Melding Engineering into a Liberal Arts Tradition: 
A Unique Nine-Semester BS/BA Electrical Engineering Program

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Abstract: In 1986, the University of San Diego (USD) began an initiative to enhance the science portion of its liberal arts tradition. A new nine-semester program in Electrical Engineering was created as one of the flagship components of that initiative. Founding and building an engineering program, not only within a liberal arts university but also within a College of Arts and Sciences, presented a challenging set of objectives and constraints to the founding Electrical Engineering faculty. In particular, satisfying the extensive general education component at USD while fulfilling the needs of a quality engineering program presented an interesting set of tradeoffs. The resultant program is the only EAC/ABET accredited nine-semester course of study automatically leading to a dual Bachelor of Science and Bachelor of Arts degree in Electrical Engineering. The dual nature of the degree proclaims the breadth of academic experiences required of every student. This paper chronicles the first ten years of Electrical Engineering at USD: the growth from its first classes in 1987 to national recognition.

Introduction

In 1986, the University of San Diego (USD), in an effort to enhance the science portion of its liberal arts tradition founded an Engineering program as a component of its College of Arts and Sciences. Since most Engineering programs in the United States exist as separate schools or colleges within comprehensive universities, this unusual placement of the Engineering program challenged its founding faculty with an interesting set of sometimes conflicting goals and constraints. The resultant program is the only EAC/ABET accredited nine-semester course of study automatically leading to a dual Bachelor of Science and Bachelor of Arts degree in Electrical Engineering.

Background

The University of San Diego was chartered as an independent university in 1949. The College for Women, sponsored by the Society of the Sacred Heart, offered the first classes at USD in February 1952. This unit was joined by the College for Men, sponsored by the Catholic Diocese of San Diego, and the School of Law in 1954. Unification of the Colleges and Schools occurred in 1972. As the University matured, it added Schools of Business Administration, Education, and Nursing. Throughout its development, USD has remained committed to the ideals of liberal education, which emphasizes the potentialities of men and women as human beings and creatures of God. The cornerstone of the University's educational approach is "striving for academic excellence, strengthening the liberal arts tradition, and maintaining priority on effective teaching." In that vein, class size in all programs is kept small (typically under 30 students) and the use of teaching assistants is minimal: student-faculty interaction carries high value.

By 1986 USD had grown to approximately 5000 students and was in a period of introspective evaluation. One result of this careful self-evaluation was a goal to enhance the undergraduate science portion of its liberal arts tradition. The science component of the University was then comprised of two science departments: Biology (with nine faculty) and Physical Science (with five Chemistry and four Physics faculty). Among other components, it was decided to add to these existing science programs an undergraduate program in engineering. This program was attached to a department within the College of Arts and Sciences: a new department of Physics and Engineering. The program was also under the leadership of a "director" with a direct (but informal) link to the Provost/Academic Vice President.

The decision as to the field of engineering was developed with the strong participation of the San Diego corporate community, including the particularly valuable assistance of the USD Corporate Associates. While the temptation was great to attach engineering to one of the science fields already present and create a program in Engineering Physics, Biomedical Engineering, or Chemical Engineering, it was considered more advantageous to stay with one of the more mainstream engineering programs that would better fit the aerospace orientation of San Diego at that time. Specifically, Electrical Engineering seemed to be the best choice as a first program.

The development of the program was to be gradual, building from the bottom up and hiring one faculty member a year until the EAC/ABET minimum of four (changed to five in 1987) Electrical Engineering faculty was achieved. The first few faculty were to be experienced engineering
educators capable of developing a new program from the ground floor. As such, the first three faculty were hired in consecutive years (1986-88) and respectively had the following experience:

- a full professor, previously chairman of an Electrical Engineering Technology program, with prior experience in industry and as a TAC/ABET evaluator - the founding director of the USD engineering program.
- an associate professor with prior industry experience who had been active in the preparation for three EAC/ABET (or ECPD) accreditation visits.
- an associate professor, previously CEO of a San Diego engineering firm.

These three faculty had the major responsibility for development of the program, all the engineering courses, and setting the atmosphere for engineering at USD. It was hoped that the student population of the Electrical Engineering program would rapidly grow to reach a steady-state output of 20-25 graduates per year. While the possibility of additional engineering programs was contemplated, no specific plans for increasing engineering beyond a stand-alone program were made at that time.

**Fitting the Program into the USD Atmosphere**

All undergraduate students at USD participate in a rather extensive General Education (GE) program of 49-60 semester units:

I. Indispensible Competencies
   A. Written Literacy (6 units)
   B. Mathematics (3 units)
   C. Logic (3 units)

II. The Roots of Human Values
   A. Religious Studies – (9 units)
   B. Ethics & Philosophy (6 units)

III. The Diversity of Human Experience
   A. Humanities and Fine Arts (9 units)
      History, Literature & Fine Arts
   B. Natural Sciences (6 units)
      Both Physical and Life Sciences
      One lab course
   C. Social Science (6 units)
   D. Foreign Language (0-9 units)
      Third-semester competency
   E. Classic and Contemporary Issues (1-3 units)

The variation in USD’s total GE load is due to two factors: foreign language and Classic and Contemporary Issues. The foreign language GE requirement is a third-semester competency requirement: students may have adequate previous competencies that will allow for either partial or complete satisfaction of the requirement before entering college. The Classic and Contemporary Issues GE requirement (abandoned in 1990) was a course requirement: the courses could be 1, 2, or 3 units. Even with the removal of the math and physical science components, the remaining USD GE requirement of 43-54 semester units is 2.7 to 3.4 times the EAC/ABET minimum of 16 units in the Humanities and Social Sciences. In addition to the extensive GE course requirements, there is also a University requirement that each first semester freshman enroll in a preceptorial course that will “foster a supportive, interactive environment which regards all students as individuals.”

While the typical engineering approach might be to make all efforts to reduce the GE requirements for engineering students in order to make the program fit within the usual four years, that was not an option at USD. As an alternative approach, reducing the engineering requirements so that the program could fit within the normal eight semesters and still meet EAC/ABET requirements seemed nearly an impossibility. The founding faculty concluded that an engineering education strong in the liberal arts could prove to be extremely attractive to industry and was the best choice for engineering at USD. Such a program could produce a graduate who is both well-rounded and literate, as well as technically competent and current. A program that tailored the GE experiences to closely fit the needs of the modern engineer was the result. In that effort, the following adjustments to a normal course of study were made:

- An *Introduction to Engineering* course was created to satisfy the preceptorial course requirement.
- A course in *Engineering Communications* was created to satisfy part of the written literacy GE requirement.
- A course in *Engineering Ethics* was created to satisfy the ethics GE requirement.
- A course in either Math or Philosophy will satisfy the logic GE requirement.
- The social science GE requirements for engineers were increased to 9 units -- courses in Economics, Public Speaking, and Organizational/Industrial Psychology.
- The course of study in Engineering was increased to 9 semesters.

In order to compensate the students for the course load beyond that found at typical engineering schools, two atypical benefits automatically come with completing the course of study:

- A minor in Mathematics.
- A dual Bachelor of Science and Bachelor of Arts degree in Electrical Engineering.

The minor in math and the dual nature of the degree proclaim the breadth of academic experiences required of every student.
The program places emphasis on computer-aided engineering, electronic circuits, devices and systems, digital systems logic design, electronic communications, control systems and signal processing. It also contains a large laboratory component. In addition to the three laboratory courses in the first two years, the EE program includes weekly laboratories in ten upper division courses. These courses are taught by the same faculty members who teach the associated lecture section: there are no teaching assistants in Engineering at USD. Due to small initial enrollments, no elective courses exist in the program. A two-semester design project serves as capstone to the program. A listing of the typical course of study is shown below.

### Freshman Year
- **Calculus I** (4)
- **Calculus II** (4)
- **Intro to Engr** (3)
- **Comp. Aided Engr** (3)
- **Chemistry**<sup>1</sup> (4)
- **Physics I** (4)
- **GE** (6)

### Sophomore Year
- **Calculus III** (4)
- **Engr Math I** (3)
- **Physics II** (4)
- **Physics III** (3)
- **Engr Prog. I** (2)
- **Engr Prog. II** (2)
- **Statics & Dynamics** (3)
- **Electric Circuits** (4)
- **GE** (3)

### Junior Year
- **Engr Math II** (3)
- **Prob. & Statistics** (3)
- **Engr Materials** (3)
- **System Dynamics**<sup>2</sup> (3)
- **Energy Conversion** (3)
- **Electronics I** (4)
- **Microcomputers** (4)
- **GE** (3)

### Senior I Year
- **Comp. Aided Anal.**<sup>3</sup> (1)
- **Microcmptr. Systems** (4)
- **Electronics II** (4)
- **Control Sys. Design** (4)
- **Comp. Logic Design** (4)
- **Comm. Circuits** (4)
- **Engr. Comm.** (3)
- **Sr. Design Project I** (3)
- **GE** (6)

### Senior II Year
- **Sr. Design Project II** (3)
- **Digital Signal Proc.** (4)
- **EM Fields** (4)
- **GE** (6)

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<sup>1</sup> Originally, a 5-unit course designed specifically for engineers. Changed to the 4-unit course required of Chemistry majors in 1996.


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### Faculty duties and recognition

When the Engineering program director arrived on campus in 1986, his duties the first year were centered on curriculum development. While preliminary catalog information existed, no formal attempt had been made to develop a population of engineering students. Engineering classes began in fall 1987 with the arrival of the second faculty member. In that year, freshman and sophomore courses were taught for the first time. As the first class progressed through the curriculum, the appropriate higher level courses were taught for the first time. Due to the start-up transient, none of the first class of five students completed the program in the proscribed nine semesters: they all completed it in ten semesters: after the transient approximately one-half of the students complete the program in nine semesters.

Engineering course and laboratory development in an environment where none has existed before is a somewhat daunting experience. The original three faculty developed essentially all the engineering courses and laboratories in the program during a 3.5 year period: the director focused on the freshman courses and the senior design sequence while the other two faculty were primarily responsible for the more technical component of the program. As is the tradition at USD, all laboratories are taught by the faculty.

Laboratories were particularly difficult to develop. Aside from the usual financial constraints impeding the timely arrival of necessary, the absence of a historical cache of “odds and ends” created problems. Building a backlog of items such as wire, resistors, capacitors, inductors, transformers, transistors, etc. took time. Fortunately, local industry was quite generous and helped immensely with laboratory development. The program began with a single laboratory space in 1987 and now has three 10-station Electrical Engineering laboratories, each station of which has a full complement of test instruments and a computer loaded with engineering software.

The engineering teaching load at USD is significant: typically four lecture courses and three associated laboratory sections per year. With this large load teaching load and the heavy course development component of their workload, the founding engineering faculty were able to negotiate a significantly reduced research expectation in matters of promotion and tenure (now the start up phase is complete, scholarly activity is increasing). The faculty, however, felt that it was extremely important to make the University aware of the presence of Engineering. In that effort, Engineering faculty took it upon themselves to contribute significantly in the area of University service. The USD Engineering faculty have served on essentially every University and College of Arts and Sciences committee and is making its mark in the School of Business...
Administration: from the parking committee, to the Rank and Tenure Committee, to the University Senate.

Development of the remainder of the EE faculty suffered a temporary interruption with the fourth member: this member was only in residence for one year. The EE faculty development was then completed in the 1990-91 academic year with the hiring of three assistant professors (one more than planned and one more than the EAC/ABET minimum present at that time). All of the six initial EE faculty have received tenure: one of the original three founding faculty has recently retired and an experienced assistant professor has been hired as a replacement.

**Engineering Participation in the GE**

In order to establish a presence in the USD GE, the Engineering program has created with two courses: *Technology and Society* and *Introduction to Electro-Technology*. The first course was designed to satisfy the GE requirement in Classic and Contemporary Issues (CCI). As such it was one of the first of these courses on campus and enjoyed significant enrollment until the CCI requirement was abandoned in 1990. The second course satisfies a GE requirement as a Physical Science course. Convincing the College of Arts and Sciences that Engineers could teach GE Physical Science was a surprisingly difficult task. However, the course is now firmly established as part of the GE at USD.

**Recognition**

The Engineering program at USD requested EAC/ABET evaluation as soon as there were graduates in 1991. In 1992 full accreditation was granted to the Electrical Engineering program and has been applied to all graduates of the program. As one measure of the quality of the program, the 1996 US News and World Report survey of deans of Engineering schools in the United States, ranked Engineering at USD in the top 30 engineering schools without Ph.D. programs.

Engineering accreditation continues to be an issue of significance. An upcoming EAC/ABET evaluation of the Electrical Engineering Program in the fall of 1997, has delayed any significant reformulation of the engineering curriculum at USD to address Criteria 2000. It does appear, however, that the significant GE component of the USD engineering curriculum will be an asset when applied to the new criteria. Engineering at USD has defined itself and its goals well -- it has all the necessary components of engineering education specified in Criteria 2000. The major concerns of the faculty lie in the areas of “multi-disciplinary design” experiences and outcomes assessment. Demonstration of the ability of students to function in multi-disciplinary teams when a wide variety of engineering disciplines are not present will present a particularly interesting challenge. Similar challenges come with attaching appropriate significance to outcomes assessment tools and taking appropriate subsequent action when the number of current students, past graduates, and years of existence are all small.

**Recent Growth and Change**

After an initial spurt in enrollment, the student population leveled out at approximately one-third of the initial projections. While this was a cause of concern among the Engineering faculty, two changes seemed to have ameliorated the problem:
- The freshman sequence was revised to emphasize orientation to Engineering with a strong emphasis on Engineering Problem Solving and Design.
- A companion program in Industrial and Systems Engineering was initiated in 1996.

The first change was accomplished internally. The addition of a second engineering discipline, however, necessitated an organizational change. In 1995, Engineering separated from its union with Physics and moved the locus of its administration into the School of Business Administration. Engineering now exists as the only department in a school proud to have a structure without departments. Since the two changes occurred simultaneously, it is difficult to determine which is the dominant factor in increased freshman enrollment and essentially doubled student retention levels. Currently there are approximately 80 engineering majors, with a very steeply increasing trend line.

Long-range plans include the addition of a third engineering major within five years, eventual splitting from the School of Business Administration, and ultimately a School of Engineering at USD.

**Acknowledgment**

The author would like to acknowledge the efforts of all his engineering colleagues and the academic administrators at USD in building this program. The most significant contributors were: Dr. Thomas Kanneman (the founding director), and Dr. Robert Mertz.

**Bibliography**