

2010 Research Residency Pre-Institute Assignments



Team 2

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Assignment #1: Introductions

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

My teaching responsibilities include three very different courses with very different students. The first course I was asked to teach at Kingsborough Community College, an introductory course on Anatomy and Physiology which is for students planning to pursue a career in nursing or other health related fields. The students who enroll for this course are determined to do well as this is a gateway course for which students need a minimum of a B to apply for the nursing program. Despite this, the vast majority of the students are very much underprepared for the rigors of the course. I was told at the outset I would see a bimodal curve of very low and very high grades, and that information was aligned with my experience to date. I struggle with this reality since it seems that many of the students who fail are shocked by that reality. They seem surprised despite having not taken many or any biology courses previously. Students who excel seem to have prior knowledge and/or a single minded focus.

The second course I was asked to teach is a non majors course called People and the Environment. This course is for students who simply want to complete a biology requirement. The subject matter is much closer to my academic expertise as an Ecologist, yet my passion and knowledge are inadequate to inspire the students to care about the environment even a fraction of the amount that they care about their grades. The students are in my classroom to fulfill a requirement not to become impassioned tree huggers. My approach includes use of classroom activities, humor, multimedia, field trips and attendance of relevant lectures. I look forward to hearing the student's feedback at the end of the course and intend to administer a questionnaire to assess their attitudes towards the environment and how it may have changed as a result of taking the course.

My final teaching responsibility involves teaching as an Adjunct at Columbia University's Center for Environmental Research and Conservation. These students are working, white-collar seasoned professionals who are seeking to become more educated about the environment as either a means of career lateral, shift or for their own edification. These students are eager to learn the information intuitively more so than obediently. Their innate curiosity and desire to learn

is evident and a stark contrast to my Kingsborough students who are in my classrooms because they are seeking to use the credits as a stepping stone to improve their lot in life or advance to a professional career from a non-professional career. With so much more at stake, it would seem that the Kingsborough students will excel more readily, but with so much less experience in the art and science of learning, their disadvantage remains evident.

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

First and foremost, I would like to become a better professor and a better educator. This desire is not only to improve my skills and advance my career, but to improve the skills and advance the skills of my students. I would like to take home a deeper understanding of the learning process and some skill sets to better navigate that terrain.

I would also like to become a better researcher in the domain of pedagogy and quantification of learning. I spent several years as a curriculum specialist and was continually challenged by the difficulty of demonstrating the efficacy of a given curriculum approach or initiative given the myriad variables that can confound and obscure the cause of a given learning outcome. Any additional skills I can gain to better assess the impacts of my approach to learning will be a valuable tool.

The final thing I would like to gain from this institute is exposure to potential new colleagues, teachers and peers. Access to the expertise, experience and insight of others will help me formulate my own understanding of the scholarship of teaching and learning.

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

My interests outside of the classroom are varied. My primary interest is in wildlife research and nature conservation. I conducted my dissertation on the ecology of a small carnivore found in Southeast Asia and I recently received a grant to conduct a follow up study of this little known species. My desire to continue to study this species and to return to the field site of my initiation into field conservation research.

My other prime area of interest is nature based travel. As such, I have pursued a side interest in freelance travel writing. This has led to authorship of Frommer's several guidebooks to the Caribbean. I have not only enriched these books with conservation information for the readers, but have expanded my research to include investigations of sustainable wildlife tourism in the Caribbean. This has led to my expanded research interest in using informal education and edutainment to enact profound changes in attitudes towards nature and conservation.

A recent book I read was authored by a dear friend and amazing mentor Edward O. Wilson. His book entitled *The Creation* is a cogent and concise argument for conservation of biodiversity made to the clergy of a fundamentalists church. E. O. Wilson's goal was to convince the most challenging audience he could envision that saving nature is in the interests of humanity and aligned with all dictates of faith. Another book I read recently is also by the same author and is called *Biophilia*. This is an articulation of the author's theory that humanity has a fundamental affiliation for nature that is genetically based as a result of evolutionary forces. He uses a variety of evidence to argue his position, including the high real estate value of waterfront property and the landscape architect's obsession with creating lawn interspersed with spreading trees, which is essentially a recreation of the planes of Africa from which humanity emerged.

Assignment #2: Reflections

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

My research problem involves students learning environmental science and ecology. My goal is to have them all be critical thinkers at the end of the semester. I want them to be able to critically examine information, draw conclusions about raw data, and assess that data for errors, bias and inaccuracies. This goal is important to me because I have found that the public is presented with a great deal of misinformation about critical environmental issues. Media or marketing pieces are sometimes presented as, or mistaken for, scientific literature. I feel that if we do not have a citizenry who are scientifically literate, they will be ill-prepared to deal with the many scientific issues facing society. My assessment therefore may revolve around asking students to critically assess a media piece or draw a conclusion based on some sort of data.

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

The themes that resonate with me based on my readings include the premise that evaluating teaching methodology is a valid academic pursuit. As a science educator, the idea of applying a scientific approach to solving the “problem” of understanding how students learn has great appeal. I have also long marveled at the dissonance between the teaching credentials required for teaching high-school versus the content credentials required for teaching college. I am also fascinated with the question of how best to impart a fundamental level of scientific literacy among students. The current paradigm is that students retain and understand best through hands-on, inquiry-based experiences, which runs counter to the mainstream approach of teaching science through chalk and talk lectures. I would like to test this approach with my students.

3) Based on Pat Hutchings article, what taxonomy would you use to describe your research question and why?

Based on Pat Hutchings article, the taxonomy I would use to describe my research question is a combination of What Works and Visions of the Possible, because my goal is to find a way to impart a process skill set on students while making them active participants in their own learning.

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

The primary question I have with regard to this data, is whether I will be able to discern how students are learning or processing information when I do not have access to their out-of-school learning modalities. For example, I know that not all students purchase the text book or access the lectures online. These myriad variables make it difficult to tease apart each element that contributes to student learning. Another concern I have is how to avoid bias in my analysis of my own teaching. This will require that I avoid all the classic pitfalls such as not putting a disproportionate amount of effort into lessons that employ one approach versus another. A final concern is with regard to my tendency to want to evaluate many aspects of my teaching rather than just one. I am also concerned with assessing two different groups (such as majors versus non-majors) or the same class taught during different semesters. As a new faculty, I will be teaching classes this Fall that I have not taught before (at least at this institution), that have not been taught in recent history, and that were taught by faculty who have passed on. My first semester versus the second semester will no doubt differ primarily by virtue of the former being a first attempt. This will make it challenging to attribute different outcomes to other factors.

Assignment #4: Annotated Bibliography

1. Drake, KN and D Long **A Comparative Study of Problem Based Learning and Direct Instruction/Experiential Learning in Two 4th Grade Classrooms** Journal of Elementary Science Education Volume 21(1) 2009. 16pp.

This article summarizes the efficacy of Project Based Learning (PBL) in a variety of educational settings, including; clinical medicine, engineering, law as well as classroom science. It does a good job of describing the way two classrooms were statistically compared to draw out significant differences in learning outcomes. Several parameters of interest that were quantified include testing performance on multiple choice tests, depth of content knowledge, retention of content knowledge over time, and problem solving skills in general. Other parameters measured that were of less interest were time on task and stereotypical perceptions of science and of scientists. This paper could serve as a model for a study in which I could compare PBL classes with non PBL ones to help assess whether this approach is effective at the college level to teach science.

2. Ronsheim, ML, M Pregnall, J. Schwartz, MA Schlessman, KM Raley-Susman **Teaching Outside of the Can: a New Approach to Introductory Biology** Bioscience 16 Volume 35 (1) 2009 11pp.

This investigation examines the use of processed based learning to instill a greater sense of interest in pursuing biology as a major. The use of open ended and discovery based lab projects yielded an increased ability to engage with the literature and increased enthusiasm and confidence. At the same time there was no measurable decrease or gaps in content knowledge observed. Students also showed increased levels of sophistication and experimentation. While it would not be possible to teach Ecology as a fully open ended course, it would prove interesting to give students an opportunity during the course of the semester to engage in an open ended inquiry lab experience and compare their learning outcomes to those of non inquiry based labs.

3. C Hardin **Effectiveness and Accountability of the Inquiry Based Method in Middle School Science** MSE School of Education Dominican University of California 2009

While targeting the middle school audience, this thorough work investigated the ongoing issue over quality versus quantity in science education settings. It also concludes that inquiry is ineffective without adequate scaffolding and age appropriate guidance in the implementation of the inquiry process. This study reviews the literature and the history of inquiry science, pointing out that on international tests such as TIMMS and PISA, the US ranks 19th out of 21 in science literacy and 29th out of 34 respectively. The greatest value of this publication is that it emphasized the need to improve science literacy among our science bound and non science bound students and citizenry.

4. C. Friedel, Irani, T. Rudd, R. Gallo, E. Eckhardt, J. Ricketts **Overtly Teaching Critical Thinking and Inquiry Based Learning: A Comparison of Two Undergraduate Technology Classes** . Journal of Agricultural Education Volume 49 (1) 2008

This article compares using an inquiry based approach versus overtly teaching critical thinking skills to foster greater critical thinking ability. The study found that overtly teaching critical thinking skills leads to improved critical thinking skills. The researchers also tested for gender differences in critical thinking skills but found none despite other research that has concluded that females show different problem solving skill sets than males. This study tests an interesting means of improving essential learning skills that students need and can apply in every aspect of their lives.

5. Alcazar, MTM, VL Fitzgerald **An Experimental Design to Study the Effectiveness of PBL in Higher Education, in First Year Science Students at a University in Peru, South America** College Quarterly Volume 8 (2) 19pp 2005

This article explored the use of PBL in improving student academic performance in such tasks as critical thinking, group problem solving, cooperation. The study employs Bloom's Taxonomy, in which skills at three levels of cognition are tested (cognitive, affective and psychomotor) to assess learning. Assessment of both lower order thinking (knowledge, comprehension and application) along with higher order thinking (eg analysis, synthesis and evaluation) were quantified. Because higher order thinking skills are essential for success in any scientific and non scientific study, it would be interesting to test these skills specifically in an evaluation of PBL versus non-PBL classes. It appears as though the non PBL students performed significantly lower on lower order thinking skills but they scored higher on the higher order skills.

Cindy Graham

University of Calgary, Calgary, Alberta, Canada

Assignment #1: Introductions

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

I teach a wide variety of courses as part of my joint appointment in the Natural Sciences Program and the Department of Biological Sciences at the University of Calgary. The Natural Sciences Program is a multidisciplinary program where students concentrate their studies in two scientific disciplines. As such, our student population is very academically diverse and each builds a unique program based primarily on their interests. In this program, I teach a relatively small capstone research project course (30-55 students) where students work in multidisciplinary groups to create a research proposal on an area of their own choosing. Within this research proposal framework, students work on improving their teamwork and communication skills as they develop the ability to analyze and synthesize large amounts of information from the scientific literature, apply sound research design principles within their proposals and provide constructive criticism to aid others in the development of their research ideas. The course is very challenging to teach but also very rewarding.

Within the Natural Sciences Program, I also teach a scientific writing service course, primarily to chemistry and geology majors. These students are very good at quantitative/analytical tasks but are not always the best communicators of scientific information. The class has undergone a major redesign in the last few years and now includes active-learning activities in nearly every class. The students work to create a toolbox of transferable skills around scientific writing through a series of in-class activities and milestone assignments aimed at modeling writing as a process. This strategy has been extremely successful, both in terms of student buy-in and satisfaction with the course and we now see gains in written communication skills over the course of a semester.

Within the Biological Sciences Department, I teach a second-year plant physiology class to 96 students/year, part of an environmental physiology class (~30 students) and one lecture section of our first-year organismal biology class (~350 students/section X 3 sections per year). The students in my biology classes are primarily biology majors (with a large proportion wanting to go into a professional program) and most start university directly out of high school. We have a diverse student population: about 61% are female and, although my university doesn't keep

statistics on minorities, there is a lot of ethnic diversity (many students with Asian and East Indian backgrounds).

In the upcoming year, we will be redesigning our first year courses to take a more integrative approach. We are designing two sequential courses that will cover topics from biomolecules to the biosphere in two main areas: (1) Energy flow in biological systems and (2) DNA, evolution and inheritance. I am working with two of my colleagues on the design and implementation of the energy course (one of whom was bioscholar in 2005 - Bill Huddleston) and we will offer these courses starting in the the 2011-2012 school year. We will likely have 3 sections of 400 students. These courses will both take an active- learning/ problem-based approach in both lab and lecture and we are hoping to design activities to allow students to acquire and retain significant foundational skills and knowledge over the course of the year.

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

We intend to complete a substantial assessment of the first-year experience in the new biology courses described above. Bill Huddleston and I will be working together on the assessment; we will try to understand how the incorporation of active learning techniques impacts student learning (I have chosen three major areas to assess) and whether there is measurable improvement (and retention) in student skills around the scientific process (e.g. drawing/analyzing graphs and reading the scientific literature). I am hoping to learn effective strategies for designing clearly answerable and publishable education research questions that will help me assess the effectiveness of the new teaching approach that we will take in these classes.

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

I am an avid golfer (note that I said "avid" rather than "good") and I enjoy gardening and photography. Although I haven't read a lot of "fun" books recently, I did just start a very fluffy mystery novel this past weekend - "The Brass Verdict" by Michael Connolly - but it is too soon to make a ruling on it yet. I just finished reading "Power, Sex, Suicide: Mitochondria and the meaning of life" by Nick Lane and it is definitely worth a read.

Assignment #2: Reflections

My research focus is to generate a quantitative understanding of the effectiveness of our first-year biology courses in helping students learn. It is my goal to compare the effectiveness between current and redesigned courses and also gauge the effectiveness of newly devised lecture and lab activities. Specifically, I am interested in the following research problems: (1) how does the change from traditional to integrative content organization and the intentional incorporation of active learning activities in lecture influence student understandings (and misconceptions) of energy, evolution, and flow of information in cells (i.e. transcription and translation); (2) how do redesigned laboratories impact the acquisition and retention of student skills around the scientific process (e.g. graphical analysis, experimental design); (3) what are the major predictors of student success in our first-year biology classes (e.g. study strategies, ways of thinking, prior knowledge, entrance grades) and (4) how are measures of student and faculty satisfaction influenced by the redesigned curriculum?

I think these four questions are all just different aspects of understanding student learning and experience in our classes and fit within all categories outlined by Hutchings; by evaluating the "relative effectiveness of different approaches" in the current and new classes we are focusing on "what works"; by investigating the preexisting comparators influencing student success we are

focusing on “what is” and by examining the acquisition and retention of student understandings of the scientific process we are focusing on “visions of the possible.” I also think that the entire redesign of these courses is about “formulating a new conceptual framework for shaping thought about practice”. For me, this last point is particularly important and relates not only to the taxonomy of my research problem but to the resonant themes I took from the articles. While there are a few institutions that have taken an integrated content approach to student learning, the vast majority teach biology in a traditional way where knowledge is compartmentalized into subdiscipline areas (e.g. botany, ecology, zoology, biochemistry). The unfortunate outcome of this approach is that many students find it difficult to make connections – both between, and often within, their science courses. If, as a scientific community, we are honestly working towards an integrative understanding of biological processes, then we should also be fostering that same level of understanding in our students. If we state in our course goals that students should integrate knowledge throughout a course, but then “teach” the material in a compartmentalized fashion without modeling an integrative approach and providing opportunities for the transition from novice to expert thinking then we shouldn’t be surprised when students fail to meet expectations.

Two other ideas from the readings resonated with me. First, effective teaching, like science, is an iterative process. Although we are spending considerable time designing our new courses, it is likely that there will be aspects that do not encourage student learning in the way that was intended. This means that while this initial research project is focused on a comparison between two very different course frameworks, ongoing classroom action research will be necessary to ensure that learning activities are meaningfully tied to both student learning and course goals.

Second, I like the idea of the scholarship of teaching as self-reflective, transformative practice. My motivation for undertaking educational research is to create learning opportunities for my students that are based on carefully planned observations and inquiry rather than perceptions and anecdote. These articles reaffirmed the need for a thoughtful research design and well-articulated research questions in order for the data collected to yield meaningful results.

Although I have done a great deal of reading related to my project in the last month, and I am feeling more confident in my research goals, my biggest concern is still the scope of my project. While Gass suggests that it might not be possible to investigate more than one question at a time, I feel that reducing the scope to a single question is not really possible because of the expectations of my department and that doing so would obscure, instead of illuminate, our understanding of the impact of our course redesign. I will have to keep thinking about ways to rectify/merge my goals as a teacher and the goals of my department in this research project.

Assignment #4: Annotated Bibliography

In considering the relevant literature for my project, I have split the project into two major parts:

- (1) what preexisting understandings and behaviours influence student success in first-year biology classes and
- (2) how and what needs to be evaluated to understand student learning gains in our existing and newly designed courses.

In the first instance, I was interested in understanding how characteristics like motivations, approaches to learning and past educational success influenced student success and satisfaction in university biology classes. I started from Biggs' work on the Study Process Skills Questionnaire (Biggs, J.B. (1987). *Student Approaches to Learning and Studying*. Research

Monograph. Hawthorn, Australia: Australian Council for Educational Research.), Zeegers' long-term work on student approaches to learning (Zeegers, P. (2001). Approaches to learning in science: a longitudinal approach. *British Journal of Educational Psychology* 71(1), 115-132.) and information on the CLASSE (Classroom Survey of Student Engagement) tool developed at the University of Alabama (<http://assessment.ua.edu/CLASSE/Overview.htm>). In reviewing this, and other literature, it became clear that in addition to choosing an effective methodology, there were issues with some of the available survey tools; while the Canadian and American education systems are similar in many respects, there are substantial differences related to Canadian culture and context. The first "article" that I have chosen in my bibliography is based on a large project lead by Noel Entwistle at the University of Edinburgh that evaluated student learning in many universities in the United Kingdom. I feel that this comprehensive project and the resulting survey instruments are carefully considered and fit better with the goals of my project and the culture of my students. For the second part of my project, I investigated the various ways that researchers had measured gains in student's conceptual understanding of energy, evolution and information. I have chosen articles that have informed our pre- and post-assessment instruments and also highlight the challenges and debates around creating concept inventories generally.

Hounsell, D., & Entwistle, N. (2005). Enhancing Teaching-Learning Environments in Undergraduate Courses. Retrieved from <http://www.etl.tla.ed.ac.uk/publications.html>

This site outlines a large, discipline-specific, teaching and learning project completed in the United Kingdom aimed at understanding the factors influencing student learning and academic success with the goal of enhancing the learning environment. It contains an overview of the project, all survey tools and links to publications arising from the project. Of particular interest to me were the measurement instruments used in the project (<http://www.etl.tla.ed.ac.uk/publications.html#measurement>). This summer, I have modified and piloted two of these instruments in our classes: the Learning and Studying Questionnaire and the Experiences of Teaching and Learning Questionnaire. I like these instruments as prompts are based on student comments (although many had to be modified because of language differences) and they focus on both the students' approach to learning and how the activities in the classroom aided (or not) in their understanding of course material. The surveys can be modified to focus on a specific course unit/module or on an entire course (as is my case).

Smith, J. I. & Tanner K. (2010). The problem of revealing how students think: Concept inventories and beyond. *CBE-Life Sciences Education*, 9, 1-5.

With the publication of the Force Concept Inventory for physics education (modeling.asu.edu/R&E/FCI.PDF) similar instruments have been under development for other disciplines. Smith and Tanner (2010) describe how the potential power (and indeed promise) of concept inventories to measure gains in student understanding, scientific literacy and even the teaching effectiveness of faculty must be tempered with a critical evaluation of their effectiveness. They discuss the significant impact that concept inventories have had on driving pedagogical developments in both physics and biology education but question whether these inventories actually measure conceptual understanding and should be used to inform instruction. They highlight problems associated with the vocabulary and the format of the texts. Further, they question whether the learning gains associated with pre- and post-assessment should be necessarily attributed to learning in the classroom and question whether they give information about the depth of conceptual understanding. They focus the last part of their discussion on a concept I find very interesting - the maturation of learners from novice to expert thinkers. This article helped me to consider how we could more effectively measure gains in student learning by possibly using a blended approach between multiple choice and open-response questions. This article provides context for the articles by Nehm and Schonfeld (2008) and Anderson (2002) discussed below.

Anderson, D. L., Fisher, K. M. & Norman, G. J. (2002). Development and Evaluation of the Conceptual Inventory of Natural Selection. *Journal of Research in Science Teaching*, 39(10), 952-978.

The Conceptual Inventory of Natural Selection (CINS) consists of 20 multiple choice items designed to assess students' understanding of natural selection. The CINS was developed based on student responses to interview questions and focuses on 10 major concepts in natural selection. The CINS was tested/validated with 270 undergraduate students taking a non-majors biology class. The results indicated that the final version of the CINS had good internal validity and therefore a reasonable tool to support "constructivist and socioconstructivist learning". Although this instrument has been used by many faculty to measure gains in student understanding of evolutionary processes, the criticisms discussed by Smith and Tanner (2010) should be carefully considered. The CINS does not provide researchers with an indication of why a student answered a question in a particular way; it could be that the student truly understands the conceptual underpinnings of the question but it could also be equally true that they guessed the correct answer or that the distractors were poor or do not accurately reflect the misconception held by the student. Further, I found that the repetition in the wording of the questions despite the three separate scenarios used (finches, lizard and guppies) in some instances compromised questions in the test. Although we have chosen some of the questions from this test for our own instrument, in most cases we have substantially modified the questions to be simpler for students to understand without the long set up for the multiple choice questions (a copy of the CINS can be downloaded at the following link...

bioliteracy.colorado.edu/Readings/Natural%20Selection%20CI.pdf

Nehm, R. H. & Schonfeld, I. R. (2008) Measuring Knowledge of Natural Selection: A comparison of the CINS, an open-response instrument and an oral interview. *Journal of Research in Science Teaching*, 45(10), 1131-1160.

In this paper, the authors compare the ability of three methodologies to identify student misconceptions regarding natural selection. They compared the CINS (described above) with an open-response instrument (ORI) and face-to-face student interviews. While they found that CINS and ORI are valid instruments, student responses varied from those in the interviews. Furthermore, I was concerned to see that the internal reliability statistics for the CINS in this study in some cases varied dramatically from that reported by Anderson et al (2002). For instance, the most difficult question identified by Anderson was found to be the "easiest" in this study. Based on the commentary and results in this paper, we decided on a mixed approach to our pre and post assessments where both multiple choice and open response questions would be asked. It is important to note that while the criticisms of the CINS in this paper seem reasonable, the student population tested was biology majors rather than the non-majors tested in Anderson et al's original paper. I think that this paper highlights the difficulty in identifying misconceptions around evolutionary theory but I found it very helpful in considering the design of our assessment instruments.

Entwistle, N. (2010). Taking Stock: An overview of key research findings. In J. Christensen Hughes & J. Mighty (Eds.). *Taking Stock: Research on Teaching and Learning in Higher Education* (pp. 15-57). Montreal and Kingston: McGill-Queen's University Press, Queen's Policy Study Series.

There are so many things that I like about this article! It contains an excellent discussion of a number of research projects aimed at understanding how teaching and learning environments impact student learning (including the ETL project mentioned above). Additionally, this is one of

the first articles that I have read that discusses philosophical/psychological aspects of learning, knowledge etc... without making my eyes glaze over. I found that the figures in the paper were not only helpful in explaining concepts like dualism/relativism but the heuristic model of interacting influences on student learning really helped me to think about my research project and how I approach teaching. I just received the book a few weeks ago but it seems like a real gem. I have had a chance to read a number of the articles and they are all very thought-provoking.

Cori Fata-Hartley

Michigan State University, East Lansing, MI

Assignment #1: Introductions

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

I teach at the Lyman Briggs College, a residential college for students interested in science within Michigan State University. The majority of LBC students will go on to professional or graduate school. The course I teach most often is an introductory level cell and molecular biology course, which includes both a lecture and laboratory component. The typical class size is 70-80 students. The laboratory is inquiry-based and students spend up to 6 hours a week working in the lab.

During the upcoming year I will also teach a course call Introduction to Quantitative Science and Research Methods. This course was recently developed to help retain a group of underrepresented, unprepared students. Approximately 10% of incoming Lyman Briggs freshmen earn low scores on the MSU math placement exam such that they must complete pre-algebra and/or algebra courses before they can enter the typical science track. Because these courses are not offered through LBC and they cannot begin their LBC science courses their first year, these students are often marginalized from the LBC community during that first, very formative year of their college experience. Historically, these low math placement (LMP) students have not graduated from Lyman Briggs at rates comparable to those for students with higher math placement scores. A disproportionate number of these students are underrepresented minorities, students of lower socioeconomic status, and students who are the first in their families to attend college. The goals of the course are to improve student competence and confidence in applying mathematical principles to scientific problems, to improve student understanding of scientific methods and research approaches using real world problems, to augment familiarity with scientific units, basic formulas, and problem solving techniques, to improve understanding of natural ecosystems and their organisms, and to improve understanding of basic cell and molecular biology concepts.

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

I am specifically interested in assessing the effectiveness of pedagogical approaches in the Quantitative Methods course described above. While interventions such as supplemental instruction and undergraduate research have been shown to improve success and retention of underrepresented students in STEM disciplines, I would like to know if there are certain approaches in the classroom that also improve success.

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

My interests largely revolve around my family, which recently expanded. I have a 5-year old son and an almost 3-month old son. I have greatly enjoyed introducing the 5-year old to the natural world. Most recently we have been catching frogs and caterpillars on nature walks and looking at the moon through a starter telescope. I also recently got to rediscover Beatrix Potter with him. The 3-month old has kept me quite occupied with feedings and general fussiness so I have not had much time for reading adult books lately, but I started “Mendel’s Dwarf” when I was still pregnant. It is still sitting on my bedside table. I am also a bit of a political junkie and enjoy watching college and NFL football.

Assignment #2: Reflections

My research question has emerged from two distinct “problems” I have encountered. First, I believe a significant portion of my students overestimate their understanding of course material. They do not understand what they do not understand and they do not understand why they do not understand—they lack metacognition skills. This conclusion is based on my personal discussions with students (“I read the book and reviewed my notes—I thought I knew the material.”) and on evidence from previous assessments I have administered. The second problem involves the issue of retaining underrepresented students in STEM disciplines. Though I teach at a residential college for science students, an environment that ought to promote the retention and success of underrepresented students, these students leave the College and the pursuit of science at disproportionate rates compared to majority students. My colleagues and I have made curricular changes to address this issue, including the creation of a new course to introduce under-prepared students to quantitative methods in biology and chemistry. The course is in its infancy and I would like to determine how to incorporate approaches that improve student retention and success. Since there exists evidence in the literature to suggest that metacognitive abilities are positively correlated with student achievement, I plan to combine these two problems as the basis of my research question. I intend to compare student metacognitive abilities with achievement in this introductory science course. The ultimate goal will be to create interventions that improve metacognition and therefore improve student success.

Randy Bass addressed a similar issue in his discussion of SoTL, when he notes that student “self-awareness of learning might help them develop a deeper understanding of certain disciplinary principles more quickly and meaningfully”. On the first day of a culture and history class, Bass asks students to critically examine historical artifacts and then asks them to comment on “what they thought about what they knew”. I found this exercise very intriguing. The responses provided insight such that Bass could alter the course to best meet the needs of the students. The act of handing the first-day responses back to the students on the last day for reflection struck me as being a rich, summative assessment. Certainly, similar exercises might prove useful for sciences courses and I will certainly consider this as I develop the methods to approach my research question.

As I see this research now, the first phase will involve determining what type of metacognitive skills the students use in approaching their science courses. I believe this would fall into the “what is” category of the Hutchings taxonomy. I want to know what types of skills the students bring to the classroom. Once I have a grasp for the range and depth of student metacognition skills, the second phase of the research would involve formulating interventions that improve metacognition to see if this resulted in improvements in student understanding. The second phase would fall into the “what works” category.

Assignment #4: Annotated Bibliography

Cao, L. and J. Nietfeld. 2007. *College students' metacognitive awareness of difficulties in learning the class content does not automatically lead to adjustment of study strategies. Australian Journal of Educational & Developmental Psychology 7:31-46.*

The purpose of this study was to (1) observe student ability to identify learning challenges in a class and (2) study the relationship between identifying those challenges and subsequent study strategy selection and test performance. The study involved college students in an educational psychology course. During each normal class period, students completed a monitoring worksheet that prompted them to describe concepts that they found difficult to understand and how they would improve their understanding. The worksheet also included 3 review, multiple choice questions. Students indicated their confidence in answering each question on a 0-100% scale. Analysis of the open-ended responses by constant comparative method (something I should probably read up on) revealed seven different categories of perceived student difficulty and four categories of study strategies. Statistical analysis revealed no relationship between perceived difficulty, strategy selection, and performance on quizzes. The authors indicate that feedback was given on the review questions. However, no feedback was given on strategy selection and rehearsal methods were most often selected. I would argue that the ability to identify learning challenges does not necessarily indicate students know how to address those challenges. Perhaps if students received feedback about how to approach difficulties with "understanding relationship between concepts" (one type of perceived difficulty reported in the paper), for example, they might learn to select better strategies over time. The paper provides a good example of alternatives to Likert-scale surveys for obtaining data on student metacognitive awareness.

Cooper, M., and S Sandi-Urena. 2009. *Design and validation of an instrument to assess metacognitive skillfulness in chemistry problem solving. J. Chem. Educ. 86: 240-245.*

Cooper and Sandi-Urena describe the creation and validation of a survey that assesses the ability of chemistry students to perform problem solving activities. The outcome is a 27-question instrument called the Metacognitive Activities Inventory that the authors claim is valid and reliable. Tests for instrument reliability revealed Cronbach's coefficient values > 0.85 , suggesting the survey is indeed reliable. While the face validity of the instrument seems sufficient, the evidence for content validity is not as strong. The authors note that further studies will address the relationship between self-reported metacognition use and complex task solutions. I found it interesting that the authors were unable to extract specific factors through factor analysis and attribute this to the interrelated nature of metacognition skills, a characteristic other researchers have also reported. The paper provides a useful example of survey development and analysis.

Dunlosky, J. and J. Metcalfe. 2009. *Metacognition. Sage Publication Inc.: Los Angeles, CA.*

This book provides an overview of metacognition research. The authors describe the different methods and analyses used to study metacognition and basic metacognitive judgments. The chapters on Judgments of Learning (JOL) and Education are most pertinent to my interests. JOL are an individual's ability to monitor learning. Most of the studies performed by psychologists are done in the lab and involve students learning paired words. As I was reading about these studies, I noted that while this is useful to provide evidence for metacognition theories, it is not particularly important in considering the role of metacognition for higher order cognitive tasks in an applied setting. Indeed, the authors concede this point and further note the complexities of education-based research in the Education chapter. The Education chapter explained the relationship of metacognition and models of student self-regulated learning. This book provided

useful background information and explained some of the theories guiding metacognition research.

Isaacson, R. and F. Fujita. 2006. Metacognitive knowledge monitoring and self-regulated learning: academic success and reflections on learning. Journal of the Scholarship of Teaching and Learning 6: 39-55.

This study tested the hypothesis put forth in several previous published reports that high achieving students have better metacognitive knowledge monitoring skills than low achieving students. Since I am interested in applying my research to a group of students who have struggled to succeed in science courses (low math placement students, disproportionately underrepresented minorities), this is the type of research that is of particular interest to me. Before each exam, students answered a series of questions about how they studied for the exam, what they expected to score on the exam, and what score was necessary to meet their goals and expectations. Immediately following the exam, students did postdictions—they estimated performance on the exam. This differs from predictions where students estimate how they will do before they take the exam. The exam format was very intriguing. It was comprised of 40 questions; 18 were knowledge/comprehension (1 point each), 18 were application (2 points each), and 4 were analysis/synthesis (3 points each). Students selected 30 of the 40 questions. In order to get an A in the course, students must correctly answer some of the more difficult questions. The authors did extensive statistical analysis to determine the relationships of these different factors. Their overall conclusion is that high achieving students had better metacognitive monitoring skills than low achieving students. The study design is interesting and I may be able to adapt and/or build upon these ideas.

Martin, B., Mintzes, J., and Clavijo, I. 2001. Restructuring knowledge in Biology: cognitive processes and metacognitive reflections. International Journal of Science Education 22: 303-323.

This study examined learning by college students in an upper level biology course and their own understanding of how they learned. Students completed concept maps 4 times during the semester, which were evaluated for changes in structural complexity. Changes in the concepts maps were determined for categories such as concepts, relationships, hierarchies, and branches and the scores served as a quantitative assessment of learning. Students also completed a survey called the Inventory of Learning Processes as a measure of student metacognition. Individuals with the 5 highest and 5 lowest scores participated in clinical interviews to further assess metacognition; responses from two interviewees were included in the paper (one high scorer and one low scorer). Among other conclusions, the authors suggest that, “successful learners in the natural sciences may excel in self-awareness, and the ability to monitor, regulate and control their own learning.” I believe their work provides strong evidence for that argument. This paper addresses meaningful learning in college level biology and the effect of metacognition on that learning. This is dissimilar to many of the psychology studies that use the learning of paired words to measure metacognitive abilities and therefore much more applicable to my own study.

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Assignment #1: Introductions

Most of my time is focused on directing 2 programs at the University of Toronto: a large Arts & Science program (>3,000 life science students in human biology, undergraduate years 2-4), and a 10-week block of first year medicine (~240 students in Metabolism & Nutrition, co-directing). For both programs, I have designed and implemented recent expansions. The Human Biology Program has undergone rapid growth in the last 3 years to accommodate the large number of students: ~30 new courses, 6 new programs, and 4 new lecturers. My major roles have been to create courses & programs, obtain funds, train faculty, and teach where needed. The expansion of the medical program has not been as monumental: growth from 8 to 10 weeks.

To get all the work done, I tend to get up very early so that I can focus without interruption. My 'outside the classroom interests' have made this particularly difficult over the last month since one of my two daughters has been very ill. I realize that an advantage of this illness that I hadn't appreciated until answering this 'book' question is that I have found time to read 5 novels by the author who inspired/directs the TV series 'Bones'. Waiting rooms present opportunities! For those of you who don't know this series, it is about a forensic anthropologist and her cohort of scientists and an FBI partner who solve CSI-like crimes. Definitely for me this is an escape, along with running and gardening!

Assignment #2: Reflections**1) How would you describe your “research problem(s)” to the Research Scholars group?**

How effective is the enhanced, expanded Human Biology Program? This question represents the big picture “problem” that I am faced with. There are multiple other “problems” or questions that look at individual facets of this issue. Are we attracting the expected type of students? Are we providing the appropriate breadth, depth and sequencing of learning in an academic home? Are our students graduating with the inspiration and skills necessary for life-long learning and career satisfaction? According to Bass' citation of Shulman's elements of the process, I am at the final stage (analysis) in some aspects, and at the penultimate stage (outcomes) in others. The biggest challenge is to survey our graduates.

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

I think that one of the biggest issues in addressing the problem is to find the time away from the “doing” of teaching and its administration. But I also recognize that the analysis and its dissemination are important aspects of the entire process. So guilt sets in, and is reinforced by Shulman's quote in Bass's paper: "For an activity to be designated as scholarship, it should manifest at least three key characteristics: It should be public, susceptible to critical review and evaluation, and accessible for exchange and use by other members of one's scholarly community." I have great faith in BSP to reinforce the importance of publishing our educational experiments! For me to leave work early to read and think about this assignment, when there are huge numbers of pressing deadlines, is a very big step in the right direction! I also thoroughly appreciate Bass's strong support for the necessity to focus teaching directly on what you want the

students to learn. To me, knowing several goals for each teaching situation and teaching to the goals is one of the most critical aspects necessary for success.

3) Based on Pat Hutchings article, what taxonomy would you use to describe your research question and why?

“What works” is definitely the category that my research question fits into. For example, I want to know if the translational skills development that we have integrated into all 3 years of our programs is not only successful for graduation, but also successful post-graduation. But my research question also includes other categories. The “what is” question is also directly applicable. I have collected much information in the way of assignments and student surveys that needs to be analyzed to provide a much more accurate description of initial, intermediate and endpoints of student learning.

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

I really liked the opportunity to reflect – the references were perfect in providing enough context. I hope to find time to read papers cited in the three posted articles! Thank you for also including the paper on CAR projects – not an area that I am familiar with, and it looks more attainable than traditional educational research!

Assignment #4: Annotated Bibliography

One of my major projects over the next year is to set up an appropriate, ongoing evaluation system of our expanded undergraduate program. I really liked this assignment because it forced me to take some time out of my administrative duties to read some new literature. Having an annotated bibliography was much less daunting than a comprehensive literature survey – I’m going to incorporate this format into some of our courses, so thanks! Even though I am at U of T with the best description of these formats, I haven’t used it previously!

1. Harris L, Driscoll P, Lewis M, Matthews L, Russell C, and Cumming S, “Implementing curriculum evaluation: case study of a generic undergraduate degree in health sciences”, *Assessment & Evaluation in Higher Education* 35(4): 477 – 490, 2009.

These Australian researchers provide a step-by-step description of curriculum reform and evaluation using a longitudinal, evidence-based approach applied to an undergraduate health sciences program. I really find that the framework that they espouse is useful for me to mimic: the assessment needs to be multilevel, longitudinal, and developmental in the contexts of intended, implemented and attained goals.

2. Macpherson K and Owen C, “Assessment of Critical Thinking Ability in Medical Students” *Assessment & Evaluation in Higher Education*, 35(1): 45-58, 2010.

I like this paper for several reasons, not least of which is that a study design flaw may have had a large impact on the results: students did worse on a critical thinking test after the first year of medical school. The design could have been much improved if the post-test wasn’t so close to the final course exams. Otherwise, it may be that the first year of medical school reduces critical thinking ability. Since I direct part of the first year medical program at U of T, and have grave concerns about our students’ abilities to think critically, this paper is very relevant. The other information that is useful to me is the various resources cited/used for testing critical thinking, a major thrust of our new Human Biology curriculum.

3. Jordens JZ and Zepke N, “A Network Approach to Curriculum Quality Assessment”, *Quality in Higher Education* 15(3):279-289, 2009.

These teaching practitioners promote the necessity of having the people who teach as an integral part of the team that assesses the quality of the curriculum. This approach has several obvious but major advantages that lead to continued optimization of the curriculum. It prevents a schism between evaluator and evaluated. It includes those with most knowledge of the curriculum. It extends best teaching practice of reflection and renewal beyond individual courses to optimize the chances of continued curriculum renewal. This article really resonates with me, since this process worked well for me in setting up our curriculum. It reinforces the necessity of continuing this practice, and extends these principles.

4. Wood WB, “Innovations in Teaching Undergraduate Biology and Why We Need Them”, *Annual Review of Cell and Developmental Biology* 25: 93-112, 2009.

I think that this article reviewing the most important changes for teaching science effectively is brilliant. I find it very useful in my quest to improve curriculum, but also to assess the impact. It not only highlights the best improvements, it also provides a resource of the best literature to access for more information. For my goal of assessing our changes, it also cites multiple sources that I can model.

5. Powell L, “NRES 311 Wildlife Ecology and Management”, *The Peer Review Site* (<http://www.courseportfolio.org/peer/...ioObjectid=169> accessed July 8, 2010).

This portfolio by Larkin Powell in the School of Natural Resources at the University of Nebraska is in the “section [of] examples that highlight excellent documentation of student learning” for entirely obvious reasons. It gives an extremely thorough description of a course using best practices. This includes a scholarly approach to assessing the course and its improvements. The organization of the material is exemplary. I feel very fortunate that this type of resource is recommended for this assignment, since I wasn’t aware of this availability! For our curriculum, we can emulate this process on an annual basis.