A WALK ON THE MOON: 
AN INTERDISCIPLINARY INQUIRY-BASED COURSE

Catherine Mavriplis and Rachelle S. Heller 
The George Washington University, Washington, DC 

Charlene C. Sorensen and H. David Snyder 
Gallaudet University, Washington, DC 

INTRODUCTION 

The scientific and engineering professions are at a crossroads in their evolution. The 
professions have realized that there is a potential for greater creativity and diversity through the inclusion of women and underrepresented groups such as minorities and the Deaf. Furthermore, changes in science and engineering education have been mandated by industry, to provide more useful employees, and by society, to provide equal access and opportunity to all. One approach to implementing these changes is to modify the traditional science and engineering education technique to include one of guided inquiry and multi-disciplinary project performance. We have designed an interdisciplinary science and engineering seminar course to investigate this new approach. Our hope is that in offering an alternative learning environment, we might reach more women, minorities and traditional students, encourage them to persevere in their fields and offer them some useful tools for their career development. 

The course was developed as part of a National Science Foundation (NSF) grant for the advancement of women and underrepresented groups in science and engineering. The NSF-funded project is entitled FORWARD in SEM. This project aims to increase the numbers of women and individuals from underrepresented groups in advanced science, engineering and mathematics (SEM) studies and careers. Our particular focus is on the bridge between undergraduate and graduate studies in SEM fields. We have developed activities designed to encourage women and students of other underrepresented groups to consider graduate studies, apply to graduate school and, once in, stay in and complete advanced degrees. The project has five activities: a workshop for sophomores and juniors considering graduate school, the interdisciplinary seminar course described here (A Walk on the Moon), a summer research competition for first year graduate students, a mentoring network, and a program for improving Deaf access to SEM careers. 

The course was implemented for the first time in the first semester of 1999 and was repeated in 2000. Both times the course was offered at GW and Gallaudet concurrently.
Goals

The aim of the course is to get students together, especially women and members of underrepresented groups in SEM fields, to work on a cooperative project much like in the professional world, with different levels of expertise, different disciplines, different cultures and communities. Through this experience, the class, including faculty and students at all participating institutions, might build a sense of community at the university and beyond, build professional skills in SEM, learn to communicate effectively orally, in writing and electronically, and learn to critically assess technical merit.

The goals in developing the course were to have a mixed science and engineering experience, to involve students of all levels (freshman through graduate), to run the course simultaneously at several institutions and to have those classes learn from each other. The approach that best suits these goals and the overall intended aim, we believe, is a nontraditional approach: no formal lectures, heavy use and reliance on the World Wide Web and Internet materials and tools, and an emphasis on student participation and responsibility are key features.

The skills addressed are several: among the most important, “real world skills” that the students could readily apply to their careers and that would help them visualize a career for themselves in SEM. These skills include working on real problems that do not necessarily have complete answers “at the back of the book”, working in heterogeneous groups, writing proposals, analyzing data, designing and proposing original SEM work, and making presentations.

Methods

Choose a rich topic: the topic for the course was chosen to be the Moon for several reasons. The topic is rich and addresses a broad crosscut of science and engineering disciplines. Furthermore, ethical, environmental and policy issues play a significant role as well. The topic provides a level playing field for the course: both faculty and students are unfamiliar, in terms of expertise, with the topic. The remoteness and the unknown of the Moon also contribute to this equality. This equal access issue is important to our target audiences: women and underrepresented groups such as the Deaf and minorities suffer from the real or perceived impression that they are less knowledgeable or able in a particular technical discipline. Removing barriers to these equalities has been a primary goal of this project. Finally, the topic of the Moon and space exploration is fascinating, exciting and current, as live data from the Lunar Prospector mission is available to the students through Moonlink.

Use an interdisciplinary team of faculty who are concerned about women and minorities: the current team consists of four faculty members in different science and engineering departments and different universities. As such we have chemistry, physics, computer science and mechanical and aerospace engineering represented. This allows for
a broad pool of expertise in equally important areas that often interplay. Our resource
pool is even larger through our respective contacts and research areas. Information from
all four faculty members is communicated electronically and through shared lecturing.
The faculty must be trained or aware of engaging methods for delivering information to
students. All of us have participated in the University of Wisconsin System Women and
Science Program Curriculum Reform Institute\(^6\), where we have learned valuable tools
and techniques for improving science and engineering education.

**Make use of electronic communication tools:** course materials are collected on the
Prometheus\(^7\) electronic courseware developed at GW. This application facilitates computer supported
cooperative work from the point of email, discussion and shared files, organization and easy access to World
Wide Web and Internet (WWW&I) materials through directly clickable links. A range of multimedia
references may be used, including video interviews of professionals, who serve as role models and become
part of a community for the students. For example, shown at right is a still image from a video interview with MIT professor Dava Newman,
an expert in biomechanics of astronaut extra-vehicular activities and the effects of
reduced gravity environments on astronauts. This courseware provides a communication
tool for the distributed audiences of the course at the different institutions, including live
videoconferencing. This web-based format for the course establishes a high standard for
learning and self-guided inquiry, creates communities of science learners, and provides
opportunities for scaffolding\(^8\): educators can provide students with as little or as much
support as deemed appropriate at the participant sites.

**Make the course project-oriented:** students are given a request for proposals (RFP) for
a mission or any subsystem of a mission to, on or around the Moon. The students are
expected to deliver a proposal by the end of the course. The proposal must be presented
orally before the class and a group of experts and must be submitted electronically in the
form of a written document. Several other requirements are incorporated into the RFP: in
particular, students are expected to make use of recently acquired data from the Lunar
Prospector (LP) and/or Clementine mission(s).

**Use a nontraditional approach:** no formal lectures are held. Instead, the approach of
guided inquiry and discussion, group and individual research are used to learn about the
Moon and science and technology. The self-guided inquiry and research is done mainly
through the WWW&I, though library research, networking and personal contact are also
encouraged. The use of the WWW&I is a key ingredient in leveling the playing field for
disadvantaged, disabled or nonconfident participants such as those we are targeting.

The group inquiry in class is designed to launch the students into their own
investigations. In order to prepare the students and provide them with the skills
necessary to deliver a proposal, the course provides weekly investigations of the pertinent
topics or disciplines related to a Moon mission. These are listed in the class outline in Figure 1. The students are expected to generate the “organizing questions” (OQs) as a group in class to begin forming a background foundation in the discipline. This approach promotes discussion and cooperation among the group. The students then spend some class time researching answers to the OQs on the WWW. The instructors then guide a class discussion on the topic, with input from the students’ search results, using prepared lecture material as a guide to ensure coverage of the pertinent information. Notes on the lecture material are posted on Prometheus after the class session.

Figure 1: Course outline as viewed in Prometheus\textsuperscript{7} (electronic courseware application).

This format is enhanced by having guest lecturers, who are working in fields closely related to the topic, in this case space. Among our visitors were:

- Dr. Mario Acuna, physicist at the NASA Goddard Space Flight Center. As one of the developers of the Lunar Prospector instruments, Dr. Acuna gave the class a close-up view of the significance of space missions, their science and engineering, while providing us with a physics tutorial to enable us to grasp the importance of the issues.

- Dr. Charles Camarda, US Astronaut. Dr. Camarda gave an overview of manned space missions, past, present and future and provided specific insight into the interdisciplinary nature of engineering hardware design for these missions.

- Dr. John Logsdon, Director of the GW Space Policy Institute. As a recognized expert on US and international space policy, Dr. Logsdon was able to paint us a picture of
the political drivers for space programs and the unique historical significance of the race to the Moon.

In each case, the guest was instructed to not lecture, but rather give us the basics of the topic through answering questions from the group. The overriding unifying thread in each of the guest presentations has been the interdisciplinary nature of this work, something that is not traditionally taught at the university level.

**Help the students build some career skills:** the course uses presentation opportunities for science and technology learning, for development of SEM and professional career skills, for confidence and self-esteem building, and for skills in critical assessment of technical merit. The students learn to give professional oral presentations and learn to critique other presentations for their technical merit. The students also learn to write technical proposals, enhancing their written and electronic communication skills. The students must analyze data, design and analyze a science or engineering process. They learn to work in diverse teams and appreciate the challenges of other disciplines as well as those of merging disciplines.

**RESULTS**

**Student Outcomes**

The students in all cohorts participated in multidisciplinary projects and submitted respectable proposals. The students were paired by different disciplines and, when possible, different levels. Many of the students reported that they enjoyed having the opportunity to learn in a discipline out of their major. Most students reported that the course helped them to realize the enormous scope of their disciplines, however only half reported that the course changed their attitudes about engineering (in the case of the engineering students). In each class, it seems there is at least one or two motivated students who really appreciate the interdisciplinary aspects of such a project. Required anonymous comments submitted weekly by the students showed significant progress in intellectual maturity.

**Overall Results**

The use of the electronic courseware is an excellent means of getting students and faculty off to a productive and motivated start: both post interesting links to pertinent information in the first part of the semester, thereby creating the atmosphere of a community of learners. Certainly, the most difficult issue for both students and faculty is the nontraditional format of the classroom sessions. The students need to be motivated and mature to follow up on the material after the sessions. Faculty have to resist reverting to the traditional lecture format. While both students and faculty need time to get accustomed to this nontraditional approach, both learn to take risks. Since they are responding to the RFP based on an open-ended question with no right or wrong answers, students have a vehicle with which to explore. They have to grapple with topics of complex scope, discover that science is not a set of closed experiments but a process. Professors also learn to take risks. A Walk on the Moon is a course in which they are not the expert. It gives the professors an opportunity to say "I don’t know, let’s find out
together.” Professors are challenged to think clearly and uniquely about topics, making the explanations accessible to all levels of students.

We have found the experience of merging science and engineering fields in the classroom to be rich and rewarding. There is no shortage of available resources, be they electronic or written documents, venues for field trips or people willing to share their knowledge and experience with students. We feel the students and the faculty have benefited tremendously and have had their traditional education paradigm shaken enough to generate serious questions in their classrooms and in their lives.

CONCLUSIONS

The design and implementation of an interdisciplinary inquiry-based course has been presented. A number of methods for constructing such a course have been suggested. The nontraditional format of no formal lectures seems to be successful: 1) in preparing students for real engineering situations that they might encounter in their careers ahead of them and 2) in making them more comfortable in the engineering field. While we did not distinguish a difference in attitudes between men and women in the offerings of this course, we do believe that the novel format allowed for greater diversity within the classroom: the built-in impression of “no one is the expert” allows for greater self-confidence in students to express themselves and hence to learn.

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