AC 2010-1774: SPACE EXPLORATION: SCIENCE, ENGINEERING, AND SOCIAL IMPACT IN A FRESHMAN TECHNICAL COMMUNICATION COURSE

Paul Ross, University of Wisconsin, Madison

“Space Exploration: Science, Engineering, and Social Impact” in a Freshman Technical Communication Course

Creating opportunities: the 21st century, first year programs for engineering students, and the freshman writing challenge.

An academic course, like a planet, is formed in a universe of laws and both internal and external forces that determine its nature; conditions may vary over time and are not even necessarily consistent. Whether or not a planet will be hospitable and welcoming to intelligent life seems in many instances unpredictable. Academic courses are a little like that.

The “freshman comp” course described in this paper exists within a “first year” program in the College of Engineering; it covers basic communication skills, research, oral presentations, and elementary project management; it addresses professional and liberal education issues; it attempts to create a “learning community” by focusing on the big theme of “space exploration.” At UW-Madison this course has its home in a Technical Communication program within the College of Engineering; additionally, the opportunity and empowerment to innovate have been provided by the Freshman Interest Groups (FIGs) program, a campus-wide “first-year enrichment” opportunity.

Many challenges in the engineering curriculum center on time and resources. There is enthusiasm for adding first year program enrichment – and then the despairing questions must be asked about “where” and “when” such elements can be added. The very real limitation for many innovations is that the curriculum is already crowded, even in the first year. Engineering courses, especially beginning core courses, have a clear agenda that must be fulfilled in order to provide the necessary structure for the next well-defined steps in the program. [2, 6, 7, 9, 11, 14, 16]

Several first year innovations have been successfully implemented in the College of Engineering at the UW-Madison: a freshman design course, an introduction to engineering, a “grand challenges” course. The scope of this paper does not permit a detailed appreciation of the numerous efforts at the college and departmental levels.

Instead, the focus here is on “freshman comp” which provides another opportunity for first year enrichment and one that does not require an expensive addition to the existing curriculum. This “freshman comp” course within the College of Engineering has benefitted from a unique set of circumstances.

Anecdote and motivation

In 2007, a student returned from her engineering co-op at a major U.S. automobile company. As the coordinator for the Technical Communication Certificate program in the College of Engineering, I interviewed her about her experiences. Of course, overall, it had been a great opportunity – but then she added: “But something was wrong. There were a lot of sad faces and empty desks.” Except for insiders and experts, the situation facing the U.S. automobile industry was not well understood. When the economic problems became acute, the U.S. watched with surprise and dismay as the auto industry went into economic and competitive meltdown. In general, it came as a surprise.

The lesson is that things change very quickly and rapid change has been cited as a major factor in the 21st century. Engineers cannot count on past performance; new technologies arise quickly;

competition comes from unexpected sources; economics and demographics drive change and competition; jobs are not secure. More than ever before, flexibility is necessary for individual professional survival; and, perhaps more important, the engineering profession overall faces new challenges that have global impact.

So it was with some interest and concern that in freshman writing classes I noticed that first year students with a commitment to engineering were not aware of the new challenges. Many students with an interest in mechanical engineering intended to work for the auto industry; many others were influenced by the most obvious news emphases, so there was a superficial interest in all things green, including bio-fuels and alternative energy sources. And that was good as far as it went; my sense was that it did not go far enough.

FIGs at UW-Madison

In Fall of 2007 I had the opportunity to conduct one of only two FIG (Freshman Interest Group) courses in the College of Engineering. This led me to a review of ideas for first year curriculum reform. Most first year programs have as a primary aim the improved retention and academic support for beginning students; an emphasis on under-represented students is usually important. In addition, such programs strive to move freshmen more quickly into a mature and productive understanding of their career choices and their implications; essential skills can be emphasized in such programs to speed up the students' development of engineering professionalism; the establishment of social and intellectual communities improve student attitudes and retention.

The FIGs program at UW-Madison is a cross-campus opportunity; most FIG courses are NOT in engineering – note that data summarized in Table 1 is based on 32 FIGs classes, only TWO of which were in the College of Engineering – and both were "freshman comp" classes.

In brief overview, students elect to join the FIGs program for their first semester work; they then register for a core class plus two linked classes. They usually have the same dorm housing and are encouraged to build a social and intellectual community within the larger university setting. For an overview of FIGs at UW-Madison, visit: http://www.lssaa.wisc.edu/figs/

As already stated, the vast majority of FIGs sections are outside the College of Engineering (COE). There are several inherent challenges for COE courses. Although one expressed purpose of the FIGs program is to encourage students to register for a variety of other courses, in fact freshmen who have committed to the engineering curriculum have little choice for variety. In the past, the "core course" has been the freshman comp course offered in the COE and the linked courses were calculus and chemistry; these courses could not provide much "linkage" to the subject matter of the core "freshman comp" class except for the general topic of communication and composition. Starting in 2009, linkage has been to the freshman "Grand Challenges" course that included specific topics relevant to the "comp" intellectual topics as well as to the skills of written and oral technical communication.

Table 1, provided by Dean Greg Smith, Director of FIGs at UW-Madison, summarizes some of the most important assessment data for first year programs: GPA. A significant level of success based on GPAs seems to be apparent in these data.

However, with respect to the unique challenges of the engineering program, Dean Smith commented: "One thing I did learn recently is that students who take ANY math and ANY physical science course in their first semester have lower GPAs than students who do not take those courses" (Dean Greg Smith, Personal Correspondence).

Table 1: Preliminary Assessment Data from Fall, 2009: Based on 32 FIGs classes, 598 students.

FIGs Students	Non-FIGs Students
GPA: 3.38	GPA: 3.17
GPA Targeted Minority: 2.86	GPA Targeted Minority: 2.5
Seventh Semester Students: 79% have GPAs > 3.0	Seventh Semester Students: 65% have GPAs >3.0

"FIGs students are 3 times more likely to graduate with GPAs of 3.0 than non-FIGs students."
(Table 1 - quotation and data provided by Dean Greg Smith – personal correspondence.)

Figure 1 is a reminder of the constellation of benefits that are usually cited for "first year" programs. The UW-Madison FIGs program encourages work in all these areas; the challenge is to carry through with these benefits in a freshman composition course in the COE.

The "First Year Constellation"

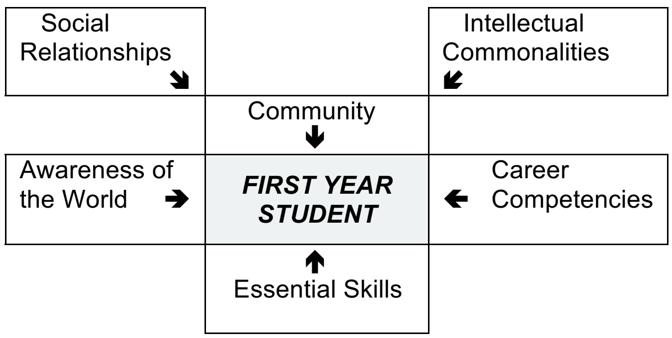

Figure 1. Expected benefits of first-year programs.

The technical communication course for freshmen

The opportunity provided by FIGs has been to work within the requirements of the established freshman comp course to incorporate some of the benefits advocated in first year reform. [5, 9, 11]

Most incoming students take "freshman comp" – they have the options of taking a comp course from a number of departments (English, journalism, communication arts, for example), but UW-Madison has the advantage of a Technical Communication (TC) program within the College of Engineering and the 2-credit TC freshman course is the preferred course for incoming engineering majors. For an overview of the TC program, visit: http://tc.engr.wisc.edu/

If there is an innovation and any controversy in this approach, it probably lies with the effort to set an intellectual theme for a whole class; the theme of "space exploration" may at first glance be unappealing – it is useful to view the topic in the context of the "Social, Economic, Engineering, and Scientific Impact of Space Exploration." Students are informed of the nature of the class in advance (Appendix A is a copy of the handout that students receive at summer registration). They have a choice to sign up for a FIG – or not; besides the two FIGs sections, there are usually at least 10 non-FIGs TC freshman comp sections. In the past, there was sometimes confusion about what would be expected but improved communication with the summer registration has improved that problem. [3, 4, 13, 15]

Freshmen choose this section, presumably making an informed choice. The common intellectual theme is presented in the context of a mini-conference – bringing together a variety of technical and professional competencies to meet a uniquely 21st century challenge. One of the requirements of this freshman composition course has been that students must "watch" and analyze the news (using online tools such as Google news and its archives) to be aware of what is going on space exploration and how new developments can affect specific technical or engineering opportunities and society. Appendix B is an informal summary of some of the main events that demonstrated that "space exploration" is a lively and rapidly evolving area of interest to engineers.

Figure 2 expands on Figure 1 with some specific attention to "first year program" goals and the contributions that can be made by the TC freshman communication course.

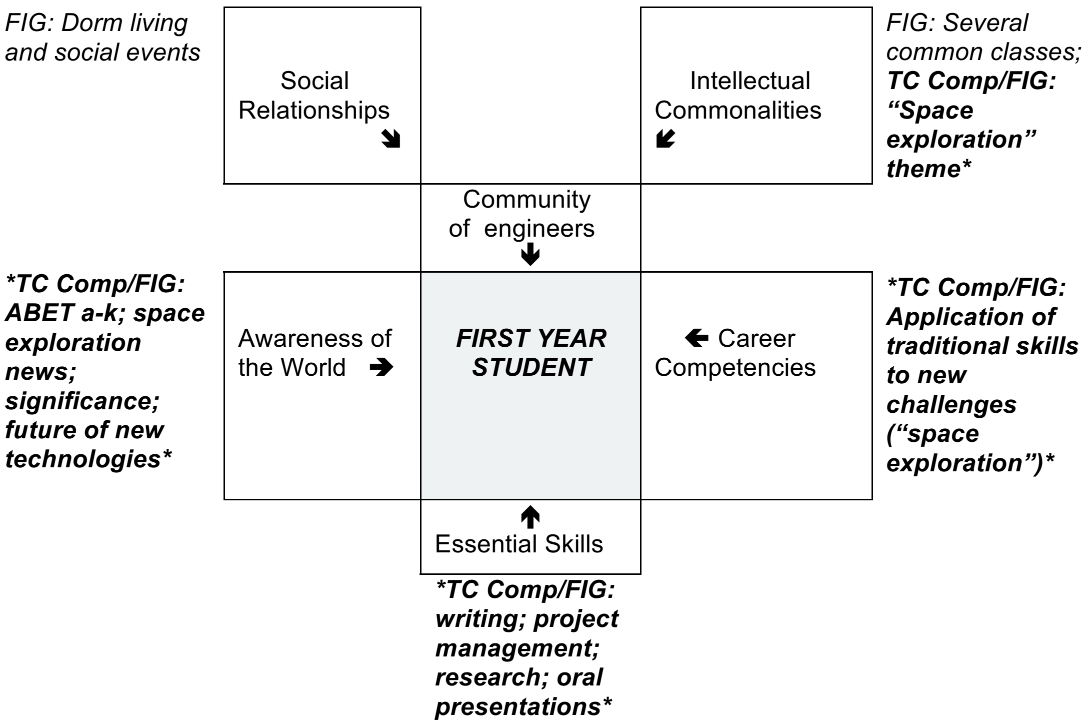

Figure 2. The FIG (Freshman Interest Group) Technical Communication course contributes to all the benefits listed for general program enrichment previously enumerated in Figure 1. (Dorm life, however, is essentially an out-of-class factor!)

Community: A large element of first year program work has been to help establish both the social and the professional sense of community. For this course, the "technical theme" has been used to build a community within the larger community of students who are starting to think like engineers as well as the social community for mutual support and "fun."

Awareness of the world: this means two things, of course. Professionals must be aware of the large social, economic, and political movements that will affect them and their professions. In addition, "certification" requires that students begin to understand that they must fulfill certain professional standards set by certifying agencies. ABET a – k (see abet.org) provides a useful definition of professionalism and the skills, experiences, and abilities that a professional must demonstrate.

Career competencies: At the freshman level, students are just beginning to understand the range of core competencies required in the traditional areas of engineering. The 21st century challenge is to both understand the traditional requirements and to be able to see the new demands and complexities as old processes become obsolete and new – as yet unexpected competencies – become obligatory.

Essential skills: The required syllabus for this freshmen course in technical communication requires a research project. This fits well with the recognition that the 21st century – more than any before – is in fact an information age. Research requires students to go beyond the comfort of general Google searches and Wikipedia (both of which have value but also limitations) and to dig into the databases maintained by the university through the library system. Reference librarians work with students individually and in at least one hands-on workshop on research tools. Other competencies have to do with elementary project management for a research project: project planning, formal proposal, literature review, draft, and final project document. In addition, the course requires at least two technical oral presentations, one using PowerPoint.

Table 2 summarizes the general syllabus for the TC freshman comp courses – but with the additions to the FIGs course with a focus on space exploration.

Table 2: The General Syllabus with Educational and Professional Implications

General Course Syllabus: 2-credit Technical Communication course in the COE UW – Madison Based on the general syllabus, focus is on the technology and social impact of space exploration.	
"Assignment"	Expanded definition and implications
#1 Assessment and Introductions	Evaluation of current writing and communication skills; career goals, professionalism, autobiography. Significance of new technologies and space race.
#2 Research Project Consider all aspects of space exploration	Elementary Project management: Project Planning. Proposal (written and oral presentation). Progress report indicating Review of Literature plus planning outline for project. Secondary Research – joint venture with Wendt Engineering Library. Delivery of a substantial and focused technical research report. Oral presentation using PowerPoint summarizing accomplishment and significance of the completed project.
#3 Academic Argument The space race "debates"	Academic Argument Project Planning. Formal Proposal for Argument Project. Continued development of relevant specialized second research tools. Deliverable – a position paper: science, technology, and major social problems.
#4 Group/team discussions Implications for space exploration	1. Breadth of Knowledge – Humanities, Social Sciences, Sciences, and Business. 2. Best Practice and Ethics – focus on the NSPE Code of Ethics.
Enrichment Activities News, opportunities, realities of space exploration.	Representative Lectures: A Local Small Business, NASA funded, making artificial "moon dust." Scientists from the UW-Madison Space Science and Engineering Center. Representatives from the "Lunar Reclamation Society" Tour and viewing at the historic Washburn Observatory Group dinner meetings for class

Writing and Thinking Across the Curriculum – and the Liberal Education Connection

A "freshman comp" course must serve students "across the curriculum" as well as preparing them for serious professional competencies. A special challenge for engineers is to embrace the "breadth of knowledge" required in ABET certification standards and increasingly in work that demands a "liberal arts" perspective in addition to technical abilities.

"High-impact educational practices" are well served by this syllabus.[8] George D. Kuh's "overview" includes the following examples of effective student engagement and contributions to cumulative learning. Kuh includes first-year seminars and experiences, common intellectual experiences, learning communities, writing-intensive courses, collaborative assignments, research, and global learning. Kuh notes that these and other practices may be carried out in different ways depending on the academic opportunities and environment. A detailed analysis is not possible here, but the context of the UW-Madison FIGs program plus the basic syllabus of the TC freshman comp course serves these practices well. An assessment of "success" must look at breadth of experiences, competencies beyond individual courses, and the development of skills and attitudes for lifelong professional growth.

A new opportunity for the TC Comp course is a new link to the UW-Madison Grand Challenges course. This FIGs linkage permits a reinforcement of the "intellectual community" through explicit attention to "breadth of knowledge" in engineering and society; it will enrich the perspectives that can be brought to the Composition course. The Grand Challenges course includes the following themes:

Theme 1: Engineering challenges on a personal scale
Diagnosis/treatment of disease, assistive technologies, rehab engineering, biometrics.
Theme 2: Engineering the Wisconsin Idea
Energy, regional eco-systems, transportation, security
Theme 3: Engineering for developing communities
Water, housing, health care, lighting, energy, information.
Theme 4: Engineering the megacity
Pollution, transportation, energy, natural disasters, security.
Theme 5: Global engineering challenges
Energy, terrorism, biodiversity, pandemics, climate change.
Theme 6: Engineering beyond planet Earth
Space travel, inhabiting space, near-earth objects, extraterrestrial communication.
(See: http://www.cew.wisc.edu/docs/news/UWGrandChallenges2010-1-15-10.pd)

Writing courses, particularly those that emphasize "writing across the curriculum" can provide a "one stop" shop for improved thinking in the "breadth of knowledge" often summarized under the rubric "liberal education." For example, Leonard J. Rosen's *Academic Writer's Handbook* is not an engineering book, but it is used in many freshman technical writing courses. Rosen provides a valuable discussion of writing, thinking, and the "rules of the game" for the humanities, social sciences, sciences, and business. Unfortunately, "engineering" is not included – but that becomes one of the themes of the technical writing course: engineering is complex and is best discussed in a larger context. Space exploration with its global implications, dependence on economics, science and technology, and new and unexpected developments, demonstrates the need for broad academic knowledge. Since the course must prepare student for more than just engineering – like any freshman composition course – it must help students prepare for writing in other academic areas. Table 3 summarizes "thinking across the curriculum."

Table 3. Thinking "Across the Curriculum" – and Liberal Education breadth of knowledge

Breadth of Knowledge (LED)	Engineering Student attitudes	Connections to Engineering	Examples that might be included	Impact of Space Exploration and Technology
Humanities (art, literature, music, religion, languages, cultures)	"all opinion" "no connections" "avoid if possible"	Global issues. Toleration of ambiguities. Understanding cultural impact. Ethics in general.	International travel/study abroad; languages; design for beauty; art and photography; creative writing. Engineering and aesthetics. "Engineers without borders."	The "International Space race": national pride, competition, cultural commitments: China, India, Russia, Japan, the EU, the US
Social Sciences (economics, sociology, psychology)	"not technical" "not scientific" "avoid if possible"	Critical thinking about social impact; Economics of engineering; demographics; human behavior; understand qualitative research. Ethics and society.	Experience with a variety of people: volunteer work; outreach to public and community organizations; work with elderly, youth, sick, culturally and economically diverse groups of people. Examples of qualitative plus quantitative research. Examples of impact on society. Market research. "Engineers without borders."	Decision making processes: the vote, the political motivation, economics, setting priorities, influence of public opinion in a democracy, social needs versus science, benefits for all of society, competition for resources (politics)
Natural Sciences (physics, chemistry, biology, earth sciences, astronomy)	"emphasis on physics and math" "theory not useful" "avoid others"	Relationship of theory and application; earth sciences and pollution, sustainability; biology in bio-medical engineering. Ethics and science.	Work that helps define the differences between theory and application; examples of pure research; "scientific" impact of engineering on ecosystems. Theoretical and scientific work in non-engineering environments.	"Nothing is as practical as a good theory"; scientific knowledge determining engineering practice (e.g. design of a lunar rover)
Business (a complex field including all of the above)	A duality: For some - "avoid business" For others -" get an MBA"	Complex business decisions determine engineering project success. Ethics and business.	Work with accounting, budgeting, project management, executive and financial decision making; quality versus cost decisions; production efficiency. Marketing examples.	Science is not business; current debate (3/2010) on the US Obama's move to make space exploration a private business task; comparison to other countries and economic theories.

This table is based on information gathered by the author in freshman, junior/senior, and graduate level composition classes and in student internship portfolio projects at UW-Madison.

Outcomes of the Freshman Technical Writing Course

Appendix C lists representative projects undertaken in three TC/FIG Comp courses, 2007 – 2009. There are a few brilliant papers, many that are good, a few that are weak. What should be noted is a diversity of projects within the unity of "space exploration."

Assessment remains a challenge. Following are a few comments by the students themselves (on file with the author):

"This subject is particularly interesting to me because of the direct connection to biomedical engineer…I can picture myself researching similar problems in the future."

"I think this project really helped me gain confidence in my writing abilities….I think the step-by-step process is essential."

"During the initial research of this project I was unsure what topic to pursue since I am not a big fan of space…While researching I ran across the problem of sleep deprivation in space….I was immediately hooked by this topic."

"The topic of space radiation is important to me since I am considering majoring in materials engineering."

"I plan on becoming a mechanical engineer and possibly being involved in future space exploration with NASA."

"I really enjoyed researching this topic…My intended major is engineering mechanics and astronautics.

"When President Obama faced criticism for his policy regarding NASA, he quickly changed it but remains coy about what he really plans to do with NASA

"Any major advancement in space exploration will have to come from private companies.

"When I was first given this assignment I had no idea of what I wanted to do….Then I had the idea of thinking about what my current interests on earth were and applying that to the moon…This led me to ask if there are environmental issues in space."

"The technical constraints of constructing bases on the moon are significant. The literature search of moon base design looks at the challenges and constraints that must be overcome…This topic is relevant to me because I am considering a civil engineering degree."

"I've always been interested in cars…so I looked at the requirements for performance and safety in the design of the chassis of the next generation lunar rover…you have to know something about the surface of the moon to understand this problem."

Benefits and future opportunities

Long-term benefits require a long-term view of outcomes. The point of using a required course (freshman composition) to reinforce some of the ideas of first year curriculum reform is to make good use of an existing course and to try to go beyond the limits of the usual course. In effect, it is an attempt to build a "themed engineering community" within the FIGs program and the College of Engineering.

The opportunity offered by the FIGs program also benefits the instructors: instructors are encouraged to try something different, to build some new skills, and to apply new models of course design. I had the opportunity to build some new area of expertise (based on a lifetime interest in astronomy) by attending the 2008 American Astronomical Society/Astronomical Society of the Pacific conference with FIGs support and to present a poster on telescope design.

As Dean Smith said, "Our FIGs model is rare (other campuses have FIGs but they do not involve faculty so intensely as ours), and the kinds of assessment we've done is more extensive than I've seen elsewhere" (Greg Smith, personal correspondence).

Finally, most of us who have been teaching composition for a while are familiar with the essay by Wayne C. Booth, "Boring from Within: The Art of the Freshman Essay" (an address delivered in May 1963 to the Illinois Council of College Teachers of English and reprinted in numerous places). He presents a humane and critical analysis of what goes wrong in freshman writing programs – and, by extension, a critique of education at all levels.

Booth said:

> The old formula of John Dewey was that any teaching that bores the student is likely to fail. The formula was subject to abuse, quite obviously, since interest in itself is only one of many tests of adequate teaching. A safer formula, though perhaps also subject to abuse, might be: Any teaching that bores the teacher is sure to fail.

Experiments with current, career–based, and lively intellectual themes in a freshman writing class, supported and nurtured by innovative and empowering programs such as the UW-Madison FIGs program, benefit both students and instructors. Instructors and administrators should actively develop such opportunities, particularly making use of the flexibility and "high impact" educational power provided by "freshman comp" within first year engineering programs.

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16. Veenstra, C. P. et al. A model for freshman engineering retention. Advances in Engineering Education, ASEE, Winter 2009. 1 – 33. (first year reform)

Other resources:
ABET criteria: abet.org
UW-Madison FIGs program: http://www.lssaa.wisc.edu/figs/
Contact: Greg Smith, Assistant Dean/FIGs Director

Author affiliations, UW-Madison:
Technical Communication Program: http://tc.engr.wisc.edu/
Master of Engineering in Professional Practice: http://mepp.engr.wisc.edu/

Appendix A. Handout for freshman engineering students at summer registration. Students learn about the FIG program and the options for FIG classes for their first semester on campus in summer registration. Better communication point has made it easier for students to know what to expect in their options.

Space Exploration

EPD155
Freshman Engineering
Technical Writing course
Fall 2009
Social, Economic, Engineering, and Scientific Impact of Space Exploration

Space exploration provides far-reaching educational challenges for a variety of students in all areas of science, engineering, and technology. As a 21st century challenge, the social impact of space exploration is yet to be charted.

For Fall, 2009, this FIGs section of EPD 155 focuses on the unifying intellectual theme of "Space Exploration." This theme is suggested by the 2009 International Year of Astronomy (IYA) and the 400-year commemoration of the observations by Galileo. Additionally, the science and technology of space exploration is advancing at an astonishing rate and related global issues are growing now with a new "space race." The social, technical and economic impacts of space exploration are again becoming important issues for engineers. This is truly a 21st century concern with implications for the education, opportunities, life, and work of engineers and scientists in all technical areas.

The first "FIG" with the unifying theme of "Space Exploration: Science, Engineering, Economics, and Social Impact" was taught in Fall, 2007. This theme was determined in part by a general interest in the science of astronomy, the 50th anniversary of Sputnik, and the current news from China, Russia, India, Japan, Europe, and the US documenting a new international space race. The results of this course were quite successful.

Successful student projects exhibited a combination of astronomical knowledge, technical and engineering applications, and professional career exploration. Topics included remote sensing, next generation rovers, space medicine, alternative propulsion technologies, space food, Mars meteorites, and practical lunar or Mars habitations.

Engineering for space exploration depends on the knowledge provided by astronomy and space science: this is the lesson for engineering students. For example, one project looked at "adaptive chassis design" for lunar rovers – an innovation based on an understanding of the topography of the lunar surface. Another was based on nutrition in space, based on the research indicating special nutritional needs due to the conditions of weightlessness, radiation hazards, and psychological challenges.

Class activities have included discussions and lectures about lunar exploration, a class conducted by the space science and engineering center, and a tour of the historic Washburn Observatory on campus – a significant milestone in the development of UW-Madison as a research institution.

Appendix B. Highlights and discussion points from current affairs.
The years 2007, 2008, and 2009 were challenging and exciting for anyone who was interested in space exploration and its many ramifications in science, technology, and society.

First, there were the milestones: the 50^{th} anniversary of Sputnik (1957); the 50^{th} anniversary of Vanguard I and the establishment of NASA (1958); 400 years of telescope observations starting with Galileo and celebrated in the 2009 International Year of Astronomy; the 40^{th} anniversary of the first US lunar mission (1969).

Second, there was the rising tide of news about a new space race: dispatches grew in number and complexity about the nations that were committed to serious programs in space exploration with the usual plans for satellites, space stations, moon exploration, Mars missions, and deep space exploration through ground based instrumentation and space probes. The roster of nations with well articulated plans for space exploration included China, India, Japan, Russia, the European Community, and – lagging but not to be left out, the USA.

Third, there was rather routine and somewhat predictable news. Several very rich people (including a clown who brought large red rubber noses for everyone) spent millions of dollars to be ferried by Russian shuttle to the ISS. News from the ISS continued – everything from non-working toilets to new international cuisine to satisfy an increasingly international crew (who wanted good food!). Japan hosted an international conference on space elevators, and NASA continued its demonstration competitions for small companies to design "space elevator crawlers" – using dangling cables from hovering helicopters,

Finally, there were the surprises and game changers, some troubling and some astonishing. First China, and then the US, casually demonstrated their prowess in shooting down (their own) orbiting satellites; "just routine," the story went, but the subtext reinforced old and troubling ideas about war in space and the real stakes in space competition. On March 2, 2009, a space rock (DD45 2009) measuring about 35 meters wide appeared out of nowhere and brushed by the earth at a distance of only about 72,000 km (44,740 miles); astronomers had only about a three-day lead on this object.

Perhaps the most striking "game-changer" was the discovery of water on the moon; the implications of this are not well understood yet, but it upsets long-held "facts" about the moon. And although the US LCROSS mission received most of the publicity, India's *Chandrayan* instrumented lunar orbiter established the groundwork for this discovery.

Politically, March of 2010 saw the Obama administration's announced intention to radically alter NASA's involvement in future lunar exploration. At about the same time, Virgin Galactic's *SpaceShipTwo* made its first captive carry flight at the Mojave Air and Space Port, possibly confirming the administration's confidence that commercial space ventures may be increasingly practical. However, the politics remain highly controversial.

Students seem to respond well to these news items and are encouraged to develop the habit of keeping up with the news, if not in space exploration then in some other technical area that may be of importance to them professionally.

Appendix C: Freshman Composition Project titles, "Space Exploration": 2007–2009

Humans or Robots: Who Will Explore Space?
Mars or the Moon: Priorities in Exploration
Social Problems or Space Exploration: Money and Resources
The Space Elevator and New Materials
Significance and Progress for the ISS
Technologies Trickle
Space Race II: Compete or become a Second-class Nation
Humans or robot for future exploration
Manned vs. Unmanned Space Exploration
Robots…NASA's Answer Hard Economic Times
Virgin Galactic – Revolution in Spaceflight
Space Planes – the orbital space plane concept
Surgery in Space
Construction of a Lunar Base
Lunar Rover Suspension: Developing Safety and Efficiency
Horizontal and Vertical Launch Configurations
Methods for the Discovery and Identification of Elements on the Moon
Applications of Rail-gun technology to Space Exploration
Using Intelligent Systems for Space Flight Tasking
Next Generation Rocket Technology
Improved design for an Efficiently Powered Lunar Rover
The Mars Space Suit
New Design for Lunar Rovers
The Lunar Base: Location and Design Alternatives
Mmmm…Space Food!
Meteors from Mars
The Mars Rover
Bionics Applied to Space Technology
Space Agriculture: Above Ground Greenhouses on Mars
Constructing Bases on the Moon for Manned Scientific Research
Helium-3 as an Alternative Energy Source
Engineering Protection Against Radiation in Space
Hybrid Rocket Systems
Lunar Construction
NASA and the Ares Rocket for Future Space Exploration
Sleep Deprivation in Space:
Surviving in Space: Engineering Solutions to Disease Atrophy
Space Suites: The Constellation Space Suit System
Space Elevators: A new way to reach space