Development of an Environmental Science Laboratory Course.

Meeting the Challenges of Teaching Diverse Subject Matter to a Diverse Population of Students.

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Environmental Science 110 was redesigned to include a laboratory, and now is offered as a 4-credit course that fulfills the general education science requirement. The lab was designed to teach Environmental Science using an Earth System Science approach. Unlike a Biology or Chemistry laboratory, an Environmental Science laboratory touches on concepts from a wide variety of disciplines. The key to success in developing a conceptually diverse laboratory is a broad base of contributors having a variety of educational and life experiences. The diversity in contributors helps to insure that all aspects of the multidisciplinary material are handled by someone proficient in that area. In practice we also found that as a team we are able to relate the subject matter to a wider variety of students. Since this course now fulfills the general education science requirement, we anticipate students from many different majors will be taking this class. So not only is the subject matter diverse but the student population in the class is diverse as well. The diversity in the intended audience combined with the diversity of the subject matter presented us with an intriguing task resulting in a challenging and interesting laboratory experience.

Background

Environmental Science is the systematic, scientific study of our environment as well as our role in it, highered.mcgraw-hill.com . It can also be defined as the science of the interactions between the physical, chemical, and biological components of the environment, including their effects on all types of organisms but more often refers to human impact on the environment, wikipedia.org. In the more traditional approach to studying the Earth, students are generally taught to understand the Earth through isolated, discipline specific courses, such as Biology, Geology, Meteorology, Oceanography, Chemistry, etc. This approach places severe limitations for studying Earth's processes as they occur in the real world including global warming, El Niño and La Niña, sustainability, global production efficiency, land use, agriculture, deforestation, ocean and coastal resources, climate change, human health and population, ozone depletion, natural resources management, greenhouse gases, and environmental treaties and resource indicators.

Another method for approaching the study of Environmental Science is the Earth Systems Science approach. Earth system science views the Earth as a synergistic physical system of interrelated phenomena, governed by complex processes involving the lithosphere, atmosphere, hydrosphere, and biosphere. Within the concept of the Earth as a complex and dynamic entity involving the disciplinary spheres for land, air, water and life, there is no process or phenomenon that occurs in complete isolation from other elements of the system. Fundamental to the Earth system science approach is the need to emphasize relevant interactions of chemical, physical, biological and dynamical processes that extend over spatial scales from microns to the size of planetary orbits, and over time scales of milliseconds to billions of years.

While this systems view is elegant and satisfying philosophically, it is an enormous challenge to educators attempting to define and quantify the breadth of the system's elements, states, and processes within the classroom. Earth system science education seeks to construct an overarching interdisciplinary framework of processes and states of the system and at the same time retain the strength of traditional disciplines for understanding fundamental and complex interactions. The challenge is to provide the necessary depth and breadth needed to serve as a

foundation for advanced study among majors, and lay the foundations for sustainability and informed stewardship in striving for an Earth-aware society among the general education population.

Laboratory Objectives

The goal was to develop an Environmental Sciences laboratory course that would provide a fuller understanding of the nature of the Earth system and its importance to the human subsystem. Such is the basis for understanding natural and human-induced global and local change. The course required development of earth systems laboratory exercises, demonstrations, and lessons. In addition to a general introduction to the subject matter, these modules must incorporate learning styles and study skills into the lab section in order to enhance student retention. The lab must also serve to illustrate the concepts of Environmental Science in an active learning environment including experiments, demonstrations, team projects, and field trips. Another vital component was to introduce field and laboratory techniques used in Environmental Science and Earth System Science. Finally, the lab must help students improve their learning and critical thinking skills.

Meeting The Objectives

To provide a fuller understanding of the nature of the Earth system and its importance to the human subsystem a broad spectrum of subjects were selected to be presented. The modules included: water quality, soil as a filter, soil erosion, microbes, dust and aerosols, remote sensing, and energy sources. Throughout the course students were asked to explore how the topic of the week's lab might relate to them both personally and professionally. The final lab involved the students selecting a lab topic that particularly interested them. They related the topic to their lives either in a personal or professional manner and presented their ideas in a PowerPoint presentation.

To meet the second goal of student retention through the incorporation of learning styles and an emphasis on study skills a number of techniques were used. All labs included "Pre-Lab Questions". The students were provided with questions and relevant web sites to encourage independent reading, and promote an understanding of how scientists pose and research questions relating to an area of interest. One lab module incorporated the use of spreadsheet software to manipulate, analyze, and present data, a skill that is essential in STEM disciplines particularly but also other areas of study. Several labs required the use of basic formulas such as percent increase or decrease, proportional relationships and power output. A variety of data presentation methods were introduced including data tables, line graphs and color coded maps. The emphasis was always on helping the students understand how each calculation or data presentation was to be done through discussion, demonstration and discovery learning.

An active learning environment was achieved by having a variety of different lab activities and settings. Field trips included testing water quality at several sources around campus, and visiting the campus power station to see how NMSU's energy needs are met. Hands on activities included building landscape models to test the affects of erosion, as well as building solar powered cars. There were wet labs utilizing microscopes to explore some of the microbes commonly found in our food and water and the use of columns packed with various soils to investigate their amazing properties. Throughout the semester both the instructors and the students gave oral presentations on important global issues.

It was important that students leave this course having experienced some of the techniques used by environmental scientists. Students had the opportunity to use pH meters, salinity sensors and spectrophotometers. They also had an opportunity to manipulate and analyze remote sensing data from a variety of satellites and sensors.

The strength of this lab course is its diversity. Every week brought a lab completely different from the proceeding one. Continuity was maintained by using a lab template that contained an introduction, pre-lab resources, objectives, keywords, procedure, post-lab questions, and information on calculations and data presentation when needed. Students were also presented with lab report rubrics to ensure that they knew what was expected of them.

Diverse Student Population

In the past ES110 was offered as a 3 credit class, without a lab, strictly as the freshman level environmental science course. In fall 2005 this course premiered as a 4 credit class, with mandatory lab, fulfilling the general education science requirements, as well as being the freshman level ES course. To achieve this change the lecture was redesigned and a lab had to be developed, as has been discussed in this article.

In the lab module design process it had to be kept in mind that this lab must be rigorous enough to prepare Environmental Science majors for upper level courses. At the same time it could not be forgotten that there are no science or math prerequisites for this lab, and that there would be students in this lab for whom this might be their only science course. It was important that the material be interesting and relevant so that majors and non-majors alike would be motivated to learn the math and science skills needed to complete the lab, and possibly awaken in the students the desire to explore upper level science courses.

To further meet the challenge of the diverse student population the lab template was carefully designed. The pre-lab resources were provided so that students needing or wanting extra background information would have access to reliable accurate information on the web. The introduction was designed to be informative without being overly lengthy or technical. If calculations, charts or graphs were incorporated in a lab module, instruction and examples were provided to the students.

Diverse Contributors

Serendipity may be a good word to describe how this diverse and complementary team of developers came together. The diversity stemmed from a variety of educational backgrounds as well as unique life experiences. It was found that the ability to see this lab from a variety of directions provided an enhanced lab experience to a broader student population.

Dr. April Ulery is the principle investigator on a NASA Earth System Science Education grant that supported the development of this lab course through teaching assistantships for the three graduate students. She holds degrees in Geology and Soil Science, as well as having environmental consulting experience and teaching at the university level for several years. She and co-PI Dr. Curtis Monger outlined the lab and decided which elements would be included. Dr. Monger has degrees in Geology and Agronomy (Soil Science) and is recognized for his ability to help students visualize concepts and relate subject matter to their experiences.

Dr. Susan Brown is also a co-PI on this grant and is responsible for helping us evaluate student learning and impact. She is a professor in the Department of Education at NMSU and her area of expertise is science instruction. Since this is a freshman level course and the students are assumed to be recent high school graduates, her presence on the team provided insight into working with these students. Her knowledge of instructional pedagogy and her enthusiasm were vital to this project.

Tim Jobe holds a degree in Chemical Engineering from NMSU and is working on a Masters degree in Agronomy (Soil Science emphasis). His educational background and knowledge of research in several departments across campus made him an invaluable resource to our team. He is a native of New Mexico and was able to relate the lab topics to the campus and region.

Hernan Miranda holds a degree in Mathematics and is working on a Masters in Education. He is an international student from Chile, and a skilled web site designer. From this team he probably had the least background in environmental science. This turned out to be a great advantage due to his ability to evaluate the lab from the perspective of a non-major. His skills as a web site designer allowed us to put all of the lab information online. He was also able to relate environmental issues facing the US to those facing South America.

Sylvia Nemmers holds degrees in Biochemistry and is working on a PhD in Agronomy. She has had experience teaching on the university and high school levels, and has lived in countries around the world. Her experience with students on the high school and university level, as well as her enthusiasm for teaching contributed to laboratory development. Her life experiences, both within the US and abroad, afforded her the ability to broaden the topics of study to a global level.

Challenges for the future of ES110 lab

Now that the lab has been taught once, it is time for reflection and evaluation. Students provided their evaluations, affording a student's view of the course. Outside evaluators interviewed each student and observed one or more lab sessions including group and individual presentations. These interviews and student evaluations will be used to revise and improve future lab courses. The lab development team will also review the lab modules to optimize student learning and enthusiasm. Our goal is to make ES110 lab "the toughest lab students will ever love".