Physical Science 107 – Nanoscience in Society

Santa Barbara City College, Spring 2011

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I. Introduction

This 4-credit general education science course with laboratory was taught for the first time at Santa Barbara City College (SBCC) during spring semester, 2011. The course grew out of the 'Greenworks' course developed by the INSCITES program at the University of California Santa Barbara. The goal of the course was to introduce nanoscience and nanotechnology and their historical contexts and societal implications to first year college students majoring in science as well as nonscience fields. Like the original Greenworks course, it was based on four pillars: science, technology, society, and history. The scientific course material was developed from elementary but rigorous basic scientific principles as they apply to physics, chemistry, materials science, and biology. In order for this course to happen, it first had to be accepted by the SBCC Curriculum Advisory Committee and the college administration. Since the majority of students at SBCC transfer to the UC or CSU systems, the course also had to be accepted by the articulation boards of these university systems to become a viable option for students within the California Community College system. These tasks were successfully completed during fall semester 2010. In addition, the course received IGETC certification while the course was being taught. It is thus now a fully transferable general education science course with lab that articulates to the UC and CSU systems.

The course consisted of two lecture sections of 1 hour, 20 minutes each and one lab section of 3 hours every week. 18 students were enrolled in this course. All but one student remained full participants throughout the semester. The major fields of these students spanned a very diverse range from those interested in scientific fields from biology to artificial intelligence as well as those interested in nonscience fields such as media arts and English. Despite this diversity, both the lecture and lab material seemed to be accessible and interesting to all with a high level of engagement from everybody.

II. Course Content

The course was designed around a set of specific topics to which the four pillars were applied. In chronological order, these topics were: LEDs, solar cells, new materials, alternative energy solutions, water, information technology, nature as the original nanotechnology, nanoscience in society: future applications and potential dangers, and finally the work of some select scientists. Throughout the course, extensive use was made of online videos. There were reading assignments from a variety of sources (book excerpts, articles, and web pages). During the lecture period, there were often fairly lengthy discussions about the topics at hand as well as some prepared written questions and group activities. The laboratory experiments and activities were built around these topics and consisted of both scientific and more sociological activities. A schedule of the labs can be found at the end of this section. Grading for the course was based on lab write ups, written assignments, presentations, and participation in lab and lecture.

The course began with a basic but rigorous look at atoms and molecules, the building blocks of matter. Their structure and function as applied to chemistry, biology, and material science were then discussed with an emphasis on the development of these fields over time and the impact of our evolving knowledge on society. The concepts of nanoscience and nanotechnology were then introduced as an integration of these classical sciences. Much emphasis was placed on the possible future applications as well as potential detrimental effects of these emerging approaches in scientific inquiry and application. For the first topic, light emitting diodes (LEDs), we looked at lighting from historical and scientific perspectives and described the basic concept of p-n junctions and the materials and methods used to produce LEDs. We then took a look at solar cells as well as methods that are currently used to produce low-dimensional systems such as quantum dots, quantum wires, and quantum wells. This brought us to a discussion of new materials and their potential applications. Here, we emphasized the inherent multidisciplinary nature of nanoscience and the growing idea of using nature's own nanotechnology as a guiding principle for modern scientists (biomimicry). From here, we embarked on a fairly extensive look at alternative energies as possible solutions to the global energy problem and climate change. Many aspects of this topic from regulation to sustainability, to political questions were examined in addition to the science behind the various energy alternatives. In addition to solar energy, we looked at various biofuel options, hydrogen fuel cells, and wind. Since the availability of potable water is likely to be a serious concern in the

near future especially in developing countries, we examined the difficulties of overcoming these problems using modern materials and nanotechnology. We also looked at some specific problems of water distribution in the state of California, a serious issue in this populous but dry state. We then took a look at some interesting fields that are becoming more and more accessible as our ability to control matter at the atomic level increases. These include spintronics, quantum computing, artificial intelligence, and robotics. In the last part of the course, we took a look at some of the world's organizations that are at the forefront of scientific discovery and nanoscience such as synchrotron radiation facilities around the world, the Foresight Institute, the Molecular Foundry at Lawrence Berkeley Laboratory, and others. We then looked at the work and commentary from a number of contemporary scientists such as Angela Belcher, Michio Kaku, Richard Feynman, and several others.

The lab schedule is given below. Lab met every Friday morning for 3 hours.

Week	**Lab**
1	Decide Game; Intro to Nanoscience
2	Synthesis of Nanogold Colloidal Suspension
3	Personal Energy Audit and Mini-debate
4	Presidents' Day Holiday – No lab
5	Exploring LED's
6	Titanium Dioxide Solar Cells
7	Photovoltaic Cells
8	Biological Solar Cells - Photosynthesis
9	Fuel Cell Cars
10	Synthesizing Biodiesel and Student Presentations
11	Water Testing/Distillation
12	Role Playing Policy Forum; Money Allocation
13	Field trip to UCSB Materials Research Lab
14	Nano Ice Cream/Final Debate Prep
15	Final Debate

II. Comments/Future Improvements

Before the course began, I was not sure what the students' scientific level would be nor what range it would span. Although we had a very diverse group from many fields in the sciences and humanities, the overall scientific level was higher than I expected. This made the teachers' jobs somewhat easier than I had feared. I feel that we were easily able to cover the material at a level that was rigorous but informative at the same time. Additionally, this course demanded more 'give and take' from the students than I am accustomed to in the lecture portion of the class. However, this also proved to be a nonissue because after the first week or two, everyone was willing to participate and share their thoughts with the others. This certainly is in part due to the size of the class. There were 18 students and this is a good size for all-inclusive discussions. This would have been much more difficult with a larger class. Another aspect to this course that was daunting to me was the inclusion of the historical and sociological elements. This remained difficult for me throughout the course although the students' interest in these elements helped me guide discussion and content along these lines. Overall, I feel that both the lecture and lab portions of the class went well. In fact, I have never had so many positive comments from students during the semester in any course I have taught.

Nevertheless, such a project takes many years to evolve and there are a number of things I would do differently the second time around. We had one field trip to an electronic materials lab at UCSB (the lab of Prof. Palmstrom). This trip came near the end of the semester and was a success. I think a 2nd field trip would be a good idea. Because this course aims at a huge range of content, I would also plan to have at least 2 guest speakers. The more experts involved in teaching a course like this, with both scientific and sociological content, the better. In fact, I believe that a better way to teach the lecture portion of the class would be to team teach it with at least one science and one humanities instructor involved.

The evaluation of students' work needs some expansion with quizzes, more written assignments based on the class readings, and perhaps a 2nd formal debate. In addition, the written output of the students was quite poor so some work needs to be done at the beginning of the semester to aid students in writing methods and citing references correctly.