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RENEWING CURIOSITIES, MARVELING AT THE WONDERS OF BIOLOGY, AND PROMOTING DEEP APPROACHES TO LEARNING WITH NON-SCIENCE MAJORS

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Introduction

This scholarly essay provides reflections from a faculty member and two students on our experiences in a general education biology course at James Madison University, a large, comprehensive public university. The course is a three-credit introductory biology course for non-science majors described as an in-depth exploration of selected biological concepts connected to current, relevant topics and emphasizing an understanding of science as a way of obtaining knowledge. We begin by reflecting on our perceptions of the role of asking questions in learning and ways to foster deep approaches to learning. We then explore how we feel this course succeeded in overcoming the situational factors faced by faculty and students in introductory classes by fostering student interest, curiosity, and ultimately, deep approaches to learning.

Instructor Reflections – Dr. Carol A. Hurney

Of the many situational factors that instructors face when teaching required biology courses for non-science majors — the once and done curricular construct — is the most daunting. How can you teach *all* that is biology in one semester? Hoag and Browne (2009) argue that introductory courses should encourage students to think deeply about a discipline by allowing students to explore the complexities of a discipline especially since it may be the only course a student takes in this particular discipline. How can you stimulate scientific thinking and foster deep approaches to learning in this challenging group of students who are often intimidated and ambivalent by one of the many general education courses they must take to fulfill their degree requirements? Other situational factors such as large class sizes and student perception that the typical biology curriculum is not relevant to the *real* world compound the challenge to foster deep approaches to learning. So why bother? Because, from my perspective, exploring biology in all of its wonder provides opportunities for students to ask questions about the natural world, develop critical thinking skills to evaluate the role of biology in their lives, and most importantly — renew childhood curiosities about the wonders of life.

All children perform endless experiments seeking answers and solutions to construct knowledge about their world and how it works. As language skills begin to form, children ask their parents bold and creative questions such as: Why? How come? What for? Parents dutifully answer even though the answers spawn another set of probing questions. Even when children do not verbalize questions, they are asking them because they really cannot help themselves. Humans are curious and for good reason — the more we understand about our complex word, the more likely we will survive, reproduce, and help our offspring thrive. So what happened to college students? In my experience, it seems they lost their inherent curiosity. Yes they still ask questions, but only to find out what they need to know for the exam, assignment, or paper. In fact, one group of students informed me that it was my job to answer all of their questions — as

if I was their parent helping them understand why the stove is hot — rather than encouraging *them* to find answers to their own questions. I knew at that moment that my definition of excellence in teaching would be defined by developing a course that provided students with the skills and tools they needed to ask *and* answer questions that will continue their developmental journey in constructing relevant, meaningful information about their ever changing world.

Initially my journey to empower students to ask relevant questions did not push them to seek relevancy. Rather, my course provided opportunity for students to explore topics I *thought* they would find relevant. Instead of covering the traditional introductory biology curriculum of mitosis, meiosis, photosynthesis, and cellular respiration, I designed units based on recent developments in human genetics such as cloning and stem cell research. I also developed units on the biology of cancer, emerging infectious diseases, and drug addiction. Students seemed to be engaged in these topics and generally performed well on exams and assignments.

But, I was in the driver's seat — I was asking all of the questions, creating all of the assignments, and providing the context that would *hopefully* allow students to see the relevance of biology to their everyday lives. Although my course offered varied opportunities for students to engage in active learning through cooperative learning activities, pre-class quizzes, and clicker questions, my class was not a learner-centered experience and did not offer the opportunity for students to select topics relevant to their lives or take responsibility for learning (Weimer, 2002). More importantly, my course did not really allow students to ask their own questions or expand on their own curiosities. Encouraging students to ask good questions or reconnect with their inner toddler seems easy enough, but as an instructor you soon realize that each student approaches learning and asking questions in different ways, which makes course design challenging.

Numerous scholars suggest that how students approach learning is a response to situational factors in the course, such as class size or discipline, and is not a style or stable trait of the student (e.g. Marton, 1983; Ramsden, 1998). However, some scholars argue that the students' predisposition to change and their ability do have an affect whether they take deep approaches to learning (Entwistle, 1981; Schmeck, 1988). Whichever the case may be, my experience is that students in my course are there because they have to be. I resonate with Wright, who also teaches introductory biology to non-majors and suggests that at the very least we should "do no harm." By this she is not implying that we should have low expectations of non-science majors (2005). Rather, she believes that introductory courses should be invigorating experiences that do not turn students away from our discipline but offer opportunities to ignite interest and build skills that allow students to explore our disciplines in *their* future.

Unfortunately, many instructors faced with the situational factors of introductory courses fall victim to course content and provide a survey approach to the discipline that often produces more harm than good. Students can academically survive this type of course, where consumption of knowledge trumps absorption, but little or no information sticks with the students and in the worst-case scenario, student interest in the subject often diminishes (Wright, 2005).

But was my class promoting deep learning or were my students simply being strategic and playing the part of an "engaged student" by seeming to be engaged in the topics and assignments I developed for them? I had no idea but I knew I wanted more – so I decided to give them more. More what? More choices! I let students choose course topics they found relevant and how to allocate course points for assignments and exams. Analysis of student learning and attitudes revealed that allowing students to choose course topics and points enhanced student performance and attitudes in the course (Hurney, 2012). Students also reported that they felt more confident in their ability to understand complex biological topics and more interested in biology than they had expected. I also designed assignments where students could ask *and* answer a biological question that I felt would allow them to explore something they were curious about.

For most students, every science course they have ever taken starts with a boring list of steps referred to as the scientific method. Really? Seems obvious and boring. Why should they really understand about variables, controls, or the peer-review process — they are not going to be scientists? But they *are* going to be consumers of science. Bingo! I had to create an environment where students realized that they are the intended audience, the consumers. Thus, they needed to know when to eat the good science and when to spit out the bad. I decided to foster this kind of inquiry by baiting them with some of the beautiful questions in my discipline.

This strategy, explored by Bain (2004), seems like a natural place to stimulate learning and one many strategies the best college teachers use to promote deep learning. Most of us spent the first decade of our lives asking questions and I wanted them to ask and search for answers to big questions. I started with a project called, "What is Science?" This assignment asked students to find the elements of science in recent news articles instead of looking for science in pre-canned laboratory experiences or asking them to design experiments that they would never perform. The next assignment built on the answer to the "What is Science?" question and asked students to explore the reliability of the science found in a series of articles related to an advertised cure for cancer. The goal of this assignment was for each student to answer the question, "Based on the science, would you let someone in your family use this cancer treatment?"

Students probably did not start taking deep approaches to learning while completing these first two assignments. Instead, I think they built a skill set to evaluate science. However, I believe many of them shifted to deep approaches to learning during the last assignment where they selected their own question, located sources that contained the key elements of scientific inquiry, evaluated the sources used to support their answer — and most importantly, provided a reasoned answer to their question that would be relevant to their peers. Work with middle school students supports that providing compelling questions, scaffolding course content, and encouraging students to ask questions and make predictions fosters deep approaches to learning in science classes (Chin & Brown, 2000).

Seems simple, getting them to ask and answer their own questions but I think it worked in my class as well. Instead of assigning a student the topic — Skin Cancer — students generated questions like "Do sunscreens decrease the risk of skin cancer? Finding answers based on scientific evidence to their own questions about a topic stimulated their curiosity and pushed students to do more research, taking a deeper approach to learning than they would if they simply wrote a paper on skin cancer. I also let them be creative. I accepted papers, songs,

poems, play scripts, and more. I am not sure whether this helped them take a deep approach to learning, but I think it helped them be happy learners — which is still a far cry from being surface or strategic.

In the end, I graded some pretty amazing projects that really posed thoughtful, beautiful, and reasoned answers to a biologically complex question. And yes, I still graded a few projects where students had taken strategic or surface approaches to learning, where they simply followed the directions or skimmed the basics. By and large, my sense is that the majority of the learners challenged with this assignment pushed themselves into a deeper learning experience — but maybe that is just my current fantasy *or* the next research question that begs for an answer.

I can only hope that students who have taken my non-majors biology course reflect the research that demonstrates that as introductory history students' ability to think like historians by evaluating historical arguments grows, so does their depth of curiosity (Bolinger et al., 2004; Kibler, 2004). I feel more confident each year that my course allows students to think like scientists within a construct that provides relevance and stimulates curiosity through deep approaches to learning that sticks with them in two very powerful ways.

First, I believe that my students develop essential skills to evaluate scientific resources based on authorship, publisher, timeliness and the role of peer-review. I pay particular attention in creating assignments that push students to explore how the peer-review process functions in science but also helps them explore ways that peer-reviewed science can be meaningfully and reliably integrated into websites, Blogs, newspaper articles and other forms of media.

Second, I think that although content details may not stick with my students – something in the course will rekindle their curiosity with the natural world and this curiosity at some point will open opportunities for them as they continue their development as questioning, knowledge-seeking adults.

Integration

Next my students embark on their scholarly reflections about deep learning. Their reflections stem from their experiences as college students, conversations we had about this course, and relevant literature we read and discussed together. Both students were sophomores when they took my course and are currently in their junior year. Working on this paper together fulfilled a need we did not know we had; a need to stay meaningfully connected in the fast-paced world of academia that seems to promote student-faculty interactions, but often falls short of delivering rich and rewarding experiences.

Student Reflections – Alexandra & Sofia

On the first day of the semester we entered the classroom with traditional expectations for a general education introductory course where we would probably embark on a broad, surface-level analysis of biology. We assumed we would study topics such as photosynthesis, cells, and other traditional topics that we were honestly not that interested in. However Dr. Hurney had

something else in mind; this was one of the most challenging general education courses we were about to embark upon.

Originally, we were not planning to invest much more attention than needed into the class; however, her enthusiasm and passion was infectious and drew us in. Unlike the majority of the general education courses we had already taken, Dr. Hurney's course sparked our interest. Although most professors lecture for an entire class period, Dr. Hurney did not. The class was interactive and we felt as if she was a student herself, growing and learning with our class. Her non-traditional class structure eliminated the approach to learning focused on content recall and required abstract thinking for hands-on examinations.

Curiously, we discovered we were studying less for this class than others, in general, we sit in classes, listen, and take thorough notes, only to forget the information at the end of class and have to re-learn the material again before an exam. This was not the case for biology; instead we were studying everyday by answering clicker questions and participating in collaborative, problem-based assignments during class. The class structure and Dr. Hurney's enthusiasm pushed us to rethink what introductory, required courses could be like and inspired each of us to take a deeper approach to learning. As we reflect on the experience we realize that our approach to learning represented a shift in when and why we ask questions.

We believe that we ask questions and approach learning based on our role as students. It is our job to ask questions. Using questions as a clarifying tool is a major aspect of the learning process in college and the kinds of questions students ask often reflect whether they are taking a surface, strategic, or deep approach to learning. Surface learners ask questions to clarify content, while strategic learners ask questions to determine expectations for assignments and exams. We think that deep learners ask questions to explore things that are relevant to them or understand things that matter. We believe, that as college students, we all to some degree take strategic approaches to learning because we are grade-oriented. However, students may be a combination of all three types of learners depending on the learning situation.

In general, we admit that most of the time, we are strategic learners. We enjoy learning, but when there is a goal or mission behind the reason for learning, we are most definitely strategic learners. We both agree that in classes for our major we learn through a combination of deep and strategic learning approaches. We take learning in our major seriously because success in our desired fields of expertise will predict our success as professionals. Interest in our profession, along with the need to retain knowledge and skills from these courses influence how we approach learning. Taking a deep approach to learning in our major courses means that we ask questions because we are genuinely interested, curious, and want to learn more. We also know that doors to our profession will open more easily if we earn good grades. Wanting to be as prepared as possible for the next test or assignment results in students taking strategic approaches to learning and asking questions simply to clarify expectations. Thus, we utilize a combination of learning approaches that reflect what kind of learning we need to achieve in different situations.

Pondering how asking questions influences how we approach learning offered us the metacognitive realization that we also ask questions to satisfy curiosity. Students' curiosity is

most engaged when they are learning about something that they care about, such as something that is or will directly affect them. Making the transition from traditional disciplinary content to content relevant to students is a challenge that all college professors face, especially if they want students to take deep approaches to learning in courses where students often take surface or strategic approaches. Each of us have had situations in courses where we took a combination of surface and strategic approaches to learning because we could not find relevance in the content, our curiosity was not stimulated, and thus, we did not ask any good questions.

One of these classes was a general education history class where assignments such as fact-based exams and essays fostered strategic learning. Knowing exactly what had to be memorized for the exams was more important than really knowing the true meaning of the content. Even more disturbing is the realization the learning how to take notes was more important in this class due mostly to the desire for success when answering essay questions for the graded papers. Another introductory science course failed to stimulate deep approaches to learning because the content was generic and watered down. In addition, the lecture-based teaching style did not stimulate interest or questions and could barely command student attention. The course information was not clicking and surface learning prevailed. Ultimately, dropping the class was the only option. After reflecting on our approaches to learning, we believe that based on our college experiences we are surface or strategic surface learners in classes that we do not find relevant to our lives or would not have personally chosen to take if we did not have to. But that we take strategic and deep approaches to learning in classes that resonate with us and will impact our future.

Dr. Hurney's non-majors biology class stood out from other General Education classes because she targeted relevant topics and allowed us to pick the topics we wanted to study. The opportunity to choose topics helped motivate us and seemed to resonate with the other students. Having the power to choose kept us engaged in learning because the topics that intrigued us also turned out to be the topics we cared about. Choosing a topic, evidently, made learning more meaningful. These relevant topics (e.g. cancer, drug abuse etc.) sparked our interest because we believed that at some point in our lives we could have a grandmother with cancer, a neighbor battling drug addiction or a child with a genetic disorder who could benefit from an experimental drug. Therefore, we were motivated to understand these topics by taking a deep approach to learning.

We both agree that our curiosity about course topics piqued during our work on the final assignment. We had to develop and answer a question regarding a unit that we found interesting by exploring reliable scientific evidence. At this point in the class, we both experienced learning on a deeper level; things were soaking in, scientific researching techniques were becoming second nature to us, and biological topics were a part of our daily conversations. We both realized that we were not just learning biology, but we were living it. In Dr. Hurney's class, we came in with the mindset of a surface and strategic learners. But we left at the end of the semester having utilized strategic and deep learning strategies.

It is difficult for us to know with complete certainty whether Dr. Hurney's class really succeeded in promoting deep learning… *yet*. As of now, content and skills we learned in Dr. Hurney's class are sticking and we are applying them in other classes and in real life situations. However, the true test to discovering the success of deep learning approaches will develop over time. One

skill we believe will stick with us is the ability to evaluate the science found in articles and other sources. The series of assignments that culminated with the "Answer Your Question" assignment trained us throughout the semester to defend whether a scientific resource was reliable on the basis of authorship, peer-review, publisher, and timeliness. In addition, we had to answer questions about these skills on each test and feel that using this skill has become second nature.

While we practiced finding reliable resources on biological topics in Dr. Hurney's course, this skill and knowledge about reliable sources can be used in a variety of settings to answer a wide range of questions that involve science. We have thus learned not to believe everything we see, hear, or read just because it sounds or looks legitimate. In the future, we will *probably* remember the four components that make a reliable scientific source, but will we remember what mutations cause cancers? It takes a great deal of confidence to go out into the world and seek new scientific information and learn it on your own. However, we are certain that the kind of learning we used in Dr. Hurney's class has given us the confidence to persevere through the scientific jargon and figure out reliable information when we leave the sheltered world of academia. While only time can tell whether this approach to learning was a true success, at this time we can vouch that the course was successful in converting two surface and strategic learners into strategic and deep learners.

Concluding Thoughts

Our reflections reveal that students in introductory courses take deeper approaches to learning when their curiosity is piqued and they have the opportunity to explore a discipline from a perspective that provides relevance. We encourage faculty to develop opportunities for students to ask important questions, seek answer to the beautiful disciplinary questions and most importantly, stimulate curiosity by allowing students to explore the answers to questions that the students find relevant and interesting. Based on our experiences in this introductory course, we believe that courses should be designed with long term, significant learning in mind, where backwards planning prevails and instructors are mindful of enduring learning outcomes as they plan course activities and assessments (Fink, 2003). Most importantly our reflections reveal a taxonomy for inviting deep learning built on the themes of interest, relevance, curiosity, and autonomy. When students experience the base levels of interest and relevance, they are poised to ask questions fueled by curiosity. Curiosity leads to student autonomy, which we feel shifts the motivation for asking questions from surface and strategic approaches to deep approaches.

The reflective experience we took drafting this manuscript affirmed our personal perceptions of the potential for deep learning in general education courses and provided insights to continue the growth and development of this type of course for non-science majors. Our consideration of the role of asking questions to promote deep learning allowed us to be co-learners on a quest to understand faculty, students, and ourselves. We spent time brainstorming ways to react and change to situational factors that influence *quality* teaching and learning in higher education. Most importantly, we built on the trust we developed during the course and feel that the lines between our roles as faculty and students diminished revealing curious biologists, questioning how to inspire wonder and curiosity.

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