9.A. Teaching Philosophy, Goals and Methods

Teaching at its fundamental core is the passage of knowledge from one person to the next. Although universal in its theme, the implementation of teaching and learning is individualized. Breaking down and exposing the fundamentals of learning requires the teacher to be malleable and responsive to the student's needs and environment.

My outlook on teaching in the sciences is rooted in three main goals for my students:
1. Overcoming the intimidation of science
2. Developing critical thinking and reasoning skills
3. Correlating facts with practical application

1. Overcoming the intimidation of science. To the uninitiated, science can be overwhelming. With so many disciplines and associated jargon students, especially non-majors, often feel intimidated by the diverse and complexity of science. To help students begin to feel that science is accessible to them, I have often used in my classes techniques such as primary literature tutorials to help students navigate through the key elements of this important form of scientific communication. By training students with the primary literature, students can begin to systematically break down commonly used methodologies and define key terminology. It has been my experience that by exposing students to these fundamentals of the science process, they feel more comfortable with the subject matter. Additionally, I have tried to help students examine the Latin or Greek roots of unfamiliar words used in scientific papers, thus allowing the students themselves to decipher their meaning. These techniques, such as exposing students to the lexicon and methodologies of the science literature, have helped me enhance the confidence of my students.

2. Developing critical thinking and reasoning skills. In my opinion, developing critical thinking skills is an essential component to a student's repertoire regardless of their discipline. Specifically, learning how to ask a question is one of the most underestimated skills a student must obtain. Students must learn to make the transition between just memorizing facts to correlating the material into a cohesive context. In the past, I have used different methods to develop this skill. One way was to require the students to write two or three questions about the research paper we were covering that week. Initially, I allowed the students to write the questions after the group discussion so that they could see the critical components of the paper. However, after two papers I required the students to develop their questions ahead of the discussion and we used their questions as a core component to the discussion on the primary literature article. Initially the questions were often superficial, (i.e., definition of terms and methods) however, as the course progressed the students were able to become more analytical of the results and experimental design. In fact over the course of a semester I often try to incorporate some of the student’s questions on quizzes and exams as a further reinforcement of the material and their ability to pose succinct and developed questions.

3. Correlating facts with practical application. In science, students are required to have a working knowledge of a great many facts, which often must be memorized. However, it is the duty of the teacher to present these facts in a logical and organized manner in which correlation can be made between these seemingly independent components. Once the student is capable of correlating and inferring meaning from the material, then true progress can be made in understanding the subject. An eye opening

experience for me as a student was in my senior year as an undergraduate. For the first exam the instructor gave us a polyacrylamide gel and asked us to interpret the results based on the gel and previous lecture material. At the time many of us, including myself, were at a loss to apply the knowledge from the lecture to the practical application of the gel. However, by the end of the semester I became more comfortable with such data interpretation and delineating the optimal experimental approach. Now as a teacher, I have attempted to learn from my own experiences and expose students much sooner in their academic careers to the practical application of science and not a regurgitation of memorized facts. Often in my lectures I present gels, spectrographs, phylogenetic trees to the students to facilitate the development of their data analysis and interpretation skills.

Educational Design and Implementation:

To implement the preceding goals in effective manner, I have often tried to complement the classroom lectures with my laboratory and research experiences. At the K-12 level, I have helped teachers and students design interactive experiments that can be done in the classroom if laboratories sections are not available. I believe that coupling the lecture with hands-on experiences (even demonstrations) reinforces the principles being discussed. For example, as part of National Institutes of Health's campaign to promote dental health I developed a low-cost protocol in which all of the students could visualize their own dental plaque. I coupled this individualized demonstration with a lecture on how oral microbial communities develop and form symbiotic associations within the human oral cavity. Similar approaches are also effective also at the undergraduate level.

In addition to the classroom and laboratory components, I have often encouraged peer-associated learning. In my current Astrobiology course, I require students to give two ten-minute topical oral presentations to the class. To engage the rest of the class while the student is talking, I require the class to grade and critically, but constructively, evaluate the presenting student. Their comments account for 5% of their own grade, and 10% of the presenting student's grade. I provide these anonymous peer-review comments to the students so that they can see the class perceptions of whether they were able to make a clear and effective presentation. Often the class feedback reiterates my own comments and students are encouraged to use this feedback to enhance and improve their presentation skills.

Expectations of student learning and efforts to help students achieve that goal

My expectations of student learning are fundamentally rooted in the idea that each student will take an active role in his or her own educational experience. My job as educator is to guide the student through the learning process and foster the development of their critical thinking and qualitative reasoning skills. While the standards for each level of students that I interact with may vary (i.e., K-12, undergraduate, or graduate), my expectations regarding student performance remain high. In addition to offering guidance, my role as a teacher is to challenge and engage each student to excel beyond their starting point so that they grow intellectually. So regardless of the subject matter that I am teaching, whether it is astrobiology, biogeochemistry, or microbial diversity, I expect each student to gain a fundamental knowledge of the specific subject as well as deeper understanding of the scientific method. To help students reach their potential and improve their learning experience, I provide students with in-depth, constructive feedback on their exams, oral, and written assignments by stressing their individual on-going progress in the course rather than comparing them to an arbitrary standard or to other classmates. I try to monitor the students' progress closely throughout the semester and continually communicate my expectations of the students. Additionally, I try to emphasize to my classes that different students excel at different things and that by observing their peers

in class discussions or oral presentations they can learn from each other just as they can learn from me.

In addition to the student assessments and standard end-of-year evaluations I include in my course pre- and post-knowledge surveys to examine and monitor the student learning experience and student perceptions of the field of astrobiology. These surveys have proved to be useful indicators of the student learning experience regarding the subject of astrobiology and the technological teaching tools used in the course, such as distance learning and podcasting. The surveys have enabled me to reflect on potential weaknesses of the incoming students and topical areas that I may need to focus on and emphasize in the course. These student knowledge and learning assessments have also proven to be valuable to the field of astrobiology. The results of these learning assessments have been published in the leading astrobiology journal serving to enhance the development of other astrobiology courses nationwide.

Assessment and Evaluation of Student learning

Although there is no one single assessment tool that can effectively reveal all the aspects of teaching and learning comprehensively, I try to frame the evaluation of students individually to promote students in developing their own intellectual and practical skill set. If a student is having difficulties in the course I have always tried to approach them individually and make myself available to them beyond the normal class time and office hours. I try to incorporate participation as well as enthusiasm for the subject into the summation process and not strictly limit myself to grades as a means of evaluation. For example, once when I was acting as a science fair judge a high school student with a disadvantaged background and a very poor science fair project was so enthused and eager about learning animal behavior, that he inspired me to gave him a science fair special recognition award for his interest level. Although he didn't "win" the science fair, I was able to help him become involve in the National Zoo Volunteer Program, which he completed the next summer.

By providing a diverse array of evaluation methods (i.e., tests, reviews of primary literature, oral presentations, group podcasting projects) I try to facilitate the learning process of the student in a way that he or she is suited. Although I do set different demands and standards for different levels (i.e., introductory undergraduate course versus graduate seminars), I think that as a teacher a major part of my role is to challenge every student and help them meet and exceed that challenge.