Innovative Integrated Mechanical Engineering Curriculum

Devdas Shetty, Member
Vernon D. Roosa Chairholder
Department of Mechanical Engineering
University of Hartford
West Hartford, CT 06117
shetty@hartford.edu

Chittaranjan Sahay, Fellow
Professor and Chairman
Department of Mechanical Engineering
University of Hartford
West Hartford, CT 06117
sahay@hartford.edu

The College of Engineering has developed and tested a model for an innovative mechanical engineering curriculum by emphasizing hands-on experience, design integration and creativity with multi-disciplinary open ended problems. This is done by (i) Integrating engineering design with the mathematics, humanities, social sciences and sciences courses, (ii) Inter-disciplinary research and design project throughout the four years of the program, (iii)Experiential and collaborative learning by faculty and students, (iv) Partnership with the industry in the creation of real-life engineering projects for students at all levels, (v). Introduction of ethical components in design through industry sponsored projects. The revised curriculum continues to have a powerful impact on student learning. The design sequence followed by mechanical engineering students beginning in the freshman year shows a clear and cumulative building process of engineering and mechanical design skills while also being linked with important inter-disciplinary perspectives and knowledge. The students contextualize the design projects in terms of social, political, economic, cultural and human dynamics that prevail in industry

1. Introduction:

One of the major strengths of the University of Hartford is its location in the Greater Hartford area surrounded by high technology mechanical engineering based companies and able to interact with hundreds of business organizations, government agencies and hospitals. The University has developed a basic infrastructure of close ties to area business and industry through the College's Engineering Application Center (EAC). The EAC is well respected in the community, and among its external partners are such corporations as United Technologies, Kaman Aerospace, Carrier Corporation, Hamilton Sundstrand, Sikorsky, Pratt and Whitney, and General Electric Corp., to name a few. The EAC has become a vehicle for collaboration between industry and the University in the conduct of applied research, which involves students, faculty and staff. The partnerships developed in the EAC are based on the belief that industry is an important partner in the University's ability to sustain excellence through both education and applied research.

Like many of its peers, the COE strives to retain students, attract them with innovative curriculum and effectively prepare them for careers in the rapidly changing labor market. The National Research Council reports on "the need of putting a premium on students who have a broad knowledge of different subjects, skills in synthesizing and communicating information, and the ability to work in teams" *(From Analysis to Action)*. The engineering curricula at the COE has been modified by integrating substantive work in the humanities, social sciences, and mathematics in order to avoid the narrow disciplinary focus-confined learning style. The restructured curriculum has included hands-on experience, design creativity, multi-disciplinary problems, teamwork, open-ended problem-solving experience, communication and integrative learning methods.

2. Integrative Learning Blocks throughout the Curriculum:

We have integrated interdisciplinary design projects through out the engineering program. This is done by introducing *Integrative learning blocks* into the curriculum. At the freshman level, *First year Interest Groups* (FIGs) are created, which consist of two courses, *Principles of Engineering* and *Rhetoric, Language and Culture*. In the second semester, FIGs consist of three courses, *Principles of Design*; *Calculus II* and *Physics I.* A new course, entitled "*Engineering by Design*" was introduced at the sophomore level. The industry-sponsored projects demonstrate the ethical components of design.

These learning blocks are constructed so students become engaged in collaborative projects with clearly defined learning outcomes that have been developed by faculty from the identified disciplinary areas. In addition, they allow faculty members to pursue the educational goals of integration while students experience a learning situation that is not fragmented by disciplines or courses.

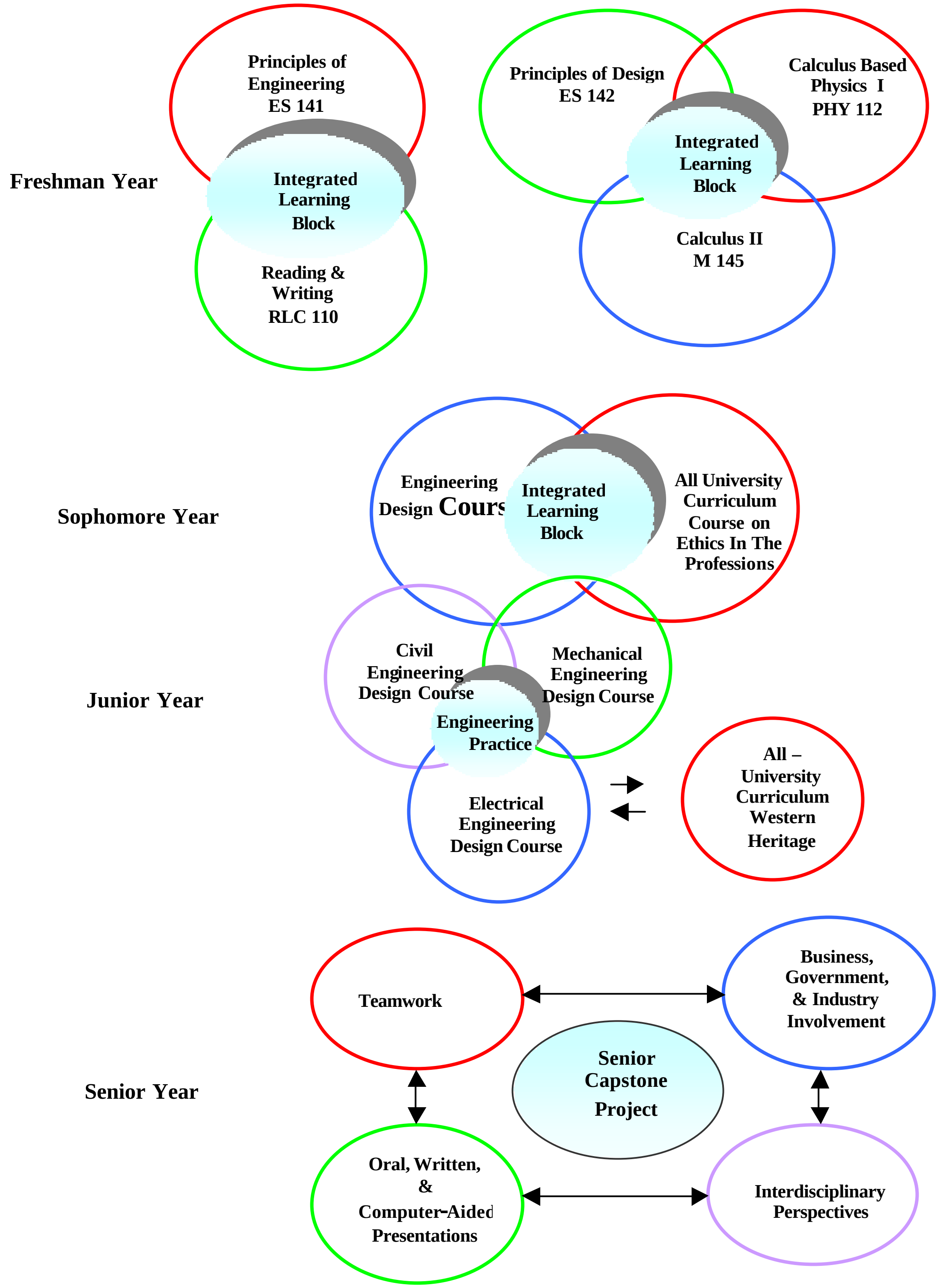

Figure 1: Elements of the redesigned curriculum

2.1 The Freshman Interest Group

FIG is a pairing or clustering of courses in which a group of students take two or three courses together. The goal is to get faculty to cooperate on the shared outcomes between the FIGed courses; the ILBs. It could be between two or three courses. The process involves cooperation and several discussions among the faculty involved. It can be briefly described as follows:

- Each faculty prepares and examines the expected outcomes of his/her course.
- Exchange the syllabi, the expected outcomes and textbooks among the faculty.
- Based on the expected outcomes, the instructors then meet several times and work on a list of the shared outcomes, activities to support the outcomes, the technology to support these outcomes, the assessment method and finally, a list of week-by-week topics to be covered in each of the FIGed courses.

3. Innovative Restructuring:

3.1 Curriculum Restructuring – (a) Freshman Level

During the nineties, while there were nationwide efforts in curricular design, the University of Hartford had redesigned the freshman program in engineering. This has helped the students to be exposed to fundamental engineering concepts in their freshman year side by side with science and humanities courses. Although the assessment of this first year program showed positive impact on student performance, the fragmented structure of the first –year curriculum still created problems in terms of student learning. Students seldom relate engineering topics to math, science, social science or writing.

3.2 Curriculum Restructuring – (b) Establishing Linkage:

The problem of fragmented structure was overcome with the creation of unique course combinations where faculty from engineering, math, science, humanities, and social science worked together to define student-learning outcomes for project-based curricula. Engineering and non-engineering courses were clustered into integrated First-Year Interest Groups (FIGs). Engineering and interdisciplinary courses were paired in the sophomore and junior year, by emphasizing collaborative projects involving engineering and non-engineering students. The integrated learning blocks created for four years of curriculum are shown in ***Figure 1*** .

3.3 Curriculum Restructuring – (c) Design Projects across the Curriculum:

The integration of applied research and contextualized design throughout the engineering curriculum, starts from a design-based, freshman-level course and progressing through intermediate courses at the sophomore and junior level, culminating in the capstone design experience at the senior level. The introduction of design-oriented courses in each year of the engineering curriculum has given the students an opportunity to make connections between various courses and obtain a better perspective of engineering practice. For each of the four years, design-oriented courses have been established, as shown in *Figure 2*. Both technical and non-technical aspects of design are treated in depth using lectures, case studies and collaborative group projects. These courses and design projects provide the skills in problem solving, communication, computer skills, ethics, time management, team building skills, and business knowledge in addition to technical knowledge.

The pattern of pairing courses to form an integrated learning block is repeated in the freshman through junior years of the program. Thus, by the senior year, students understand and appreciate the fact that many engineering problems and situations are multi-disciplinary in nature. Further, they understand that skills acquired in one course can be used in multiple courses and situations.

4. Ethics in Profession

The tendency in undergraduate engineering design projects is to concentrate on the technical process of design and presentation techniques. There is little time left to examine ethical issues in depth, although ethics problems may be as daunting as the technical questions. The development of a new sophomore level engineering design course at the University of Hartford required the integration of design and ethics. The new design course shares a one credit integrated learning block (ILB) with a sociology course, "Ethics in the Professions". The ILB mechanism allows for the study of specific ethical issues associated with the design projects being undertaken by the engineering students. In the sociology course, engineering students benefit from wide ranging discussions of ethical issues, and non-engineering students and faculty are brought to understand the nature of engineering work and its broad based social context.

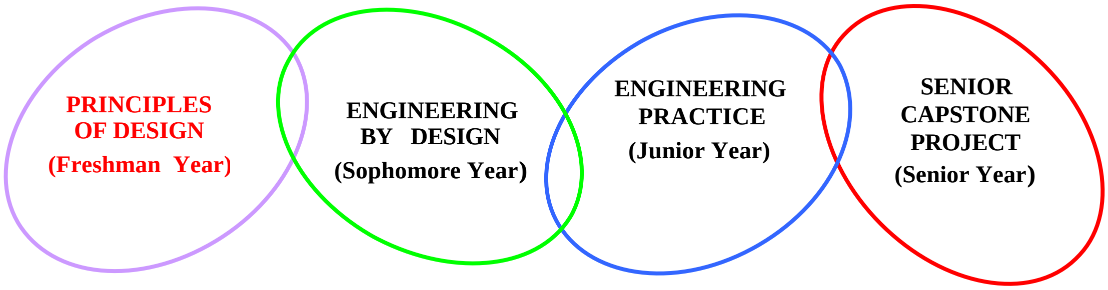

Figure 2: Design Oriented Courses through out the Curriculum

The ILB creates space and time for entertaining such ethics questions. Secondary benefits of this arrangement are due to the fact that non-engineering students bring a more universal vision of ethics and they, in turn, are introduced to the working atmosphere of engineers.

5. Engineering Practice:

The objective of the "Engineering Practice" course is to illustrate that most large projects involve a team of engineers of different specialties. The course introduces the students to social, economic and political considerations for such projects. A key aspect of the revised curriculum is practical experience. In both the sophomore and senior years, students are provided with an opportunity to work in teams on a "real-world" engineering problem. These experiences enable students to put their learning into practice while simultaneously bringing them into contact with industry mentors and the challenges that real companies wrestle with. An added advantage of these linkages with area companies is that it allows them to provide input into the curriculum and paves the way for job opportunities for engineering program graduates.

The senior year capstone project captures some of this real world element by both using industrial problems and having as a mentor the engineer who is part of the project team submitting the problem. The experience is made more real by requiring each student to be part of a project team consisting of from two to three students. What these project often bring out are the "art" of engineering. Students coming into the work place with such project experience are better prepared to deal with the uncertainties that accompany many projects.

6. New Design Courses:

6.1 Thermal System and Mechanical System Design:

This course provides dual track of design practice. The first part of this course prepares students for design practices associated with energy systems. The second part concentrates on detailed product design, which will include drawing, tolerancing, and probabilistic methods.

6.2 Senior Capstone Project:

Students' work independently on projects of advanced engineering design practice with no formal class meetings.

7. Conclusion:

This project has energized the College of Engineering by helping the faculty transition to new models of teaching and assessment – especially those that help to insure the success of women and minorities- and by redefining the relationship between instructional faculty and students and industry community. Our reform efforts have impacted 150 mechanical engineering students. Besides the faculty in the College of Engineering, this program has support from the faculty of the Business School and the College of Arts and Sciences as well as senior administrators. A design panel, consisting of faculty representatives along with the representatives from the industry, has been established to mentor and assess the design projects that have been created through out the curriculum.

The project has allowed the department of mechanical engineering to carry out some radical educational innovations throughout the four years of the curriculum. This curriculum model could be replicated in a cost effective manner, by other institutions large and small.

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