A First Year Course in Design and Creativity for All Students

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Introduction

A new course was offered at Loyola College in Maryland in the Fall of 2002. The course was entitled, “Engineering, Design and Creative Problem Solving in the Built World” and it was part of a special program for first year students called “Alpha”. This program is intended to enrich the experience of first year college students by providing them with a small class, more contact hours with the professor, and models of scholarly writing, conversation, and critical thinking. Faculty members in both the humanities and sciences have embraced this program. It posed some unique challenges to integrate the idea of an elective engineering course into this framework, which emphasizes reading, writing and conversation. The initial results suggest that this kind of course can provide much needed exposure to engineering design concepts to the general undergraduate population. It also provided some ideas for improving the introductory pedagogy for engineering majors. The following is a detailed course description that was created as part of the proposal for this new course to the Alpha program committee of the Office of First Year Programs. Some excerpted material from the student syllabus is provided in a table at the end of this paper.

Detailed course description (from proposal to the First Year Programs Committee)

The pyramids, gothic cathedrals, grand structures, but also transportation, communication, agricultural public health and sanitation systems are just some examples of our engineered world. This course explores what makes engineering unique from the sciences; the elements of design and creative problem-solving. Emphasis is given to the historical and social contexts of engineering design and its impact on our society.

This course is intended to explode the stereotypical image of “the engineer” and begin to appreciate the creativity inherent in the design process. We explore the connections engineering has to visual thinking, the visual arts, and graphic and industrial design.

The other central theme of this course is to understand the threat and promise of our dependency on the built world and the controversies that surround engineering decision-making made under conditions of risk, uncertainty, and moral ambiguity.
This course is open to both engineering majors and non-majors.

This course requires extensive critical reading, as exemplified by the proposed reading list. Although there is use of mathematics, computers, and a laboratory experience, the central pedagogy of this course is reading, writing and discussion.

Students are expected to write, edit and revise essays in response to their readings. The iterative cycle of writing is essential to improving one’s clear expression of ideas. The writing is collected in a portfolio format so that students are able to have an appreciation of the breadth of topics covered and their progress throughout the course. A visit to the writing tutor (“The Write Place”) to enhance the editing and revision process will be required. Students also share their writing in class or in smaller groups.

Students both singly and in teams make oral presentations during class. They also share their reading and writing in class discussions. In addition, scholastic conversation among peers in more informal settings is encouraged during casual get-togethers. Students often don’t know how to create opportunities that allow them to get excited about discussing ideas. A selection of videos on appropriate engineering topics (Building Big, To Engineer is Human, Miracles of Design, NOVA) is already available at the Loyola-Notre Dame Library, which makes an excellent starting point for such discussions.

Engineering decision-making is practiced under conditions of uncertainty, risk, and moral ambiguity. It is therefore natural for controversies to surround both engineering successes and failures. Critical understanding of the technical and non-technical constraints that go into such decision-making is crucial to an appreciation of the complex nature of the practice of engineering.

Technically literate citizens of the 21st century need to become more self-conscious of how they use and enjoy the fruits of engineering ingenuity (health, transportation, communications, agricultural systems). We live in a highly technological environment, much of which is often kept invisible to us, so that we forget how dependent we are on the smooth functioning of those systems and how vulnerable we are when they are disrupted. For example, when electrical power is disrupted as the result of a severe storm, people often comment how that experience alters their view of themselves in the world. There are positive and negative aspects to this so-called “progress”, and a balanced approach must present both the clear benefits as well as the more questionable effects of advances in technology.

Proposed reading list:

“The Evolution of Useful Things”, Henry Petroski
“The Design of Everyday Things”, Donald Norman
“To Engineer is Human”, Henry Petroski
“The Existential Pleasures of Engineering”, Florman
“Machine Beauty”, David Generator
“Engineering by Design”, Gerard Voland
“Creative Problem Solving”, Edward Lumsdaine & Monika Lumsdaine
“Strategies for Creative Problem Solving” H. Scott Fogler & Steven E. LeBlanc
“Taking Sides: Clashing views on controversial issues in science, technology and society”, Thomas Easton
“The Engines of our Ingenuity: An Engineer Looks at Technology and Culture”, John Lienhard
Something by or about Buckminster Fuller.

Proposed Plans for Writing:

Essays in response to articles and current events related to technology.
A portfolio of essays from the course will emphasize the importance of research, editing and revising written work. Students will practice other oral and written communication skills in team projects and presentations.

Essay topics may include the following:

- What is engineering
- Past engineering achievements
- New fields of engineering
- Analysis of a famous engineering failure
- Current global problem and possible engineering solutions
- Responses to various articles presented weekly (e.g. “ancient” engineering, engineering for materials recycling, human-computer interface design)
- “How it works” poster presentation
- “Everyday problem-solving” oral presentation and report

“Extra” Class Time:

The extra time can be used to create a lab setting, if the extra fifty minutes is used to create a double length period. Students can use the time for their team-building and design projects (how things work, bridge building, LEGO® robots, etc). The time will also be used for the scheduling of trips and guest speakers both from outside and from Loyola faculty.

This double period may be used for some of the following:

- Guest speakers (fine arts, engineering dept, outside speaker)
- Video and discussion (e.g. “Building Big”, “To Engineer is Human”)  
- Design contest (bridge building/ LEGO® robots/other)
- Oral presentation period
- “How things work” lab and poster presentation

Topics, and themes to be covered with sample activities/assignments:

(1) Engineering as creativity, design, and problem-solving
   a. Brain models
      i. Left brain/right brain creativity, Kolb cycle, Kiersey temperament (Meyers-Briggs)
b. Design process
   i. Failure as a part of the design process, iteration (Henry Petroski)
   ii. Visual arts as part of the design process and problem-solving (Graphic Design – possible visit from Fine Arts faculty)

c. Exercises in problem-solving
   i. Creative problem-solving (brainstorming)
   ii. Oral presentation: (suggest solutions to everyday problems, being aware of the presence of design constraints-time, performance, cost)

(2) How things work
   a. “Take it apart” lab (e.g. hair dryer, disposable camera)
   b. Poster presentation of how an everyday object works.

(3) Historical background and frontiers of engineering: “the cutting edge”
   a. Engineering achievements (accelerated progress, importance of power/energy, movement from mechanical to electrical systems)
   b. Examples of “the cutting edge”; nanotechnology, biotechnology
   c. Industrial and Information revolution (overview?)
      i. Possible videos: (NOVA series, Building Big, etc)

(4) Social implications, interactions, constraints on engineering
   a. Ethics, whistle-blowing, disasters (Challenger case study – what goes wrong – human management)
   b. Environmental and global concerns (the green engineering movement)
   c. Technological solutions or technological problems?
      i. Possible videos: (on Challenger whistle-blowing, bio-tech moral dilemmas, etc)

(5) Class trip – Baltimore science museum, cryptology museum, Northrop-Grumman, National Air and Space museum, Baltimore museum of Industry

(6) Other topics:
   a. Impact of computers
      i. Digital divide
      ii. Privacy
   b. Communications systems and communications revolution
   c. Industrial and Information revolution (overview?)

Lab or “Hands-on” Experiences:

The labs or hands-on experiences included the following:
• Paper tower contest
• Video (“To Engineer is Human”)
• Graphical communication (engineering drawing, of candy!)
• Computer lab (open a computer)
• Soldering lab
• Lego robot lab
• Bridge building contest
• Problem-solving presentation
• Trip (National Federation for the Blind, Baltimore, MD)
Results and Discussion

The course was offered once in the Fall of 2002 and will be offered again in the Fall of 2003. Enrollments in all Alpha program courses are capped at sixteen, and there were nine students in this first offering of the class. The response of the students was generally positive. One student is an engineering major and another is a physics major. One student is pursuing a fine arts major. The other students are either undecided or in non-science majors, such as business. Those students who will be science majors were already strongly committed to a science degree before entering college. The diversity of this small class was positive as well, with two women and a Hispanic student taking the class. Considering that the course has an extra contact hour (four contact hours), but still only receives three credit hours and that the course currently fulfills no graduation requirement for non-engineering majors, this first experience was encouraging. There exists a real interest for this kind of class. It is hoped that in the future this course will also function as a recruitment tool for engineering students. Therefore, the course fulfills the Introduction to Engineering requirement for engineering majors.

Assessment and evaluation of Alpha program courses consists of a self-reflection survey prepared by the instructor, as well as a number of student surveys, including a pre- and post- semester general attitude survey to assess the overall efficacy of the Alpha class in promoting retention of students and an easier social and academic transition from high school to college. Even for the highly capable, motivated, previously successful and privileged high school students who tend to come to such a private liberal arts college as Loyola College in Maryland, the transition to college can be difficult. In general, the Alpha program has been highly successful in improving students’ attitudes, helping them establish social and intellectual networks, improving their GPAs and overall retention compared to those of first year students who do not participate in any special freshman program.

For the engineering Alpha course, the labs and “hands-on” activities were extremely well received. Many of the “hands-on” activities were the same as those presented to the first year engineering students in their Introduction to Engineering course. Both groups of students (majors and non-majors) performed equally well in the various experiences listed above (e.g. paper tower contest, soldering lab, balsa wood bridge building contest, Lego® robot lab). These experiences were extremely successful with the non-engineering majors and greatly enriched the meaning of the readings and the course for them. No one complained about the extra time commitment involved in being in the lab or lounge, taping, gluing or soldering. The trip to the National Federation of the Blind also provided students with an appreciation for the positive uses of technology, and equally important, they were very impressed by the capabilities, rather than the disabilities, of all the staff we met there.

Although field trips and labs do require quite an effort of extra planning for faculty, it is generally well worth it. It should be noted that the First Year Programs office provides monetary and administrative support for Alpha courses that helps make the enrichment activities possible. Faculty members are acknowledged for participating in the program, which is also important, given the extra work involved.
By combining those extremely popular lab and design experiences with the reading, writing, reflection and discussion, the overall experience of the Alpha class was enriched compared to that offered in the “standard” Introduction to Engineering class. I would like to see the standard engineering class more closely parallel the Alpha class and allow the engineering students to have time to read these same texts and start reflecting on their future positions and responsibilities in society.

The most beneficial and enjoyable reading of the five texts used in the syllabus was Donald Norman’s, “Design of Everyday Things”. Its emphasis is on the human-design interface, and what that implies for good design practice. This is an extremely fruitful area for young engineers to become familiar with and may be a useful way to introduce the concept of design and inculcate good design habits in engineering students, while enlightening non-engineering majors as to the central role of engineers in their lives. Because the examples from the book are not overly technically complex, the principles of good decision are easier to emphasize. The students followed up on this by finding examples of poor design on campus and critiquing them. The examples were generally taken from frustration with lighting, doors, cafeterias and related “everyday things”.

We hope that in the future, this class, or similar such offerings at other institutions, will be considered to fulfill a college science requirement. We hope to eventually propose a version of the course as an elective that can be chosen to fulfill the natural science core course requirement that all students at Loyola College must meet in order to graduate.
Supplement – Information from Course Syllabus

Some materials from the actual course syllabus as it developed in its first year show the revisions to the reading list and some additional details for the conduct of the course as they were presented to the students.

Texts
- *The Design of Everyday Things*, Donald Norman, Doubleday
- *Invention by Design*, Henry Petroski, Harvard University Press
- *The Engines of Our Ingenuity*, John Lienhard, Oxford University Press
- *Engineering Your Future*, Oakes, et. al., Great Lakes Press (optional)

Specific Educational Objectives of the Course
At the completion of the course, the student will:
1. Be able to define engineering
2. Be able to describe steps in problem solving techniques
3. Be able to describe steps in engineering design
4. Be able to develop methods to evaluate designs
5. Be able to compare and contrast technical arguments, especially those that relate to public policy decision-making.
6. Have practice formulating, designing and building a simple design project subject to constraints.
7. Have practice with written, oral, and graphical communication

Conduct of the Course
In order to achieve the education objectives of the course you must come to class prepared to participate. This involves, regular attendance, regular reading, regular writing, and regular participation.

Grading
Your grade is based upon a weighted average of the following items:
- Exams: 30%
- Quizzes: 10%
- Writing/Portfolio: 20%
- Oral Presentation/Project: 10%
- Final Exam: 20%
- Attendance/Participation: 10%

Exams: Two exams are scheduled. They will be a combination of short answers, definitions and essay questions.

Quizzes: The quizzes are just a way to make sure that everyone keeps up with the reading. They will be brief, approximately weekly and focused on the facts of the reading.

Writing/Portfolio: You will need to keep a record of your written assignments, drafts, and final copies, including individual and group work. I will provide a “grading rubric” for written work as an additional handout. You will have opportunity to revise and improve your writing. I strongly encourage you to use the campus facilities for writing review/improvement (“the Write Place”). I will be handing assignments back, but will also collect the entire portfolio at mid-term and at the end of the semester.

Oral Presentation/Project: This is a project to explore problem solving and creativity. Look around for a problem in everyday or campus life that needs a good solution. You will work as a group and give an oral presentation on the last day of class as well as submitting written materials. More details will be provided in another handout.
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