Understanding the Greenhouse Effect: Is Global Warming Real?

An Integrated Lab–Lecture Case Study for Non-science Majors

Frank M. Dunnivant*
Department of Chemistry, Whitman College, Walla Walla, WA 99362; dunnivfm@whitman.edu

A. Moore and M. J. Alfano
Department of Geology, Hartwick College, Oneonta, NY 13820

R. Brzenk
Department of Mathematics, Hartwick College, Oneonta, NY 13820

P. T. Buckley and M. E. Newman
Department of Chemistry, Hartwick College, Oneonta, NY 13820

The Problem

A popular joke on the comedian circuit goes something like this: “You know that society is in trouble when the average American thinks that The X-Files is a documentary series.” This is only a slight exaggeration. We live in a world where it is becoming increasingly difficult for the layman to distinguish between science fiction and real science. Television viewers watch the evening news and see amazing breakthroughs on topics ranging from the cloning of higher-level organisms to images from the Hubble telescope reaching billions of light years into space. The movie industry has blurred the distinction between technological reality and science fiction with scenes showing Earth being saved in the last minute of the movie. The idea that scientists always have the answer (in the closing moments of a movie or in the classroom) is one that we commonly see portrayed by our non-science majors.

Our Approach

A variety of techniques to keep students in non-majors courses interested in course materials (1–5) have been used, especially case-study approaches (6–9). In response to the level of scientific illiteracy present in students not majoring in science and the perceived inadequacy of typical general education requirements in science, we are developing a series of integrated science courses for non-science majors along-side our traditional non-majors courses. At most colleges and universities (including Hartwick College), students not majoring in a science discipline are required to take a minimum number of lower-level science courses, often dispersed over their four years in college. These courses are usually distributed among several areas of science (physics, biology, geology, mathematics, and chemistry), but there is usually no preferred or required sequence in which the students take these courses. For years we have observed that students following this “standard format” generally view the sciences as a fragmented collection of facts that have little or no connection to each other or to the students’ lives. This is not surprising, since we generally refer to these courses as “service courses” and rarely use an inquiry-based teaching approach. In general, we feel that students going through this standard format retain little of the course material, see no real-world application of science, and have not developed critical thinking skills in any scientific area.

We are taking a joint approach at Hartwick College, where we are teaching science to some of our non-science majors through a new series of science-integrated courses while other students are taught using the more traditional non-science, discipline-segmented courses. We have set up an interdepartmental series of science courses that are team taught by professors from mathematics, chemistry, geology and biology. Enrollment is limited to 30 students. Students completing this sequence of courses receive mathematics, chemistry, and geology (or biology) credits that satisfy their general education science requirements.

The central theme of these courses is “The Science of the Environment”. The fall semester, “Earth Cycles”, covers the hydrosphere; the January term (an intensive one month of classes equivalent to one normal semester) covers “The Chemistry of the Atmosphere”; and the spring semester covers “The Biosphere”. All of the classes use an integrated lab–lecture approach. In the fall and spring semesters the class meets two hours per day, two days of the week. During the January term we meet three hours per day, five days per week, for a four-week session. The central approach of each course is to select topics of high student interest that can be fit into modules. For example, during the January term (the subject of this article) we focus on the chemistry of the atmosphere and the modules consist of (i) the greenhouse effect and global warming (1 week), (ii) depletion of the ozone layer (1.5 weeks), and (iii) pollution of the troposphere (smog; 1.5 weeks). Within each module we integrate aspects of mathematics, chemistry, and geology or biology. A module from the fall semester, “Earth Cycles”, has been previously published (10).
The integrated lab–lecture case-study module presented in this article is a typical example of the approach used during the January term. In it we explore the greenhouse effect and the influence of humans on global warming. We provide the students with data collected from a variety of sources and allow them to analyze data sets, develop hypotheses, and draw their own conclusions. This module should take approximately 15–18 hours of class time using the group rotations (and three professors) as discussed below, or more than 20 hours if completed as one group (with one professor). This is roughly equivalent to one-third of the January term class time. If classes meet for three 1-hour lectures and one 3-hour lab per week, this module will require approximately three weeks.

The Module

The details of this module on global warming are presented in the supporting electronic material. The module consists of 8 exercises. Detailed descriptions of the exercises and supporting materials are given for (i) the measurement of infrared absorption of selected gases, (ii) the illustration of molecular vibrations for selected molecules using a computer simulation, (iii) a microcosm system that illustrates the greenhouse effect, (iv) an Internet session to download scientific data sets and create data plots, (v) a simple mathematical exercise to calculate planetary atmospheric temperatures, (vi) the interpretation of various figures and data sets for evaluating anthropogenic contributions to global warming, (vii) a session of student presentations, and (viii) allowing the students to apply their knowledge of factors contributing to global warming by playing the computer game SimEarth. These exercises are designed to build on and complement each other and culminate in two capstone exercises (exercises 7 and 8). The result is a highly focused one-and-a-half-week case study in which students can evaluate the general phenomenon of global warming and assess for themselves whether humans are contributing to the current trend.

Assessment

The purpose of this article is to summarize the case study module, but qualitative comparisons can be made between the approach presented here and more traditional approaches. Student interest in environmental topics and class attendance is considerably higher in the new course sequence (referred to as the NSF courses). In addition, we have found that more insightful questions come out of our focused topic discussions in the NSF courses than out of the traditional lecture format. This may be due to the selection of a topic more interesting to the student—the environment—or perhaps to the teaching style in the NSF courses, which is more amenable to student participation. However, there have been some unexplained discipline problems in the NSF classes, such as talking during class, a few students who did not contribute to out-of-class group assignments, and Web-surfing of unrelated sites during Internet assignments. We have found that it is impossible to compare knowledge content between these new courses and traditional courses because different subjects are covered.

A qualitative evaluation of student attitudes toward the nontraditional approaches used after two years of this course sequence yielded mixed results. Some students (fewer than 5 out of 25 per year) state that they prefer the traditional style of lecture, although these same students respond very favorably to integrated lab–lecture exercises and group activities. A few students (2 or 3 out of 25 per year) feel that the teachers are not “doing their job” when the students are asked to learn through group activities and class presentations, yet we have found that students clearly learn by teaching others. The best assessment of this nontraditional teaching style comes from the students’ performance during capstone exercises such as Exercise 7, in which the student has to integrate and extend the previously covered subject matter into a class presentation. These types of activities give “ownership” of the topic (and class success) to the student and a qualitative assessment indicates that a higher percentage of students excel in these activities than in learning through passive teaching approaches. These activities are rarely used in the larger traditional courses owing to time limitations.

In general, students in the NSF course perform well during capstone exercises. Our primary goal for the new courses is to develop critical thinking skills and improve student attitudes toward science. As a consequence of having traditional and nontraditional courses for non-science majors, we hope to make quantitative comparisons of knowledge retention between the two teaching approaches in the coming years.

Acknowledgment

This work was supported in part by funding from the National Science Foundation, grant # DUE-9653090.

**Supplemental Material**

Supplemental material for this article is available in this issue of *JCE Online.*

**Note**

1. Maxis, Two Theatre Square, Suite 230, Orinda, CA 94563-3041; 510/354-9700.

**Literature Cited**