EDITORIAL

Teaching Engineering Design – One University's Program

***Patrick L. Walter**, Contributing Editor*

Independent of the mold that we have each adopted for ourselves within the engineering profession (analysis, manufacture, controls, marketing, sales, test and evaluation, etc.), we are all part of the engineering design process. Our collective performance within this process is graded based on three criteria: (1) schedule – did we get the design completed on time; (2) cost – did we get the design completed within budget; and (3) delivery – did the resultant product satisfy our customer? Note that I said 'collective' performance, synonymous with team performance. It is interesting to note that during our formalized engineering training we receive our grades based primarily on individual classroom performance. This individual process is largely disconnected from the industrial world where we win or loose in teams.

Before I left industry for academia, it was my observation that during the late 1980s and the early 1990s the young engineers being produced in universities were well versed in computer skills but had little insight into the design process. Fortunately, large companies such as Boeing felt the same way and encouraged ABET (the engineering accreditation board) to require more design content in university engineering programs. Within Texas Christian University, as in most universities, we integrate design throughout our program. However, we are somewhat nonstandard in having created a three-semester, continuous electrical/mechanical interdisciplinary course sequence beginning in the second semester of the junior year. The intent of the sequence is to create both a concentrated design and a concentrated teaming focus. The description of the junior course as presented in my course syllabus:

"The goal is to assure that participating students understand the many contributors to the engineering design process and acquire the complimentary skills necessary to their science and technology based studies to help them succeed in the workplace. Not all of the following material will necessarily be comprehensively covered every semester. However, among materials that we have covered in the past are:

- Engineering economic analysis
- Budget estimating
- Reliability assessment
- Fault tree analysis
- Engineering ethics
- An overview of engineering design
- Product liability
- Risk assessment
- Safe operating procedures
- Needs analysis/specifications
- Feasibility studies
- Patents
- Decision making
- Project planning/scheduling/tracking
- Product testing
- Ergonomics
- Writing and presenting engineering material."

The junior students work largely in teams of 4-5. Recent assignments have been as diverse as developing a fault tree analysis for a fiber telemetry link, performing hazard analyses and writing safe operating procedures for handling steel gas pressure cylinders, performing feasibility studies to neutralize a well-defended hardened/deeply buried facility within an unfriendly country, performing a work breakdown structure and developing a GANNT chart for landscaping a yard, etc. Within bounds, the students can propose their own topic for each type of assignment. During the semester, selected speakers (e.g., patent attorney, certified program manager, financial analyst) compliment my lectures.

During their junior year, I enter both the students and the university into a contract with an outside customer for an electromechanical project for their senior year. The company and I jointly develop the specifications. Typically, this project is in the area of test and evaluation or control and relies heavily on instrumentation. Constraints in sizing the project are: number of students (typically 20 maximum), proper ratio of electrical/mechanical content to balance the class and project that can be completed by the students over a 2-semester period (their senior year). Over my 7-year tenure at TCU, customers (some more than once) have included Endevco Corporation; Bell Helicopter Textron, Inc.; RockBit International, Inc.; Alcon Laboratories, Inc. and the U.S. Army Engineer and Development Center Waterways Experiment Station (WES). The customer next year will be Lockheed-Martin Company and the task will involve work on their recently awarded program for the Joint Strike Fighter (JSF).

The first day of their senior year the students are handed the specifications for their specific project. During the first week of the semester they meet and query the customer to fully understand this specification. They have been prepared to nominate and elect a program manager. The program manager delegates lead electrical and mechanical engineers, budget manager, machine shop interface(s), drafting lead, technical editor(s), presentation manager(s), etc. Within a few weeks, the program manager is responsible for running the classes (now project meetings) for the remainder of the 2-semesters. I am available to consult when asked, as are other faculty members. The students have unlimited access to phone, fax, shops, work area (day and night), appropriate secretarial support and more. They present a design and cost proposal to the customer in November, place all their orders and put drawings in the shop before Christmas break and present their completed project to the customer, faculty, local industry representatives and their families in late April (150 people typically).

How do the students perform throughout the year? Not surprising, they fumble with communications, create project plans that are too dependent upon success, become testy with one another because the work load is not shouldered equally, display disappointment when suppliers miss promised delivery dates, procrastinate initially and then work hideous hours near project culmination.

Sound familiar? The difference is that the students are encountering these experiences as a requisite part of their educational process. While never required to, a number of students elect to work on the project during their Christmas and Spring breaks. As a faculty, we become concerned when some students spend as much as 60 hours a week on their project, and we attempt to assure that they also maintain a focus on their other classes required for graduation. However, this is part of the process of acquiring time management and work prioritization skills.

A brief summary of the current project from WES: the students are to 1) design and develop a portable dynamic field calibration system with digital readout for blast pressure measurements; 2) characterize the existing WES instrumentation/cable system; 3) design and develop upgrades to this system; and 4) design and build both a local digital recording and an electronic instrumentation system characterization capability. This work supports the WES mission to conceive, plan, study and execute engineering investigations and research and develop-

ment studies in support of the civil and military missions of the Corps of Engineers and other federal agencies.

How are they graded on these projects? They perform peer evaluation, i.e., they grade each other. Each student has a closeout interview with me, provides a grade for each of their peers and provides one or two sentences of professional feedback for each individual evaluating the job that they have accomplished. This written feedback is compiled anonymously, the grades averaged and the package is provided to each senior student. Thus, they receive not only their grades but also the rationale behind them.

Does the program succeed? Each class seems to raise the standard higher for the one behind them. Last year the program was fortunate enough to win the *Design News* National College Design Competition sponsored by ANSYS Corporation. This resulted in $20K and other awards being presented to TCU's Engineering Department at a black tie dinner in Chicago last March. However, the success of the program can best be evaluated by the quote of one of our students from last year, also a former TCU football player and now a Lockheed-Martin employee. "It doesn't matter if one person gets an 'A' and another a 'C.' If you don't get the project done, you've all failed."

The author can be contacted at p.walter@tcu.edu.