
TEAM #1

TEAM LIST:

Daron Barnard
Jeff Carmichael
Maureen Knabb
Jenny Knight
James Smith
Mary Pat Wenderoth

TEAM FACILITATOR:

Heidi Elmendorf

Daron Barnard

Worcester State College, Worcester, MA

Assignment #1: Introductions

1) Describe your teaching responsibilities and the type of student you teach

I am in my second year as an Assistant Professor at Worcester State College in Massachusetts (pronounced "Wooster" or if you are from Massachusetts "Wosta"). We have a diverse student body in both background and academic ability. Many of them commute and work full time as well. In addition, many of our students are first generation college students or are nontraditional students.

Currently my teaching responsibilities mainly focus on undergraduate Biology and Biotechnology majors. A large portion of my teaching each semester is a 200 level Genetics course. I also teach an upper level Developmental Biology, a capstone Biology Seminar course and Introduction to Biology II: Cellular and Molecular Biology. Other past teaching responsibilities have included a 200 level Cell Biology, a Genomic graduate level class with Biotechnology master's level students, and a now defunct course for biology majors and non-majors called Introduction to Biology I.

2) Describe what you would like to take home as a result of attending the institute

One of my hopes for the SoTL Institute is to learn how to approach the assessment of my teaching in a more systematic way. I am in the process of trying to switch some of the labs (Genetics and Development) into more project based labs and want to learn how to assess student learning as I make these changes.

3) Tell us about your interests outside of the classroom and a book that you've read recently

Out of the classroom, my family (wife, and two children - almost 5 and 2.5) and I try to spend as much time together as possible, and we particularly enjoy outdoor activities. I also try to go running when I can, and do some woodworking and

gardening. A book that I am currently reading is *What is the What* - by Dave Eggers about one of the lost boys of Sudan. Of course it is taking me a while to get through (I am hindered by the fact that during the semester I have a tendency to pick up books that require no mental effort - books Bethany so aptly described as "mind junk").

Assignment #2: Reflections

1) How would you describe your "research problem(s)" to the Research Scholars group?

My teaching and learning research problem focuses on the laboratory portions of courses. One of the obstacles that I encounter in genetics is a fear of the subject and subsequently, student disengagement. The more traditional approach to the lab gives breadth, yet the students lack investment in the lab learning experience. I am interested in researching the effectiveness of longer projects that involve actual research projects as a way to increase student involvement with the subject, and ultimately student learning. While I believe that the problem could be extended into just about any course that I teach, I plan to concentrate on genetics lab, as genetics represents the bulk of my teaching load. In this course I have a project that extends for several labs, and traditionally this has been a classical genetics experiment (*Drosophila* crosses). The benefit(s) of a project-based lab could be a scholarship of teaching and learning research problem in and of itself; however, I would like to address the question of whether student learning and engagement is enhanced by integration of an actual research project into such a lab. A related problem that I am interested in is: would computer simulations be an effective substitute for classical genetic crosses, thus leaving greater time to explore modern topics in a project-based format?

2) What theme(s) based on your readings, resonate with your "problem" and/or your proposed approach to address your problem?

One of the themes from the readings that I feel resonates with my problem is the very basic question of needing to discover *how* the students come to understand genetics. Randy Bass incorporates a quote into his article, from Diana Laurillard, that emphasizes the need for analytical evaluation of our teaching. I found the following statement from that quote particularly relevant:

"Teachers need to know more than just their subject. They need to know the ways it can come to be understood, the ways that it can be misunderstood, what counts as understanding: they need to know how individuals experience the subject."

This problem of how can the students best come to understand the material underlies many of my questions regarding the nature of lab exercises and how they contribute to learning and an understanding of the subject.

I also think that, as Bass pointed out, the issue of assessing prior knowledge will be important. I have students in my genetics course that have taken only Intro Bio, and others for whom genetics is the last class needed for graduation. Is the understanding that I observe due to learning that has taken place during the semester or is it a result of prior knowledge? One concern that I have is how to integrate the assessment of prior knowledge into the assessment of overall learning (and how to get this approved by our HSRB).

3) Which of the 12 properties of SoTL in microbiology education proposed by S. Benson's article are particularly relevant to your project at this stage?

Of the 12 properties that Spencer Benson proposed in his article I feel that Property #1 (reflective analysis), Property #8 (problem centric), and Property #10 (practical engagement in teaching) are relevant to my project. In my mind these properties are important in framing the question or problem. Additionally, the very act of writing and posting these reflections makes Property #7 (public at all stages) a significant aspect of the project.

4) Do you have any questions/concerns/comments that have evolved from your reading?

My major concern has to do with ways to provide appropriate controls for this research. One specific example of this is how to control for prior knowledge as I alluded to above, yet still maintain anonymity.

5) What do you see as tangible products to be developed as a result of your Scholars experience within the next 12 months?

Over the next 12 months I intend to come up with a strategy for the incorporation of a research project into genetics lab and the assessment of student learning.

6) What do you see yourself presenting at the follow-up session at ASMCUE 2009?

It is my goal to initiate the research during the year and plan to present initial results at ASMCUE in 2009.

7) What will you need to develop these products?

Assignment #3: Annotations

In my project I want to investigate the effectiveness of longer project-based laboratory exercises that involve actual research projects as a way to increase student involvement with the subject, and ultimately student learning. I will be particularly focusing on this problem in the lab of my 200-level genetics course.

For my references I searched mainly for resources that described courses in which a research component was integrated into the lab instead of the "traditional" lab exercises. Most of what I encountered was journal articles, and I had limited success finding either posters or portfolios that were relevant to my project. I did enjoy looking at these resources, but the references that I found most useful came from searching ERIC, PubMed, or looking in specific biological journals that have educational sections or focus on education.

1. Sleister, H. M. (2007). Isolation and characterization of *Saccharomyces cerevisiae* mutants defective in chromosome transmission in an undergraduate genetics research course. *Genetics* 177, 677-688.

In this article, Sleister describes an upper level genetics research course designed to give students a "real" research experience. The project covered both classical and molecular genetics activities, providing a broad exposure to different areas of genetics even though the project was limited to a single model organism.

Assessment demonstrated that when compared to a traditional lab experience, students felt that the research lab experience had: "helped them better understand genetic concepts and methods", "helped them make connections between different concepts/experiments", and that the "technical skills are/will be valuable in further

studies...or in a future career". Sleister makes the point that in both types of labs the students would learn "how to perform [a] method" but in the research lab the students "gain first-hand experience with the when and why to apply a particular method". One aspect of the article that I really like is a table she provides that lists the major course objectives and ties each objective to a specific activity or assignment that is part of the research project. While this article describes a research project carried out in an upper-level course (the course has a prerequisite of an introductory genetics course), it has many similarities to what I would like to do in my genetics course.

2. Stiller, J. W., and Coggins, T. C. (2006). Teaching Molecular Biological Techniques in a Research Context. *American Biology Teacher* 68, 36-42.

This article describes a semester long project in a research context that uses many of the molecular biology techniques common in research. The authors address the benefit of such an approach as it is hypothesis driven and connects the techniques to the reason for their use and the "assumptions implicit in their use". The authors also indicate that the techniques can be coupled or "strung together" leading to an understanding of how the techniques might be used to solve a problem. They discuss the benefits of unexpected results, which are often lacking in the "canned" laboratory exercises, as either thought provoking or in need of trouble-shooting. The article thoroughly describes the steps involved in the project that the authors used in their project. Of particular interest is the indication that this project was interspersed with "traditional labs" during the lulls in project activity. The article addresses many of the advantages that I hope that a research-based lab would present to the students.

3. Chaplin, S. B., Manske, J. M., and Cruise, J. L. (1998). Introducing Freshmen To Investigative Research--A Course for Biology Majors at Minnesota's University of St. Thomas. *Journal of College Science Teaching* 27, 347-350.

This article describes a research course directed at first to second year biology students. The authors reiterate some of the benefits of students participating in research (as attributed to an article by J.R. Brandenberger – a reference I have been unable to locate) and address the importance of learning by doing. They note that cookbook labs teach techniques but students do not learn the process of science through these exercises. The article also points to the misconception that research is only something in which the top students are able to participate; the authors' class suggests otherwise. This is an argument that I think is important for the incorporation of research in my genetics class, as well as my overall philosophy of teaching and learning. Results indicate that students that complete the course are more likely to stay in the major and demonstrate a 4% attrition rate as compared to a 33% for students who have not taken the course. This article is of relevance to my project as I intend to integrate research into a 200-level course that has second year students. Additionally, this article cites some interesting references that I did not pick up in my initial searches.

4. Luckie, D. B., Maleszewski, J. J., Loznak, S. D., and Krha, M. (2004). Infusion of Collaborative Inquiry throughout a Biology Curriculum Increases Student Learning: a Four-year Study of "Teams and Streams". *Advances in Physiology Education* 287, 199-209.

The authors describe an alternative to traditional labs in introductory classes for physiology majors. They note that students do not experience the processes of

science in the traditional lab setting. They also suggest that students are turned off by the experience of labs that are of the 'cookbook' variety. By making their labs inquiry based, with students developing a research question, designing, and conducting the experiments, the authors demonstrate that they have increased the cognitive level of the learning (based on Bloom's taxonomy) from knowledge to application, analysis and synthesis. They balanced "cookbook" labs to learn techniques with the inquiry labs, but started the inquiry part very early in the semester. Initially that authors felt that the experience might be too demanding for the students, however were surprised to find that the students rose to the challenge.

Interestingly, they found that the students participating in these labs showed an increase in performance on content exams in addition to qualitative results reflecting an increase in the positive comments on student feedback forms. Once the authors established the new inquiry lab format, they returned to the traditional format for a semester, and have been using the new inquiry format since. They believe that this makes their assessment of the inquiry format much stronger, and I tend to agree. The authors give a thorough curricular design and assessment strategy for both formats for easy comparison. While my project will be different, as I will be giving them the research problem and not requiring them to initiate the development of their own research question, this is a similar model to what I hope to implement. On a final note, the authors point out that traditional labs can be very time consuming for the professor, with much work before and after the lab that does not necessarily make for increased learning, and may be a lost opportunity for student learning. They constantly quote their mantra "less teaching, more learning".

5. Buckner, B., Beck, J., Browning, K., Fritz, A., Grantham, L., Hoxha, E., Kamvar, Z., Lough, A., Nikolova, O., Schnable, P. S., Scanlon, M. J., and Janick-Buckner, D. (2007). Involving undergraduates in the annotation and analysis of global gene expression studies: creation of a maize shoot apical meristem expression database. *Genetics* 176, 741-747.

In this article the authors describe a research project involving undergraduates. While this research is not itself a course, the research project itself has similarities with the research (annotation of existing genomic data) that I plan on incorporating into my genetics course. The article describes annotation of microarray data generated by collaborators at a large university. In addition to addressing specific questions, the goal of the research is ultimately presentation to the research community, giving students a sense of their participation in the progress of science.

Some of the training for the work occurs in lower level biology courses. The outcomes in this article are anecdotal, with not assessment.

Jeff Carmichael

University of North Dakota, Grand Forks, ND

Assignment #1: Introductions

1) Describe your teaching responsibilities and the type of student you teach

This is Jeff Carmichael from the Univ. of North Dakota (UND). I have been teaching for about 12 years and spend most of my time with the introductory biology program. I teach most of the sections of our general bio classes and coordinate the labs. Each class typically enrolls 200 students (many of which are pre-meds). My background is in plant biology so I also teach an upper level course in plant form and function. I will also teach our senior-capstone course starting this fall.

2) Describe what you would like to take home as a result of attending the institute

I am especially interested in learning about effective direct assessment strategies. I have been using team-based learning (TBL) in my classes and really love it as an instructional approach. I hope to refine my TBL approaches and develop effective assessment techniques. Part of my long term goal for the Bio Scholars Program would be to increase my skills in statistics.

3) Tell us about your interests outside of the classroom and a book that you've read recently

Outside of work, I spend as much time with my wife and son (11 yrs old) as possible. We love the outdoors (camping, biking, kayaking, etc.). I'm currently reading "Closer to the Light"- a book about near death experiences in children. Favorite recent book- Three Cups of Tea.

Assignment #2: Reflections

1) How would you describe your "research problem(s)" to the Research Scholars group?

I have taken a team-based learning (TBL) approach in my large enrollment introductory biology classes this past year and have come to appreciate it as an effective way to promote student-student and student-professor interactions. I incorporate learning assignments for every chapter and in-class quizzes that students take individually and as teams (I use clickers to record individual quiz responses and IF-AT scratch-off forms for the team quizzes). My TBL classes are far more lively and engaging than my strictly lecture-based classes. Results from last year indicate that TBL increases student learning and performance when compared to lecture-based learning. My goal this year is to probe the effectiveness of TBL a bit deeper than I have in the past and refine my learning assignments and in-class quizzes. In particular, I'm interested in seeing what types of students benefit the most from TBL and if TBL promotes long-term understanding of fundamental concepts in biology.

2) What theme(s) based on your readings, resonate with your "problem" and/or your proposed approach to address your problem?

I found several noteworthy points in the assigned readings. Bass (on the first page) mentions the perspective of a problem in teaching as something that we try to avoid having. Nevertheless, I personally find that I always have “problems” in teaching and will continue to for the rest of my career. After all, we all have days that we feel a bit dissatisfied with our teaching effectiveness and are always looking for ways to improve. I also find Bass’ description of the inverted pyramid to be quite meaningful. I often reflect at the end of a semester and ask myself if I did indeed spend adequate time on the goals I value most. I’m not always satisfied with the answer I come up with. Benson addresses the historical background of the primary roles of educational institutions. I tend to think that we (as faculty members) are there primarily for the benefit of our students. That might mean teaching for some of us and research for others, but we should always keep the students best interest at the forefront of our efforts (that is to say, a top-notch researcher who can’t teach well and isn’t interested in involving students in research may not be well suited to a career as a professor).

3) Which of the 12 properties of SoTL in microbiology education proposed by S. Benson’s article are particularly relevant to your project at this stage?

Benson’s twelve properties are a constructive way to think about the SoTL in science education. Although they all ring true, I tend to identify primarily with goal number eight (SoTL is problem centric; it seeks to understand, solve, or advance knowledge about a problem). This property seems to encompass all the other properties listed.

4) Do you have any questions/concerns/comments that have evolved from your reading?

5) What do you see as tangible products to be developed as a result of your Scholars experience within the next 12 months?

I predict that many of my intangible products (e.g., becoming more familiar with the literature; thinking about SoTL in a more constructive way) will be just as valuable as any tangible products that will arise over the next twelve months. However, I will be teaching two classes this fall (one via TBL and the other via traditional lecture format) and hope to end up with an article that examines the effectiveness of TBL over lecture-based classes. This article will also probe student attitudes toward TBL and learning in general.

6) What do you see yourself presenting at the follow-up session at ASMCUE 2009?

These results will be presented at ASMCUE next summer (and possibly a workshop on TBL if the opportunity arises!).

7) What will you need to develop these products?

Assignment #3: Annotations

My overall interests this year will focus on the assessment of team-based learning (TBL) in large enrollment introductory biology. I will be teaching two sections of introductory biology this fall- one with the traditional lecture based format and one with TBL. I hope to probe the effectiveness (based on a variety of measurements) of TBL versus lecture. The articles mentioned below relate to collaborative learning in

general or provide good examples of different ways to assess student learning or performance.

1. Tessier, J. 2007. Small-group peer teaching in an introductory biology classroom. *Journal of College Science Teaching*, 36 (4): 64-69.

The author of this study examined the effectiveness of different teaching approaches in a moderate sized (~70 students) Concepts of Biology class designed for students seeking certification as elementary school teachers (the students were not biology majors). The teaching approaches included: traditional lecture; self-taught (where students had to figure out answers on their own to questions provided by the instructor); and peer-taught (where students in small groups had to teach each other, again based on the answers they found to questions provided by the instructor). Students performed better on exam questions that focused on the self-taught and peer-taught topics than they did on lecture-based topics. The small group peer teaching also seemed to help students with lower overall final grades—their performance on the self and peer-taught topics increased more throughout the semester than did their performance on lecture-based topics. I enjoyed this paper because it demonstrates an effective approach to direct assessment of small group learning.

2. Cotner, S., Baepler, P., and Kellerman, A. 2008. Scratch this! The IF-AT as a technique for stimulating group discussion and exposing misconceptions. *Journal of College Science Teaching*, 37 (4): 48-53.

I use the IF-AT forms in my classes (and love them!) and was happy to see this recent paper on their effectiveness (based on student perceptions). Although this article isn't rich in data, it does serve as a good introduction to the IF-AT forms. I encourage you to check these out as a means of promoting group discussions. These forms are a useful component of TBL. The authors of this article found that students found the IF-AT forms more useful (i.e., they remembered them more) than all other learning activities used throughout the semester.

3. Knight, J. and Wood, W. 2005. Teaching more by lecturing less. *Cell Biology Education*, 4: 298-310.

Not only does this paper have a great title, it was written by one of the current bioscholars and represents a thorough examination of the effectiveness of interactive classroom techniques over the traditional lecture approach. The authors examined student performance over three semesters. The course was taught in traditional lecture format during the first semester. The subsequent two semesters incorporated more in class interactive approaches (e.g., student participation, quizzes, cooperative problem solving). The authors used pre- and posttests as part of their assessment and found that average scores in the interactive courses were significantly higher than in the lecture course. Normalized learning gains based on pre- and posttest scores (actual gain divided by possible gain expressed as a percentage) were also significantly higher in the interactive courses than in the lecture course. Clickers were used as an integral part of the interactive courses and the authors describe how student attitudes toward the use of clickers changed over the course of a semester (students tended to appreciate clickers more as the semester progressed). The authors also include a thorough discussion of some of the concerns that instructors should be aware of. Appendices include questions on

the pre- and posttests as well as some of the clicker questions used in class (both of which are helpful).

4. Lord, T.R. 2001. 101 Reasons for Using Cooperative Learning in Biology Teaching. *The American Biology Teacher* 63 (1): 30-38.

The author was intrigued that numerous studies have either supported or refuted cooperative learning as an effective means of instruction in high school and college (all seemed to be based on good evidence). He then perused the literature as much as possible and ultimately read over 300 articles dealing with cooperative learning. He kept track of all the positive reasons for using cooperative learning and found hundreds of outcomes supportive of collaborative learning. He combines these outcomes into eleven categories (e.g., science thinking, attitudes, instruction, practical skills, reading and writing skills) and reviews studies that address each category. He tried collaborative learning in his courses and found that indeed, students started performing better on exams than they had previously. He has become a strong advocate of collaborative learning.

5. Handelsman, J. et al., 2004. Scientific Teaching. *Science*, 304: 521-522.

This is a short policy forum published recently in *Science*- it is worth checking out if you haven't seen it yet. It makes the case that college instructors should teach via approaches with proven track records of effectiveness (e.g., more interactive learning and less lecturing). The authors discuss the SCALE-UP program at NC State University where students sit at tables in groups of 5-7 and discuss issues pertinent to biology. Each group has a laptop and is able to project web sites of interest to the entire class (a standard class might hold 99 students). This format focuses on discussion and analysis and places far less emphasis on memorization. We hope to implement a similar program at my institution in the near future. This article discusses how universities might promote change in the way that instructors teach and it has been a cornerstone of my approach to thinking about how to better present my courses in the future.

Maureen Knabb

West Chester University, West Chester, PA

Assignment #1: Introductions

1) Describe your teaching responsibilities and the type of student you teach

I have been teaching at West Chester University for 22 years in both biology majors and non-majors courses. My primary responsibilities include General Biology for majors and non-majors (approx 350 students/year), Anatomy and Physiology (250 students/ year, non-majors), Human Physiology (16/ year, majors), Cell Physiology, and Biology seminar. The WCU students are really wonderful individuals who lead incredibly busy lives trying to balance school and work. Most need to work to pay for school.

2) Describe what you would like to take home as a result of attending the institute

I applied to the SoTL institute to gain more experience in gathering and analyzing data for pedagogy research. I have always been interested in developing strategies for improving student learning. In particular, I enjoy developing inquiry-based activities in the laboratory to engage students in the scientific approach. I have been successful in modifying curriculum to accomplish this goal but I can improve in my assessment of these curricular changes.

3) Tell us about your interests outside of the classroom and a book that you've read recently

Outside of the classroom, I enjoy working in the garden, the beach, dancing. Summer is my favorite season. I have 4 children, 3 sons and a daughter, and I spend as much time with them as I can. They are mostly grown; my youngest son will be a senior in high school next year. When he goes off to college the following year, I plan to go to Mexico for a sabbatical to work in the area of cardiovascular research. This will be an exciting and challenging adventure for me.

I am currently reading "Animal, Vegetable, Miracle" by Barbara Kingsolver. Barbara and her family decided to eat locally for a year and the book describes their experience with this eating strategy. It was a way to decrease the carbon footprint of their food. I am enjoying this book because I am gaining ideas about how I can use more local foods. The recipes are easy and insights of her family are also quite amusing.

Assignment #2 Reflections

1) How would you describe your "research problem(s)" to the Research Scholars group?

My general research problem is accurately defining student learning objectives and developing the most effective assessment instruments to measure positive outcomes. For example, I am constantly striving to incorporate student-driven, hands-on lab activities in my courses and hope that these curricular changes enhance student learning. I define learning as increasing knowledge of content and scientific process. My goal is that students will learn course content better using this approach but it is difficult to assess the effectiveness of this strategy. The question

is particularly daunting when I consider that I am opposed to creating a “teacher-centered control group” for a comparison.

I really enjoy “experimenting” with novel teaching techniques and am willing to try anything if it seems like it will help students learn content and encourage critical thinking. For example, I have incorporated clicker case studies in my large lecture introductory biology course. This strategy combined clicker technology, an effective way to engage more students in the large lecture format, with a case that drives students to learn content to solve a problem. The results from this study are interesting and confusing and have created more questions about effective uses of clickers and cases.

2) What theme(s) based on your readings, resonate with your “problem” and/or your proposed approach to address your problem?

Our institution prioritizes the teacher-scholar model and I used Boyer’s scholarship definition in my promotion application. For those of you still working through the tenure and promotion process, these readings are very important. It is necessary for you to highlight your contributions to the scholarship of teaching as an important component of your scholarly activities, particularly in an academic setting which requires a large number of contact hours.

3) Which of the 12 properties of SoTL in microbiology education proposed by S. Benson’s article are particularly relevant to your project at this stage?

Of the 12 properties of teaching and learning in microbiology education proposed by Benson, the most relevant to me are reflective practice (1), documentation and dissemination (2, 3), previous work (4), exchange of information (6), problem-centric (8), engagement (10), and interdisciplinary (11). I believe that I have followed many of these properties in my teaching scholarship. An area for improvement for me would be in creating connections to other disciplines (11). The use of case studies would help me address this weakness.

4) Do you have any questions/concerns/comments that have evolved from your reading?

Craig Nelson’s article was particularly relevant to me because the research question that I am posing for next semester involves the use of case studies in physiology education. He describes two cases from law journals that he found particularly provocative. I started using case studies in Human Physiology last year and the students really enjoyed them. However, I did not establish a structured format for solving the problems that emerged from the case. I presented the case, the students brainstormed questions to ask about the case, and they researched the answers outside of the classroom. The students mostly worked together outside of class (and were encouraged to do so) and the answers to the case served as one component of each exam. I did not use class time to solve the case or create a discussion board for student interaction. I would like to compare methods for using cases and determine which method is most effective. In addition, I would like to create cases that lead students to perform research in other fields (like microbiology, genetics, or biochemistry) as well as reflect on the social implications of the problems.

5) What do you see as tangible products to be developed as a result of your Scholars experience within the next 12 months?

The products that I see emerging from this project are two-fold. First, I hope to develop new case studies in physiology that are challenging and encourage

interdisciplinary problem-solving. Secondly, I plan to develop a format for presenting case studies that can be assessed for effective learning of content.

6) What do you see yourself presenting at the follow-up session at ASMCUE 2009?

I hope to present the results of this work at ASMCUE 2009.

7) What will you need to develop these products?

I need help to identify good interdisciplinary physiology cases as well as an assessment instrument to compare delivery format.

Assignment #3 Annotations

For my project, I hope to develop new case studies in physiology that are challenging and encourage interdisciplinary thinking. In addition, I plan to develop a format for presenting case studies that can be assessed for effective learning of content. I searched for references to obtain ideas for interdisciplinary physiology cases as well as an assessment instrument to compare delivery format.

1. The National Center for Case Study Teaching in Science Case Collection, <http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm>

This website provides access to hundreds of cases in all areas of science. The use of case studies holds great promise as a pedagogical technique for teaching science, particularly to undergraduates, because it develops students' skills in group learning, speaking, and critical thinking. Many of the cases are based on contemporary—and often contentious—science problems that students encounter in the news. The National Center for Case Study Teaching in Science promotes the development and dissemination of innovative materials for case teaching.

I am currently involved in a project with Kipp Herreid investigating the use of "clicker cases" in large introductory biology courses. I have written two cases in the areas of meiosis and metabolism. Since I plan to use cases in my physiology course next semester, I need to review the many relevant physiology cases on this website.

2. W. H. Cliff and A. W. Wright. Directed case study method for teaching human anatomy and physiology. *Advan. Physiol. Ed.* 270: 19S-28S, 1996

This article describes some general features of successful **directed** cases in a human A and P course: clear learning objectives, a concise and informative scenario, straightforward and didactic questions, and an emphasis on information readily available to the student. The format used by the authors involved the presentation of a case at the beginning of each new topic. The students were required to turn in their responses to the questions at the end of the unit and their responses were graded. The integration of the cases improved student learning and exam performance. The authors describe their methods for integrating the cases into their two semester course.

I was disappointed to see that the only data presented were exam scores. I could not tell if the exam questions were the same as in the previous year. Because I am teaching an upper level course, I plan to have the students develop their own questions (in the directed method, the questions are given). I did see value in the specific example of the allergic response case and could potentially modify it for my course.

3. Patrick Field. Variations on an Historical Case Study: The Extraordinary Accident of Isidro Mejia. *Journal of College Science Teaching*, 36 (2) p21-25. 2006.

This article describes the case of Isidro Mejia, a construction worker who had six nails accidentally shot into his head from a nail gun. On April 19, 2004, Isidro Mejia was working construction on the roof of a house when he lost his footing on the scaffolding and fell on top of another worker, who was using an automatic, high-powered nail gun. As the man holding the nail gun tried to regain his balance to prevent himself from falling off the second floor, he grabbed Mejia, tumbled on to him, and discharged the pressure-sensitive nail gun into his head and body. This particular nail gun is extremely powerful, as it has to drive nails into two-inch by four-inch wooden planks, enough power to penetrate through bone. Upon impact, the nail gun drove six 3 1/2 inch nails into Mejia's head, face, and neck within seconds.

In this article, there are activities for introductory undergraduate biology students with a minimal background in central nervous system (CNS) anatomy to advanced undergraduate/graduate neuroscience students with extensive knowledge of the structures and functions of the CNS. Because this article describes how to adapt a news story to different levels of student knowledge, it should be helpful as I adapt case studies to my course.

4. Berne, R.M, and Levy M.N. *Case Studies in Physiology*. Mosby 1994.

This book is filled with case studies in physiology. Although it is intended primarily for medical students, it should provide many relevant examples that could be used directly or adapted for my course. In addition, Berne was my Ph.D. advisor so I like to get his books.

5. Cliff, W.H. Case Study Analysis and the Remediation of Misconceptions about Respiratory Physiology. *Advances in Physiology Education*, 30(4) p215-223 2006.

This case study was used to help students learn about oxygen transport in the blood and reverse misconceptions about respiratory physiology. The authors identified 4 misconceptions and, through pre- and post- course testing, were able to determine that their use of a case study concerning carbon monoxide poisoning successfully helped students remediate one misconception. The pre-, mid-, and post- questions developed by the authors were helpful and the statistical analysis of the data provided convincing evidence that the students learned the material concerning oxygen transport better with the case study approach. The paper provided a good model for assessment of student learning using case studies.

Jenny Knight

University of Colorado, Boulder, CO

Assignment #1: Introductions

1) Describe your teaching responsibilities and the type of student you teach

I'm a senior instructor (non-tenure track teaching only) at the University of Colorado, Boulder. I teach a Human Genetics class for non-majors and two upper level majors courses, The Brain (from molecules to behavior), and Developmental Biology. In addition, I teach an education research class called Teaching and Learning, primarily for grad students and post docs. I am also affiliated with an interdisciplinary group on our campus called the Science Education Initiative, which is focused on improving undergraduate science education, and on carrying out science education research projects. We have been designing and testing pre-post content and attitude assessment tools, as well as studying peer interaction in our two large introductory courses. I've been using interactive techniques in my courses for about 4 years, including clickers, small group work, concept mapping, in-class problem solving, and "just-in-time-teaching". Although I have considerable experience with these techniques, I learn every semester that this kind of work is never done—there's always more to improve upon!

2) Describe what you would like to take home as a result of attending the institute

I'm interested in publishing my work, and this so far has been a struggle for me (both knowing what is publishable in the field of education, and in finding the time to put it all together!). I'd also like guidance and feedback on better designing my research projects so that they ARE publishable.

3) Tell us about your interests outside of the classroom and a book that you've read recently

Outside of the classroom, I like to run, bike, hike, play tennis, ski...well, you get the picture, and spend time with my husband and three sons (which involves watching a lot of sports, particularly soccer, making sure no one falls off the playground structures, and playing violin with the older two). I also love gardening and can frequently be found up to my elbows in dirt. Since I like to preview the books that my older sons read, my most recent favorite books were *The Lightning Thief* and *The Sea of Monsters* by Rick Riordan.

Assignment #2: Reflections

1) How would you describe your "research problem(s)" to the Research Scholars group?

As a teacher, my primary interest has always been to engage my students in the learning process. Because so many students focus on memorizing facts rather than understanding concepts, it is often difficult to convince students that struggling with difficult concepts as they acquire new scientific knowledge is truly worthwhile. We all know that students are not entirely to blame for their narrow-minded approach to learning; too often we as teachers focus primarily on details as well, imagining that the students will be able to put the big picture together later. After all, memorizing the parts of a cell is easier than figuring out what kind of proteins or machinery might be defective in a human disease (though certainly not as interesting!).

2) What theme(s) based on your readings, resonate with your “problem” and/or your proposed approach to address your problem?

In our readings, I particularly identified with Bass’ inverted pyramid –why *do* we usually assume that students will be able to figure out what we think is most important when we don’t make it obvious to them? Relating this to the five elements of teaching as a process (Shulman), I’ve been trying to focus more time on design (of a course or a project), and on analysis (what *did* my students actually learn?), rather than the elements teachers often focus on-- interaction and outcomes (where outcomes is simply the grade the student receives).

Over the past year, I have been focusing on two main research problems that address some of the ramblings above:

1. Investigating understanding of genetics topics by students who are biology majors compared to understanding of the same topics by students who are non majors. We use a validated multiple choice genetics assessment tool that we’ve just developed at CU to pick out whether students have the same incorrect ideas about genetics both pre and post, as well as comparing performance on multiple choice quiz and exam questions in common over the semester. I am curious what the persistent incorrect ideas are, and whether they are the same or different in these two populations. I also wonder whether non-majors can gain as much understanding as majors, and if not, why not?

2. Developing a similar series of activities for an upper level Developmental Biology course. This is a more advanced population of students (mostly seniors), and at this level, my goal is to get these students to really think like scientists. I am interested in measuring whether working in groups on challenging problems improves their ability to think and reason critically. I already have a few exercises developed, but have not gathered data on their effectiveness. The difficult part of this project is that it requires analysis of student’s written work (as opposed to answers on multiple choice questions). I was intrigued by Bass’ use of an opening day writing assignment that is then revisited at the end of the course. Could you measure student progress both in their scientific content knowledge and in their ability to express themselves or think critically in terms of such an assignment? I’m hoping to learn more about this type of analysis this summer and over the upcoming year. This may be a longer term project, so I shouldn’t commit to being done by next year!

3) Which of the 12 properties of SoTL in microbiology education proposed by S. Benson’s article are particularly relevant to your project at this stage?

From the 12 properties of the scholarship of teaching, although I believe they are all important and interwoven, I think 5, 6, 8 and 10 are the most important to me, because I particularly enjoy seeing what and how others teach the subjects that I teach. How do they address the problems I’ve encountered? What kinds of solutions have they thought of? What can I share with them? All this helps to better define the problems that do exist, such that we have more tools with which to guide students towards deeper conceptual learning.

4) Do you have any questions/concerns/comments that have evolved from your reading?

While defining these research problems, I have been struck by the challenge of proving that a new educational technique, or a new way of approaching a difficult concept is actually better than the old way.

5) What do you see as tangible products to be developed as a result of your Scholars experience within the next 12 months?

Looking at the data I've collected so far will help with the design of interactive exercises intended to be used in class (but could also be used in recitations) to specifically address the incorrect ideas students have.

6) What do you see yourself presenting at the follow-up session at ASMCUE 2009?

I'd like to share these exercises, test their effectiveness in my own classes as well as at other institutions, and measure whether more directed instruction on these topics helps change student thinking and understanding. Some part of this work will be ready to present at next year's ASMUE meeting.

7) What will you need to develop these products?

Assignment #3: Annotations

I have two questions I'm interested in pursuing—1. identifying misconceptions in genetics, and looking at differences in these ideas between majors and non majors, and 2. Assessing critical thinking in junior/senior level developmental biology students. The first three references relate to question 1., the second three to question 2.

1. Clerk, D and Rutherford, M (2000). Language as a Confounding Variable in the Diagnosis of Misconceptions. *International Journal of Science Education* 22(7): 703-717.

This article asserts that the labeling of student ideas as misconceptions is often incorrect, and that instead, students pick particular multiple choice answers because of language inaccuracies in how the question is written, or a misunderstanding of particular terms. The authors chose multiple choice questions on Newtonian mechanics from published physics papers that had been used to supposedly reveal student misconceptions. They tested 48 students and conducted detailed interviews with 9 of these students. Their main conclusion was that language usage frequently prevented students from answering questions correctly, resulting in "false positives", where just by looking at students' answers, one might conclude that a misconception was held. When students explained their reasoning, however, they often did not have the misconception. This paper was particularly interesting to me because I'm in the middle of writing a paper with my colleagues Michelle Smith and Bill Wood on a Genetics Assessment Tool designed to measure conceptual understanding of genetics. We have conducted many interviews, and used student's ideas to write the distracters. I'm now using common student choices from this assessment to pick out what might be shared and persistent "misconceptions" (perhaps I should use the word "incorrect ideas"?) between majors and non-majors. This paper reminded me that I need to be sure students are not being confounded by language.

2. Lewis, J and Wood-Robinson, C (2000). Genes, Chromosomes, Cell Division and Inheritance—Do Students See Any Relationship? *International Journal of Science Education* 22(2): 177-195.

In this paper, the authors discuss students' incorrect ideas about genetics, particularly their inability to connect cells, properties of cells, division, inheritance, genes and chromosomes together into a big picture. The topics they interviewed students on are exactly the topics that I have found to be challenging for students entering college genetics courses (non majors and majors). The authors are from the UK and South Africa, and they do not make explicit whether the students in the study are from both countries. They administered a written test to 482 students (aged 14-16) who were "nearing the end of their compulsory education", which includes instruction on genetics and cell biology. They then conducted focus group interviews of 3-4 students each. The written test included interpreting drawings, making drawings (of chromosomal content, for example), as well as identifying commonly used terms such as genes, DNA, alleles, and chromosomes. In the focus group interviews, the students were asked to describe the reasoning behind their answers. The paper contains many wonderful student quotes, as well as summaries of numbers/percents of students who, for example, could not distinguish between meiosis and mitosis (68%), and thought that the genetic content of each cell was different (80%). I will definitely use the themes described in my analysis of what college students continue to not understand in genetics.

3. Modell, H, Michael, J, and Wenderoth, MP (2005). The Role of Uncovering Misconceptions. *The American Biology Teacher* 67(1): 20-26.
(Thanks Mary Pat!)

This paper focuses on the value of uncovering student misconceptions—ie, we know students have these problems, sometimes even after direct instruction on a topic, so why is it useful to know what they are?

Uncovering the misconception allows the instructor to chart a course for the learners to change their mental models. The paper gives several examples of common misconceptions in physiology, and suggestions on how to proceed with helping the student figure out a new/correct model. For me the main value of this paper was the reminder that diagnosing the problem with a student's mental model is critical in designing activities or other exercises that might induce a student to change their model (emphasis on *student*, since the student must do the changing!).

4. Quitadamo, IJ and Kurtz, MJ (2007). Learning to Improve: Using Writing to Increase Critical Thinking Performance in General Education Biology. *CBE-Life Sciences Education* 6: 140-154.

This paper addressed whether structured group writing assignments as part of a laboratory course could improve the ability of general education students to think critically. The study was well controlled—there were 10 sections of students, all of whom used the same textbook and had the same essential lecture and lab format over a 9 week period (they did, however, have different instructors). In 4 of the sections, the students spent part of their lab time (1 hour per week) writing answers in groups of 3-4 to difficult questions on the material they had been studying in the course and lab. In the other 6 sections, the students were quizzed on their understanding of the same materials, and spent more time on the actual lab work itself (2 hours compared to 1 hour). The paper discusses how the writing assignments were designed and graded, and shows that students improved over time in their writing skills. To measure critical thinking skills, students were given the California Critical Thinking Skills Test (CCTST) at the beginning and end of the

course. Their main conclusion was that students in the writing sections significantly outperformed students in the non writing sections on all aspects of the CCTST. Interestingly, students who started with a higher score on the CCTST improved the most. I'd like to find out more about this test (only a few examples of the questions are given on the website for the test). The pros are that it is a validated instrument, and so can serve as a non content-related measure of critical thinking. On the other hand, a science-based critical thinking assessment might be more useful.

5. Minderhout, V and Loertscher, J, (2007). Lecture-free Biochemistry. *Biochemistry and Molecular Biology Education* 35(3): 172-180.

The authors describe the format and success of a biochemistry course taught at Seattle University, where they have been using lecture free techniques to teach biology for more than 10 years. The courses are small (less than 40 students), and have learning goals that address more than just content knowledge (for example, students should be able to analyze and interpret data and improve problem solving skills). The course revolves around POGIL activities. POGIL, Process oriented guided inquiry learning, is an NSF funded project that began in chemistry (The POGIL website: <http://www.pogil.org/>). POGIL emphasizes group work and critical thinking, and although the students are guided toward content understanding, the process of getting there has value. [Some of the resources available on the POGIL site that others might find interesting can be found primarily under the Resources tab; for example a guide on writing and designing POGIL activities, and how to assess the effects of POGIL on your students (under "assessment handbook")]. The authors report that more students in the POGIL classes receive grades of A,B,or C than in standard lecture classes. They also report student perceptions of this interactive course, using the SALG (Student assessment of Learning Gains) survey. Although some students still reject this technique, requesting more lecture time, most students self-report high understanding of biochemistry material as well as a gain in problem solving confidence. I already use some elements of POGIL in the activities I have designed both to teach genetics and developmental biology. I am considering using more of the POGIL approach for the design of in-class activities to address both my research questions.

6. Blue, J, Taylor,B, Yarrison-Rice, J (2008). Full-Cycle Assessment of Critical Thinking in an Ethics and Science course. *International Journal for the Scholarship of Teaching and Learning* 2 (1): 1-23.

This article reviews a definition of critical thinking, as well as several assessments and recent studies in which critical thinking levels and changes have been measured. Their study used a critical thinking rubric developed at The Center for Teaching, Learning and Technology at Washington State (<http://wsuctproject.wsu.edu>) to measure change in students' critical thinking skills over a semester-long class in ethics and science, in three successive years. A dozen faculty members at Miami University served as Assessment Fellows, whose goals were to create a definition of critical thinking, develop a means of assessing critical thinking, and then assist faculty in this assessment. The fellows agreed on a rubric that addressed seven primary traits of being able to think critically, ranking students on a scale of 1-4 on such items as being able to identify a problem, identify one's own and others perspectives on the issue, use evidence to draw conclusions, etc. Students' papers on case studies were evaluated over the course of the semester. Overall, students showed the most improvement from their 1st to 2nd assignments, but little improvement from the midterm to the end of the semester. Students show

surprisingly little improvement overall. When students had access to the actual rubric, and when they knew they were supposed to be “thinking critically”, they showed more improvement. The authors found their results encouraging, suggesting that even a modest improvement is significant. They also suggest that the instructor has to be skilled in using a series of pedagogical techniques to aid the students in their critical thinking growth. I am interested in studying the rubric they used to assess critical thinking to see if it might be something I can modify for my courses.

James Smith

Michigan State University, East Lansing, MI

Assignment #1: Introductions

1) Describe your teaching responsibilities and the type of student you teach

I am an Associate Professor with a primary appointment in the Lyman Briggs College (LBC) at Michigan State University (MSU), a residential college for students majoring in the Natural Sciences. In Briggs, we focus on undergraduate education, and there is a strong interest in SoTL here and on the MSU campus in general. As needs arise, I teach both semesters of the Lyman Briggs year-long Introductory Biology sequence, which consists of an Introductory Organismal Biology course and an Introductory Cell and Molecular Biology course. I also teach a graduate level course on Molecular Evolution, emphasizing molecular phylogenetics, every other fall.

Most of the LBC students major in Biology, primarily Physiology and Human Biology. On the first day of freshman year, a large number of our students want to be doctors. By graduation time, many of our students still want to be doctors and go on to successful careers in medicine, dentistry and veterinary medicine. However, many of our students change paths as they move through their college years, and pursue other careers, including scientific research, science policy, environmental law, and business, to name a few. In any case, we have very good and highly motivated students in our college, and it is fun to teach here.

I have a joint appointment (25%) in the MSU Dept. of Entomology, where I conduct research mainly on the evolutionary relationships of flies in the tephritid genus, *Rhagoletis*, which are of interest to evolutionary biologists as a model system for studying the processes of speciation and to Michigan's fruit growers as economically important orchard pests. Our current focus is microsatellite characterization of variation in cherry fruit fly (*Rhagoletis cingulata*) populations.

2) Describe what you would like to take home as a result of attending the institute

My primary goal in participating in the Biology Scholars Program is to figure out a way to design my courses, in advance, with data collection in mind that will tell me something tangible about the effectiveness of my teaching. I look forward to becoming affiliated with a group of faculty from across the country who can help me move my own efforts in both teaching and SoTL to the next level.

3) Tell us about your interests outside of the classroom and a book that you've read recently

I very much enjoy reading for pleasure. My most recent books were "Ender's Game", which my wife and I both read along with our 14-year-old son, and Carl Hiaason's "Nature Girl", pure junk that I read as a follow-up to Bryson's, "A Short History of Nearly Everything".

Outside of work, I, too, enjoy being outdoors, especially working in our yard and garden, having a beer with friends, and hosting the circus of friends our kids bring to our house (my other son is 17) for video and computer gaming.

Assignment #2: Reflections

1) How would you describe your “research problem(s)” to the Research Scholars group?

I have one research problem that I am working on and one that I would like to work on in the area of Teaching and Learning. The problem that I am working on involves asking whether or not we can use phylogenetic trees in our Introductory Biology courses to increase student understanding of organismal diversity and evolutionary relationships. Our rationale is that phylogenies serve as representational tools that can help students make connections across taxonomic boundaries. This is the problem that I will most likely address during my virtual residency, primarily because a colleague and I have already done some work on it and we have some preliminary data. My second problem, however, may end up being of more interest to a broader community and might be more fun (it will certainly be more work!) We do a lot of group work in our laboratory classrooms, with student “researchers” working in teams of 3-4 students. What is the optimum team size for these experiences, with respect to student learning and understanding? How can we ensure individual accountability, while retaining the ability to evaluate all of the student work? I think that these are very rich research questions that would be very interesting to pursue.

2) What theme(s) based on your readings, resonate with your “problem” and/or your proposed approach to address your problem?

One of the main themes from the reading that resonates with my “problems” is that of being learning centered. While we want to increase student learning and understanding, I don’t feel that our research at present is truly learning centered. I mean this in the sense that the data that we have collected doesn’t directly measure student learning and understanding of specific learning goals and objectives. I think we need to give more thought to the nature of the data that we collect.

3) Which of the 12 properties of SoTL in microbiology education proposed by S. Benson’s article are particularly relevant to your project at this stage?

Of the 12 properties of SoTL in microbiology education proposed by Benson, I would say that #8 is particularly relevant. Our research is “Problem Centric”, even though we could do a better job defining the problem(s) in such a way that the data collected will help to address the problem(s) directly.

4) Do you have any questions/concerns/comments that have evolved from your reading?

With respect to reading the set of papers that were assigned, I came away a bit surprised by the lack of depth in the research database in the field (of SoTL) and also by the lack of identifiable “big questions”. It seems to me that we need more data to draw upon as we formulate our own studies. In addition, there appears to be a lack of true “benchmark” studies. For example, one major question in microbiology that was addressed relatively recently was the relationship of the three biological domains. Which was closer to Eucarya, Archaea or Eubacteria? A lot of research went into answering this big question. The benchmark 1996 PNAS paper by Balduf et al., “The root of the universal tree and the origin of eukaryotes based on elongation factor phylogeny”, has been cited 144 times. What are the equivalent benchmark papers, and corresponding big questions, in SoTL? What is it that we really *don’t know*? How do the experiments on Teaching and Learning that we conduct in our classes illustrate broader principles?

5) What do you see as tangible products to be developed as a result of your Scholars experience within the next 12 months?

What I would like to develop in the next 12 months as a result of my Scholars experience is an experiment that I can carry out in fall 2008 and/or spring 2009 to test the effectiveness of "tree-thinking" in our Introductory Organismal Biology course. Conversely, it would be really interesting to come up with an experimental design that would allow us to test the effects of group size on learning and individual accountability in cooperative groups in the Introductory Biology teaching laboratory.

6) What do you see yourself presenting at the follow-up session at ASMCUE 2009?

I anticipate using the Scholars Experience (and the other Scholars) to sort out which of these two projects is the more promising to pursue, both in the short term and the long term. I see myself presenting the results of one of these experiments at ASMCUE in 2009, but to do so I need a good, solid, experimental plan. I guess that's where I'd like to begin.

7) What will you need to develop these products?

Assignment #3: Annotations

The question I am researching for the BSP is whether or not using a phylogenetic framework, in particular having students work with and learn how to build and interpret phylogenetic trees, leads to increased student learning and understanding of organismal biodiversity and evolution. I am studying the students in an Introductory Organismal Biology course who are studying organismal diversity not by "marching through the phyla", but by examining organisms in a comparative, inquiry-based framework that incorporates what we call, "tree-thinking". Tree-thinking involves phylogenetic analysis and employs phylogenetic trees as representational tools to understand evolutionary concepts and relationships.

My research is not concerned so much with students' ability to understand phylogenetic trees per se, but more with how the trees can be used as a tool to organize thoughts about groups of organisms. I also want students to see a phylogeny as a hypothesis, and to use data and observations to discern between two competing hypotheses (phylogenies), which may help move evolutionary biology in my students' minds away from being dogma and towards being experimental science.

I am looking for literature pertaining to how students interpret phylogenetic trees, and how to assess whether or not using phylogenetic trees in our Intro Organismal course has led to increased learning and understanding of organismal relationships.

1. Baum DA, Smith SD, Donovan SSS. 2005. The Tree-Thinking Challenge. *Science* 310: 979-980. [DOI: 10.1126/science.1117727].

This paper is really the "call to arms" with respect to tree-thinking, referring to the use of phylogenetic trees to study evolution. These authors point out that phylogenetic analysis, which is used to infer phylogenetic trees to interpret ancestor-descendent relationships, is rarely employed outside the realm of professional

evolutionary biologists. The authors would like to raise the status of tree-thinking as a major theme in our students' evolution training, arguing that phylogenetic trees are the most direct representation of ancestor-descendent relationships, which are the core concept of evolutionary theory. I have heard anecdotally that many people have used the Tree-Thinking Quizzes that are included in this paper as supplemental material available online.

2. Gregory TR. 2008. Understanding Evolutionary Trees. *Evolution Education and Outreach* 1:121-137. [DOI 10.1007/s12052-008-0035-x]

This paper provides an extensive introduction to evolutionary trees with guidelines about how to read and interpret them. The author then examines, with excellent examples, ten common misconceptions about phylogenetic trees that he claims represent "fundamental barriers to understanding how evolution operates". This paper is really nice in that it provides the reader with a reference to the tree-building quiz developed by Eli Meir et al. (contained in *EvoBeaker*), is well referenced, and has many useful links to online resources for understanding evolution and tree thinking.

3. Brewer S. 1996. A Problem-Solving Approach to the Teaching of Evolution. *Bioscene* 22(2): 11-17.

Brewer's work with John Jungck on the computer program *Phylogenetic Investigator*, available through BioQuest, has inspired some of my own teaching efforts. The goal of *Phylogenetic Investigator* was to have students use phylogenies in a problem-posing, problem-solving and peer-evaluation instruction model. I used *Phylogenetic Investigator* with a group of Honors students one semester in my Intro Organismal course to study the evolution of HIV. The *Bioscene* paper, while not particularly well focused has much valuable information on problem-solving as a general educational method with comments to its applicability to the teaching of evolutionary concepts. Again, it is argued that the historical and comparative approaches, which are important for really understanding the significance of evolutionary theory, are really given short shrift compared to natural selection and the functional perspective. This paper derives from Brewer's Ph. D. dissertation in Science Education.

Reference #3 was found only by using ERIC.

4. Julius ML, Schoenfuss HL. 2006. Phylogenetic Reconstruction as a Broadly Applicable Teaching Tool in the Biology Classroom: The Value of Data in Estimating Likely Answers. *Journal of College Science Teaching* 35: 40-45.

This paper describes an exercise that is very similar in spirit to the one that we developed in our course. Julius and Schoenfuss used a set of vertebrate skulls to have students develop a character matrix for phylogenetic analysis. Julius and Schoenfuss emphasize scientific literacy, which gets to the heart of the matter with respect to why I wanted to use phylogenies in my class in the first place. They do a really nice job of bringing in Popper's 1959 book, "*The Logic of Scientific Discovery*", in which the importance of using data to discern between competing hypotheses is brought out. This is the key concept I want to teach. Phylogenies are hypotheses of the evolutionary relationships of groups of organisms, and we have objective criteria (data and methods) that we use to decide which of two competing hypotheses is preferred. This is the key thing that makes evolutionary biology science. This paper

also includes some assessment of student learning in summary form. Senior level students who had completed this laboratory performed better on the evolution section of a summative exam (65% vs. 34%), while students in lower level courses who had completed this laboratory were found to perform an average of 11% better in an exam covering systematics and evolution. Unfortunately none of the actual data were included in the paper. .

Reference #4 was found only by using ERIC.

5. Singer F, Hagen JB, Sheehy RR. 2001. The comparative method, hypothesis testing & phylogenetic analysis – An Introductory Laboratory. *The American Biology Teacher* 63: 518 – 523.

The paper by Singer et al. is one of two papers (the other is: Giese AR. 2005. Using inquiry and phylogeny to teach comparative morphology. *The American Biology Teacher* 67: 412 – 417.) whose methods we merged to create our own laboratory stream. One goal of this work was to have students learn that phylogenetic trees are graphical representations of hypotheses about evolution. The authors also point out that practicing phylogenetic analysis provides practice in critical thinking, strengthening students' logical and mathematical abilities, and their problem-posing and problem-solving skills. Singer et al. provided skeletons of five animals (opossum, dog, cat, rat and rabbit) to their students, who were then asked to generate a character matrix based on observations of these skeletons. Using this matrix, and other information on the anatomy, physiology, behavior and ecology of these animals, students were asked to propose a hypothesis of evolutionary relationship, using the extinct *Megazostrodon* as an outgroup (there are 105 possible hypotheses). Students then tested this "tentative statement" using DNA sequence data to infer a phylogeny of these five animal group, showing the students that hypothesis are tentative statements that are open to testing and revision using additional data or data from a different source. In our own work, we have used the opossum as outgroup, and then show the students that there are only 15 possible phylogenies. Our students are given two of these 15 trees, and then asked to develop an explanation of why one is better than the other by mapping individual characters onto their trees and applying the principle of parsimony.

Mary Pat Wenderoth

University of Washington, Seattle, WA

Assignment #1: Introductions

1) Describe your teaching responsibilities and the type of student you teach

I am a Senior Lecturer at UW and teach a range of undergraduate courses dealing with animal physiology. I start with the animal physiology section of the Introductory Biology course for majors (Biol 220), and then see students again in Foundations in Physiology (Biol 350). If they have not had enough of me by then, there is Biol 460- Mammalian Physiology (all CV, renal and respiratory-- those fun housekeeping systems), Biol 462-Advanced Animal Physiology (really comparative phys) and Biol 463, Advanced Animal Physiology Lab-- an independent study lab where 18 teams of students, 3 grad students and 2 faculty see what type of experiments Senior Bio majors can design and carry out using spiders, manduca, planaria and other inverts. This is always fun.

Biology has 1,000 majors, about half are transfer from community college and most are thinking about med - dental- pharm- vet -grad school. Classes are large (90-260students) and students are bright and eager (sounds like Lake Wobegon!)

2) Describe what you would like to take home as a result of attending the institute

I am looking for minds to brain-storm with on questions about how to change our classrooms to help all students gain a meaningful understanding of biology. I would like to advance the notion of evidence based classroom techniques and determine the most rigorous methods to use to build that evidence base. Will be interesting to see how other faculty are transferring their basic research skills to address questions about student learning in Biology. I am also very excited to meet other faculty who are interested in pursuing educational research in the biological sciences. There are times I feel that I am a woman without a discipline. I am not tenure track biology basic research but I am not in the school of education either-- I want to blend those two worlds.

3) Tell us about your interests outside of the classroom and a book that you've read recently

I used to make my own beer (this is Seattle after all-- microbrew capitol of US) but now enjoy discovering new IPAs on tap around town. Always like finding the microbreweries in places I visit to see how they measure up to the Washington ones. I recently discovered the spectacular Southwest-- southern Utah and Northern Arizona. Who knew rocks could be so mesmerizing! Have fallen in love with Bryce and would make that my ideal run-a-way spot.

Books- What the Best Teachers do by Michael Bain, Three Cups of Tea by Greg Mortenson (<http://www.threecupsoftea.com/>), The World is Flat and Freakonomics are waiting by the couch for the end of the quarter.

Assignment #2 Reflections

1) How would you describe your “research problem(s)” to the Research Scholars group?

Students are introduced to many systems over the course of the quarter in physiology and quickly become overwhelmed with material if they do not build a strong conceptual framework of the basic physiological mechanisms that are common across systems found in the body. Students also have a difficult time developing a mechanistic (how things work) rather than a descriptive (sequence of steps) understanding of physiological processes. In 2000, Modell developed the pedagogical technique of using General Models to help students build robust mental models (i.e. conceptual frameworks) of physiological processes. General Models (GM) are seven common principles that can be applied to a variety of physiological systems. I have begun to incorporate GMs in the physiology courses that I teach, and need to develop the appropriate assessment tools to determine if indeed incorporating GM into my pedagogy enhances student understanding. I also need to better define the various ways GM can be implemented in the classroom and determine how to document, monitor and quantify each method.

I also find that students have a difficult time monitoring their learning. To that end, I will introduce students to how they can use Bloom's taxonomy to assist them in monitoring their learning. I will not only use Bloom's in class to help student's recognize the Bloom's level of all questions asked in class but I will categorize and identify all exams questions according to Bloom's. After the exam has been graded, each student will receive a report of how they performed on exam questions at each Bloom's level and they will be directed to a resource (BLAST, Bloom's Learning Activities for students) that will suggest learning activities to strengthen their weak areas. I need to develop an assessment tool to measure gains in metacognition that may be realized from this implementation of Bloom's.

The literature also indicates that student learning can be enhanced if students are given the opportunity to reflect on their learning. To facilitate this reflective process I will have students submit a weekly “Learning Paragraph”. Each week the learning paragraph addresses a topic associated with their learning in physiology, prompts for this weekly assignment would include the following: “What type of connections are you making between the material discussed in class and your life outside the classroom?, How has your test preparation changed since high school? After looking at your test results, how will you change your study patterns? ” (This assignment also gives students the additional opportunity to practice their written communication skills.) I am unsure of how to assess these writings.

2) What theme(s) based on your readings, resonate with your “problem” and/or your proposed approach to address your problem?

The reading that most resonated with me was the article by Randy Bass. I appreciated how he changed “the status of the problem in teaching from terminal remediation to ongoing investigation”. It is just such a paradigm shift that could provide faculty with the permission to more freely examine what happens in their classroom. Asking the questions why some students do better than others or how students learn your discipline, reframes the classroom as a place of inquiry for both student and faculty.

3) Which of the 12 properties of SoTL in microbiology education proposed by S. Benson's article are particularly relevant to your project at this stage?

4) Do you have any questions/concerns/comments that have evolved from your reading?

5) What do you see as tangible products to be developed as a result of your Scholars experience within the next 12 months?

I hope to come away from Biology Scholars with a sound experimental design for each idea and rigorous assessment methods. I am most concerned about being able to determine the correct statistical analysis to do with each of these projects.

6) What do you see yourself presenting at the follow-up session at ASMCUE 2009?

I would hope to be able to present the findings from at least one of these studies at a workshop or poster presentation at ASMCUE.

7) What will you need to develop these products?

Assignment #3 Annotations

Overview of Learning

Bransford, J.D., Brown, A.L. and Cocking, R.R. (Eds.) (1999) *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C. : National Research Council, National Academy Press.

This NRC report presents a thorough review of the literature concerning learning strategies that encourage and are barriers to student learning. Their major findings include the following: 1) student misconceptions are a barrier to their learning and these misconceptions must be challenged if they are to be changed, 2) to build meaningful understanding of a discipline need both factual knowledge and a strong conceptual framework into which to put those facts, 3) strong metacognitive skills are necessary for learners.

Mental Models

Modell, H.I., (2000) How to help students understand physiology? Emphasize general models. *Advances in Physiology Education* 23: 101-107.

This article is the basis for my intent to incorporate general models into my physiology course. Modell presents his concept of general models as a way to help students better understand physiology. General Models represent first principles that can be applied across physiological systems. General Models help student build robust mental models of physiological systems that allow them to predict consequences of changes to those system. General models help students transfer their mechanistic understanding to systems they have not yet studied.

Gentner, D. & Stevens, A. (Eds.) (1983) *Mental Models*. Mahwah, NJ : Lawrence Erlbaum Associates

This book lays out the basic premise of how learners use and develop mental models to develop deep understanding. They indicate that the ways student build, test and refine their mental models is dependent on the nature of the domain studied, the nature of the theoretical approach, and the nature of the methodology.

Herbert, BE, (2003) The role of scaffolding student metacognition in developing mental models of complex, Earth and environmental systems, DFG-NSF International Workshops on Research and Development in Mathematics and Science Education, Washington D.C. Available online at <http://geoexplorer.tamu.edu/dfgnsf/WG1.html>.

Earth and environmental systems study a complex and dynamic set of variables that cover a wide range of scales (time, size, disciplines) and thereby pose a large challenge to students attempting to build their mental models. His project seeks to develop and assess IT-based learning environments that foster student development of rich mental models of environmental systems through metacognitive scaffolding, manipulation of multiple representations, use of authentic, complex and ill-constrained problems. This project provides a thorough set of guidelines for developing and assessing educational material to guide effective student development of robust mental models.

Metacognition

Everson, H.T. & Tobias, S., (1998) The ability to estimate knowledge and performance in college: A metacognitive analysis", *Instructional Science* **26**: 65–79.

Tobias, S., & Everson, H. (2000) Assessing metacognitive knowledge monitoring. In G. Schraw & J. Impara (Eds.), *Issues in measurement of metacognition* 147-222. Lincoln, NE: Buros Institute of Mental Measurement.

Tobias, S., & Everson, H.(2002) Knowing what you know and what you don't: Further research on metacognitive knowledge monitoring. College Board Report No. 2002-3. College Board, NY.

Assessing student metacognition will be one of the challenges of my project. These authors examine learners' ability to differentiate between what they know and do not know. Their findings indicate learners of all levels of ability and developmental stages are affected by their ability to monitor their learning. They have focused on the correlation between knowledge monitoring and student's academic performance.

Isaacson, R.M. & Fujita, F., (2006) Metacognitive Knowledge Monitoring and Self-Regulated Learning: Academic Success and Reflections on Learning. *Journal of the Scholarship of Teaching and Learning*, 6, (1), 39 – 55.

These authors studied how student's metacognitive skills impacted self-regulated learning (SRL) skills in undergraduates. They found that high achieving students were: more accurate at predicting their test results; more realistic in their goals; more likely to adjust their confidence in-line with their test results; and more effective in choosing test questions to which they knew the answers.

Vadhan, V., & Stander, P. (1994) Metacognitive Ability and Test Performance among College Students. *Journal of Psychology*, 128 (3):307-311.

Undergraduate at a community college were asked to predict their grade on an exam prior to taking the exam. Predicted grades were compared to actual grades on the exam. They found that students with higher actual grades demonstrated an understanding that helped them to more accurately evaluate their own performances.

Bloom, B. (1956) *Taxonomy of Educational Objectives, the classification of educational goals – Handbook I: Cognitive Domain*. New York: McKay

This is the classic study that proposed six cognitive domains: knowledge, comprehension, application, analysis, synthesis and evaluation. Each domain is explained and relevant examples across disciplines are provided. These works provides a simple and straight forward means of helping faculty monitor and align their teaching and testing as well as provide a framework for students to both monitor and structure their studying.

Reflective Thinking

Reflective Thinking: RT

<http://www.higp.hawaii.edu/kaams/resource/reflection.htm>

This web site defines reflective thinking, indicates RTs connection to building critical thinking in learners and offers practical class room activities to promote RT.

Thompson G, Pilgrim, A., and Oliver, K. (2005) Self-assessment and reflective learning for first year university geography students: A simple guide or simply misguided? *Journal of Geography in Higher Education*. 29. 403-420.

These authors designed a set of learning materials and activities who purpose is to guide students towards independent learning by encouraging them to reflect more on 'what' and 'how' they learn. Results of the 2003 and 2004 trials showed that the self-assessment schedule had a positive impact on student learning and was at least partially effective in improving students' critical thinking skills.