were modified to assess student Core learning outcomes (SLOs) in the natural sciences (introductory physics and non-majors biology), art (introductory painting), global perspectives (upper level adolescent psychology across cultures), and introductory theology during the Fall 2015 semester. Based on the rubric performance milestones (1 – lowest, 2 – intermediate, 3 – highest), the majority of the students across the core achieved the appropriate milestone (2 or 3) for their course level. Critical thinking on two assignments in non-majors biology was assessed as part of this project. Students performed well across categories (A – Selecting and using information to investigate a point of view or conclusion, B – Recognizing methods of inquiry that lead to knowledge, and C – Reasoning by deduction, induction, and analogy) with the majority of students achieving milestones 2 or 3. Students had slightly lower performance in category A than other categories.

Faculty Burnout
Debbie Meuler, *Cardinal Stritch University*
The days when academe was a low-stress working environment are over. Many faculty are experiencing academic burnout characterized by the depletion of emotional reserves (emotional exhaustion), an increasingly cynical and negative approach towards others (depersonalization) and a growing feeling of work-related dissatisfaction. Based on 12 peer-reviewed studies in the United States, Britain, Canada, South Africa, Spain, Turkey and the Netherlands, levels of burnout among those who teach in higher education are similar to those of school teachers and health professionals. During this roundtable, we will discuss academic burnout and through discussion provide suggestions for dealing with it.

WORKSHOPS

Enzymes in Action!
Margaret Franzen, Program Director, Center for BioMolecular Modeling, *Milwaukee School of Engineering*
We'll explore enzyme structure/function through a variety of interactive models that help to uncover common student misconceptions. In a series of hands-on activities, participants will investigate i) how the arrangement of amino acids in a protein influences the final three-dimensional protein structure, ii) how secondary structure helps to stabilize protein structure, and iii) how mutations can impact the shape of a protein. We'll demonstrate how a simple but elegant model can be used to develop a conceptual understanding of many of the terms associated with enzymes: active site, substrate, competitive inhibitor, allosteric inhibitor and induced fit, then explore factors that impact enzyme- substrate specificity with another interactive model. We will conclude the workshop by exploring a specific enzyme, acetylcholinesterase, which is important in neurotransmitter recycling. This enzyme is the target of multiple inhibitors, including insecticides, snake venoms and nerve agents, as well as drugs for treating Alzheimer's disease. Models will be used to demonstrate how a change in a single amino acid, from a glycine to a serine, can lead to insecticide resistance. Handouts include a project based learning activity exploring insecticide resistance. Models and materials are available for loan from the MSOE Model Lending Library; borrowers only pay return shipping.

Smoking and Lung Cancer Microarray
Betsy Barnard, *FOTODYNE Incorporated*
Are you looking for a hands-on lab activity that combines bioinformatics BLAST searches with a biotechnology experiment? Then this workshop is for you! Participants will learn how students can connect the phenotype of lung cancer to the genotype. Designed by a biotechnology teacher, this elegant activity allows participants to determine gene expression differences in a smoker, non-smoker and former smoker. We will set up our own microarrays, as time allows, and send them off for scanning. Expected results will be discussed along with several optional ideas for classroom activities and lecture presentation. Only minimal equipment is needed, making this sophisticated biotechnology experiment affordable!

Making Physiology Happen with the iWorx Physiology Teaching Kits
Ed Sachs, iWorx Systems, Inc.
In this brief presentation, we will cover how to provide a comprehensive "hands-on" learning experience to make Physiology lab time fun!

Open Educational Resources: It's not just a buzz word anymore
Brad Beatty, *LRNR*
People have been discussing Open Educational Resources (OER) the past few years, but most professors still don't know what OER is and how to effectively use it in the classroom. In this workshop, we'll review how many institutions are transitioning to OER content to help control costs for students while improving student outcomes. Note: I will also

discuss Lrnr's adaptive learning platform that uses OER content to build a complete course for biology for majors and non-majors, as well as Anatomy & Physiology.

Case Studies in the Biology Classroom
Annie Prud'homme-Généreux, *Quest University Canada*
Case studies are stories with a pedagogical objective. The narrative component engages students and helps them apply theoretical knowledge in concrete situations. To solve cases, students must work collaboratively and hypothesize, problem solve, research, evaluate, and make decisions, all skills at higher levels of Bloom's taxonomy. Many free online databases of peer-reviewed cases are available, and cases exist in a variety of different formats (e.g. PBL, case discussion, intimate debate, role play, jigsaw, journal cases, etc), giving instructors options to best suit their classroom needs. In this session, you will experience a case study as a student, reflect on this pedagogical approach's strengths and weaknesses, and familiarize yourself with some of the tools available to implement it in your classroom. Come prepared to do the intellectual heavy-lifting, and I'll tell you a story...

How to Create a C.R.E.A.T.E. Method Inspired Course?
Lindsy Boateng, Aayushi Uberoi, Christopher M. Trimby, *Wisconsin Institute for Science Education and Community Engagement, University of Wisconsin-Madison*
Keywords: C.R.E.A.T.E., course construction, student-centeredBackground & Introduction: The C.R.E.A.T.E. (Consider Read, Elucidate the hypotheses, Analyze and interpret the data, and Think of the next Experiment) method of teaching developed by Dr. Sally Hoskins and colleagues utilizes strategies such as concept mapping, cartooning experiments, and student-driven discussions to help students experience the nature of science in their learning. Several reports suggest that teaching with C.R.E.A.T.E. can help in facilitating a student-centered approach to learning and may enhance student understanding of primary scientific literature above traditional teaching methods. We have adapted components of the C.R.E.A.T.E. method in our course, Biology 375: Secrets of Science from the Bench to Popular Press at the University of Wisconsin-Madison, to aid in development of critical thinking skills in freshman students. Learning objectives: (Participants will be able to...)1.Consider what course or unit that they might apply the C.R.E.A.T.E. framework.2.Read and interpret the steps of the C.R.E.A.T.E. framework.3.Elucidate their goals for implementing C.R.E.A.T.E. 4.Analyze the factors that may influence their implementation of the C.R.E.A.T.E. framework.5.Think of how they will implement the C.R.E.A.T.E. framework to develop (or redevelop) a learning experience for students.6.Experiment with development of a course/unit based on the C.R.E.A.T.E. framework. Workshop purpose: The aim of this 80-minute workshop is to familiarize participants with the components of the C.R.E.A.T.E. model. We will guide the participants through individual components of the C.R.E.A.T.E. framework, while they work on developing a unit or course that incorporates the elements of this teaching method. Workshop Description: In this hands-on workshop the participants will identify a course they will restructure based on the C.R.E.A.T.E. framework. The C.R.E.A.T.E. method incorporates hypothesis design, analysis of experiments and proposal writing as methods to teach students the scientific process. At the end of the workshop the participants would have experienced the teaching methodology and have participated in developing their own course based on this method. Workshop interactivity: This will be a hands-on workshop with worksheets and group exercises

Teaching Like a Pro in Your First Years
Rebecca Burton, *Alverno College* and Conrad Toepfer, *Bresica University*
Which educational innovations have been validated by peer-reviewed studies and which have been debunked or never tested? How can you maximize the cooperation of students, peers, and administrators as you implement the best in innovative pedagogy? Where can you find excellent "turn-key" activities? Master teachers will answer your questions and lead discussions on these and other topics.

The Biology of Skin Color: Using HHMI's free teaching materials to engage students in evidence-based reasoning
Elyse Bolterstein and Kara Nuss, *Northeastern Illinois University*, and Javier Robalino , *HHMI BioInteractive*
HHMI BioInteractive provides a large collection of free materials designed to engage students by bringing scientific discovery into the classroom. In this interactive workshop, you will watch short clips of the HHMI video, The Biology of Skin Color, and analyze data to refine hypotheses on why there is such rich diversity in human skin color. We will present our experiences using these materials in an introductory course for biology majors, and invite you to discuss modifications for other biology classes. We will also present examples of complementary activities and lead a discussion on strategies for using these materials to build student skills in experimental design, quantitative reasoning, and graphing.

Teaching Cancer in the Era of Genomics: HHMI's Free Resources to Explore the Molecular Genetics of Cancer

Javier Robalino, *HHMI BioInteractive*

Genomic studies are increasingly illuminating the genetic basis for cancer, and challenging our ability as educators to help students grasp an accurate and relevant understanding of how cancer works. In this hands-on workshop, we will explore active learning exercises that use real patient data to allow students to visualize and appreciate the genetic complexity of cancer. Participants will receive free classroom-ready resources to implement these exercises in their teaching.

POSTERS

Teaching Scientific Method to Non-Science Majors via Student-Designed Research Projects
Sarah B. Lovern, *Concordia University Wisconsin*
In an effort to relate the scientific method to non-major undergraduate students, research projects were incorporated into BIO 368: Ecology of the Tropics Lab during the fall 2015 semester. While research projects can be expensive and time consuming, this assignment streamlined individualized projects into a manageable four-week long undertaking. Student groups were given a list of available equipment and brainstormed topics. Students acquired ownership in the project by choosing a topic rather than being assigned a subject. Under the guidance of the instructor, each group developed a hypothesis and designed ways it could be tested. Students then used materials already available on campus to answer a research question. Data was collected at the start of lab each week before the course continued with the introduction of new material. Students experienced the pitfalls of conducting actual research not usually encountered in "cookbook" lab experiments. At the conclusion of the trial period, students wrote individual manuscripts explaining their work. This project allowed for hands-on experience for students in a cost-effective way. Changes in the assignment including more specific guidelines for the research paper are currently underway during the fall 2016 semester. Detailed guidelines for replicating this assignment will be offered to instructors.

Using our Assessments to Target our Misconceptions
Lee Ann Smith, Preston Aldrich, Allison Wilson, and Robin Rylaarsdam, *Benedictine University*
In recent semesters, we have added questions to our traditional pre-post knowledge and comprehension multiple choice questions to target the faculty's perception about students transferring into our program and be proactive in providing any interventions necessary to remedy the possible deficits. The pre-test was given in the 200-level Genetics course, which usually does not articulate from community colleges, and is taken by all of our majors in the program at our institution. Two questions asked where students earned credit for the Introductory Biology Courses (Organismal and Cell Processes) to establish if the credit was earned at our institution or community colleges in the area. This allowed us to separate the results of the pre- and post-tests based on this distinction. Although some faculty have perceived differences between the aggregated groups, our results demonstrate that there are no statistical differences between students who have passed our Introductory Biology Courses and students who transferred those courses (total n=201 over three semesters). We also evaluated students in the introductory, intermediate, and upper-level cell processes courses using the same multiple choice question on a common misconception regarding DNA replication. On the final of introductory biology course, students correctly answered this question 70% (n=69), students in the intermediate course initially answered correctly 25% on the pre- test and after spending at least one lecture on the material within the semester were up to 51% correct on the post-test (n=201). When students were asked the same question in the upper-level pre-test, again the correct answer was down to 15% (n=79). Given this eye-opening data that our students are not retaining significant details to a topic covered multiple times within the curriculum, we will re-evaluate how to address this topic and other common misconceptions within our courses.

Assessment of Students' Conceptual Understanding of Physiological Concepts
Judith A. Maloney, *Marquette University*
Many biomedical science courses utilize multiple choice questions (MCQs) to assess students learning of course content. It is well known that MCQs can assess students' foundational knowledge, but how well it assesses their conceptual understanding of the material is unclear. We addressed this issue in a physiology course, by having students write their rationale for their answer to one MCQ on each exam. The students' understanding of the material was evaluated based on their reasoning for selecting their answer. This evaluation provided feedback to the students on the extent of their ability to master the subject. In addition, the instructor gained insight into any student misconceptions of physiological processes. The students were surveyed to see if this activity helped them formulate their thought process when answering the question. The majority of the students believed this was a helpful exercise and should be continued. To determine if this activity improves student's ability to select the correct answer, we compared students' performance in this class to the performance of the previous class on these same questions. Preliminary data indicate that there was no benefit in regards to question performance. In conclusion, this exercise can give instructors insight into students' misconceptions. In addition, while not demonstrating an immediate benefit, may, over the long run, improve students' metacognitive skills.

Practice Gel Reduces Risk and Cost of Student Laboratory Activity
Christina I. Winterton and Jason R. Wiles, *Syracuse University*

The laboratory component of introductory biology courses serve a number of key goals including strengthening students' scientific thinking skills and conceptions of the nature of science, reinforcing concepts in an interactive and social context, and of course, developing techniques and skills which will provide students with the tools to transition to upper division courses and research. Basic techniques for advanced laboratories include properly calibrating, setting, and dispensing micropipettes, which are in turn useful across many other fundamental biological tools like PCR and gel electrophoresis. However, due to the volume of students in a typical introductory course, practicing these skills can become costly. In order to provide ample practice with minimal costs in terms of materials, time, and lost experimental results, students were given "practice gels" made from clear gelatin to gain proficiency with pipetting before engaging in "real" experiments. There were no harmful chemicals in this set up, only clear gelatin, water, and food coloring. The instructor performed a demonstration of proper loading technique, then groups of students practiced together. When the students believed they were proficient in these skills, they gained approval from the instructor before loading samples on a proper gel set up in the electrophoresis chamber. This practice activity appeared to engage the students and increased discussion and teamwork. Students appeared to gain confidence in their ability to use the pipets and load gels, and the number of students volunteering to load agarose gels in later experiments increased after the practice gel activity compared to prior iterations of the course without the practice run. Utilizing a practice gel is an inexpensive and safe method that allows all students in a laboratory to practice a basic skill that will be required in upper level laboratory courses.

Using online faculty mentoring networks to bring research data into undergraduate classrooms

Gabriela Hamerlinck, *BioQUEST, QUBES*; Arietta Fleming-Davies, *Radford University*; Alison Hale, *University of Pittsburgh*; Tom Langen, *Clarkson University*; Teresa Mourad, *Ecological Society of America*; Kristin Jenkins; *BioQUEST*

Using ecological research data in undergraduate courses has many potential benefits for student learning, including increased understanding of the scientific process and meaningful opportunities to develop and practice quantitative skills. As ecological datasets continue to become larger and more complex, faculty may need additional support to teach effectively with research data. We report on the design, implementation, and outcomes of two faculty mentoring networks (FMNs) collaboratively developed by the Ecological Society of America education community and the Quantitative Undergraduate Biology Education and Synthesis (QUBES) project. FMNs are semester long online communities of faculty working toward a set of shared goals with content specialists and pedagogy mentors. The 28 faculty participants in the FMNs focused on the customization and classroom implementation of data rich teaching materials from the Teaching Issues and Experiments in Ecology (TIEE) project. The two FMN communities differed in that one FMN included a face-to-face workshop component while the other interacted entirely virtually. Participants in both groups were widely distributed geographically and taught at a wide range of institution types. Measures of faculty participation including meeting attendance and assignment completion showed no significant differences between the groups. Analysis of data on faculty attitudes, and module use are ongoing.

A New Integrative Case Study That Targets Large, Upper Division Human Genetics Courses

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In genetics courses, case studies have been used as an active-based learning tool to enhance students' understanding of complex concepts. The case presented here was designed to remove many genetic misconceptions that are often hard to unlearn. Together with the teaching professor I based the case study on a published Science article. It represents a real life genetic phenomenon that integrates many genetic concepts that are presented to students throughout the semester. It was written for a large upper division human genetics class. This case was presented at the end of the semester to help students demonstrate their understanding of these topics. Students answered questions that tested their ability to analyze and critically evaluate basic genetic principles, and more specifically allele frequencies in a population using Hardy-Weinberg equilibrium. The case was briefly introduced in the classroom but the majority of the work was done as a take-home assignment. Students uploaded the completed assignment to the Marquette University learning management system and it was filtered through Turitin® software. This submission allowed for immediate feedback to the students as the assignment being graded and a faster detection of any plagiarism. As a teaching assistant, grading the assignment allowed me to see where the misconceptions still remained and where the students had a clear understanding of the material. It also gave me the ability to give individual written feedback as I was grading. I was able to point out the areas where each student needed to focus on for the final and provide positive feedback for the students who had very strong grasp on the material. Additionally, students gave positive feedback concerning this assignment, specifically the ability to connect many of the concepts that they were expected to master for the

final exam. I see the use of case studies as a powerful tool to both engage students in the classroom and to assess their learning. This case has been accepted for publication at the National Center for Case Study Teaching in Science.

The impact of geographic origin on acceptance of evolution in college students

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Evolution is the unifying theme of all biology, and therefore is crucial to an understanding of biological phenomena (Dobzhansky, 1973). However, evolutionary biology is somewhat unique amongst scientific topics with regards to the deep opposition it faces in the eyes of many members of the general public. While there are many individual level metrics that influence acceptance of evolutionary biology (Johnson and Peeples, 1987; Rutledge and Mitchell, 2002; Sinatra et al., 2003; Mazur, 2004; Trani, 2004; Nehm and Schonfeld, 2007; Cavallo and McCall, 2008; Deniz et al., 2008; Hawley et al., 2011; Moore et al., 2011; Heddy and Nadelson, 2013; Barone et al., 2014; Carter and Wiles, 2014; Wiles, 2014), larger scale metrics also have an influence. Historically, antievolutionism has had a stronghold in the southern United States (Berkman and Plutzer, 2010), and it seems that is still true today (Mazur, 2004). However, others have successfully chosen to focus not on regional differences, but rather on differences in rurality (Short and Hawley, 2012). To explore the geographic nature of evolution acceptance, we took a small-scale approach. Using students from a single university, we explored the effect of region of origin and rurality on the acceptance of evolution. Specifically, we expected to find students from the south and from more rural areas to have lower rates of acceptance of evolution. We also explored the possibility of an interaction between terms, specifically with the thought that being in more urban southern areas may have a "rescue effect" on evolution acceptance.

Cooking without a cookbook: using food chemistry to teach the scientific method

Aaron Miller, *Concordia University Wisconsin*

Good laboratory exercises immerse students in the scientific method while also demonstrating important biological concepts. This can be difficult to achieve in introductory biology courses, where time constraints, large numbers of students and small budgets sometimes favor a cookbook-style approach over inquiry-based labs. In order to negotiate these challenges, I have adapted a lab examining the food chemistry of pancakes to my course. Students are given background information related to the chemical reactions that occur during the cooking process, as well as a standard recipe to use as a control. They make a hypothesis about the effects of changing one variable from the recipe, which can be either an ingredient or preparation step. Students test their hypotheses by making the control and experimental pancakes and comparing the taste, texture, color and thickness of each batch. This lab satisfies two important educational objectives: it demonstrates biochemical concepts and gives students an introduction to the scientific method. It is also inexpensive, uses no hazardous chemicals and can be completed during a 110-minute laboratory period. Finally, the relevance of the experiment to life outside the lab and ability to eat the products of the experiment lead to very high student engagement.

Using Primary Literature to Teach Content and Improve Scientific Literacy in an Undergraduate Classroom

Scott Shreve, *Lindenwood University*

The ability to read primary scientific literature, interpret scientific data, and evaluate the evidence supporting authors' conclusions are important skills to develop in science majors. They are not only relevant to the scientific careers of students, but also help to improve their overall scientific literacy. However, it can often be difficult to sacrifice content-oriented class time to teaching and developing these skills in undergraduate classes. I hypothesize that regular, repeated exposure to the scientific literature will improved the scientific literacy skills of students. In order to retain as much science content in the class as possible, I implemented weekly journal discussions in a 200-level Biodiversity course. Journal articles were selected in part to enhance or expand the material presented during the more conventional classroom time. Student scientific literacy skills were evaluated at the beginning and end of course using an instrument modified from Gormally et al., (2012). At the end of the semester, students reported greater comfort levels reading scientific literature compared to the beginning of the semester. However, the instrument showed no significant differences in scientific literacy skills before and after the semester of weekly discussions. Even by the end of the semester, students still had difficulty linking specific results as evidence to specific claims or conclusions in the papers. Article selection may be an important factor influencing the efficacy of journal discussions.

Assessment of a Video Design Project to Promote Conceptualization of Molecular Processes in an Immunology Course

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Immunology is a subject area where most of the content is cellular and molecular in scope. Cellular processes that can be difficult for students to visualize are often difficult to understand. In this new iteration of an upper level immunology course, each student was tasked to create and produce an

instructional video that would teach a molecular concept that they found difficult to visualize. One lab, near the beginning of the semester, was devoted to video production- storyboarding, video design methods (e.g. stop motion animation, use of instructional apps, etc.), and the components of a quality educational video. At the end of the semester, we had a screening of each video, and the students and I graded each video using a rubric we developed as a class. Students were given a pre- and post-assessment of how comfortable they were in making an educational video and their thoughts on what makes a good educational video.

Bioscene: Journal of College Biology Teaching
Submission Guidelines

I. Submissions to *Bioscene*

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

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

II. Preparation of Articles, Innovations and Perspectives

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

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

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

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

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

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

Single Author:

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

Two Authors:

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

Multiple Authors:

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

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

(1) Articles-

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

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

(2) Books-
BOSSEL, H. 1994. *Modeling and Simulation*. A.K. Peters, London. 504p.

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

(4) Web sites-
MCKELVEY, S. 1995. Malthusian Growth Model. Accessed from http://www.stolaf.edu/people/mckelvey/envision.dir/malthus.html on 25 Nov 2005.

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

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

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

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

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

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

III. Letters to the Editor

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

IV. Other Submissions

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

V. Manuscript Submissions

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

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

VI. Editorial Review and Acceptance

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

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

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

VII. Revision Checklist

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

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

VIII. Editorial Policy and Copyright

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