TEACHING CORPORATE CULTURE – AN ENGINEER'S SURVIVAL GUIDE

Richard N. Savage
Associate Professor
Materials Engineering, Cal Poly State University
San Luis Obispo, CA 93407 USA

ABSTRACT

The transition from new engineering graduate to successful member of corporate America is a difficult journey. Often the skills required are not part of a student's traditional undergraduate education. At Cal Poly, we have integrated a new course into our existing Senior Project curriculum which enables students to develop the professional skills necessary to become an effective member of any corporation. Key skills such as communication, problem solving and project management are practiced through active learning techniques. These as well as other topics studied are required for ABET certification.

The new course investigates the mission and values that are at the foundation of any corporation's culture. It challenges students to evaluate their own personal leadership potential. Organization structures along with the roles and responsibilities of Engineering, Marketing, Sales, Operations, Finance and Executive management are studied along with the interdisciplinary nature of engineering and technology. The rigors and metrics of a typical product development methodology are explored along with the concepts of program management and the protection of intellectual property. Business models are studied which enable students to evaluate the impact engineering can have on a company's financial success. Moreover, the students learn that they are members of a global community with environmental and social responsibilities. The impact of technology on society can be profound and students are challenged to consider difficult ethical issues as well as exciting career opportunities.

ARE ENGINEERING UNDERGRADUATE STUDENTS EQUIPPED FOR SUCCESS

In 2002, approximately 67,000 engineering undergraduate degrees [1] were conferred. Approximately 80% of these graduates will enter the industrial sector straight from their respective Universities [2]. As educators we must ask ourselves, are these students equipped for success in the corporate environment?

Based on my 20 years of experience in the high technology industry sector and the feedback we have received from our Industrial Advisory Board (IAB), the answer would have to be "not exactly". While most newly hired engineers have a solid foundational knowledge of science, math and engineering principles, few have adequate knowledge of how to practice engineering within the corporate environment. Our IAB committee has identified that most new college graduates do not understand the interdisciplinary roles of marketing, engineering, operations and finance; they do not understand the interaction of these groups during the process of product development. In addition, the students are deficient in problem solving, communication and project management skills. In an effort to address these issues, insure that our curriculum meets ABET Criteria 2000 and, most importantly, give our students a competitive edge, we have integrated a new course entitled "Corporate Culture" into our Materials Engineering program.

WHAT'S MISSING & HOW DO WE TEACH THESE TOPICS

This presentation will outline five key areas that are addressed by this new course and discuss the critical pedagogy employed that enable our students to develop both an understanding and confidence in practicing these skills in real industrial situations. At Cal Poly we utilize the "learn by doing" approach and in this course we employ active learning, by requiring students to adopt real corporations as role models for each of the topics studied; these Companies cover the range from large public institutions to small startups. Students are organized into several company groups and topics are researched and discussed within the groups and across the entire class. Results and conclusions are organized into summary reports and written in memorandum style.

Corporate Mission & Values

In order for any new engineer entering the work force to find a successful fit with their skills and personality, it is important to understand the Corporate Mission of the potential employer [3]. By identifying the values (e.g. integrity, honesty, excellence, citizenship, respect, teamwork, etc.) and leadership style practiced by the company and then matching this up with one's own personal goals and values, an engineer can establish a more realistic foundation for choosing an employer. It is important to identify the value proposition of the company (the value their products give to their customers), understand the company's financial goals (IPO, profitability target, revenue growth, merger or acquisition) and identify core technologies. All of these factors should be considered when an engineer accepts a position, not just the title and starting salary. Each student is asked to research and identify these principles for their adopted model company and then write a memo outlining how this company would match their own personal goals and values.

A team building exercise is conducted to promote communication and practice leadership skills among the company teams. The exercise centers around building a Lego® model by sending team members into a separate room to visually observe a completely assembled model, then report back to the team enough information to reconstruct the model.

Organizational Structures

An organizational chart outlines the hierarchy of a company and also reflects the management style of the executive leadership; flat structures can lead to micro management while functional structures can lead to silos and empire building. Students study the differences between functional and matrix organization, as well as hybrid structures. The basic roles and responsibilities of Executive Management, Marketing, Engineering, Operations and Administration (Finance, Human Resources, Facilities and IT systems) are explored. The interdisciplinary nature of Product Development Engineering and the emphasis of the role of Systems Engineering are discussed. Moreover, the fact that there is not a title on the organizational chart labeled Materials Engineer is quite surprising to most students. The balance of emphasis between Research and Development, as a function of company size and market

maturity are discussed, once again utilizing their adopted Companies as role models. The students are then asked to interview a member of our IAB and outline the organizational structure for the IAB member's company. The students are then assigned one specific engineering role (e.g. Applications Engineer) and asked to write a memo describing a typical day for someone in this position (activities, responsibilities, issues, travel, meetings, management and/or technical responsibilities, etc.).

Product Development Methodology

The students study a typical seven-phase product development methodology, defining the objectives and deliverables from concept-to-alpha-to-beta and through release to manufacturing. They are introduced to the rigors and metrics of design reviews and the practice of project management. The deliverables of engineering during a product's entire life cycle, as well as the environmental, safety and reliability responsibilities of professional engineers are studied and discussed.

Shrinking time-to-market issues are being emphasized as we enter the Nanotechnology era. For example, carbon nanotubes were discovered in 1991 and by 1995 their potential as excellent field emitters was recognized. By 2000 nanotube-based light sources ("jumbotron lamp") exploiting their field emitter properties were introduced as commercial products [4]. By comparison, the time period between modeling the semiconductor properties of germanium (1931) and the first commercial Ge transistor was 23 years. In order for engineers to be able to keep up with such rapidly changing technology, it is imperative that they learn to follow a very disciplined product development and proliferation process.

Students at Cal Poly are required to complete a senior research project. This affords us an excellent opportunity to practice project management. They develop a project plan including a statement of work with clear goals and objectives that define success for their project. Their objectives are scrutinized using the SMART principle (Specific/Measurable/Attainable/Realistic/Timely). The projects are then broken down into serial or parallel tasks which are outlined using a Gantt chart and an overall roadmap with key milestones is developed by each student. The students learn to prepare a technical risk analysis with contingency plans for the highest risk areas. Finally, a budget is prepared for approval by the faculty advisor. The entire project plan must be approved before the students begin any design or characterization work. Several design reviews are conducted over the course of their year long project and progress is assessed by their peers and a faculty member. At the conclusion of their projects, the students must present an oral report to a review committee comprised of faculty and IAB members and a final written report or publication is required.

Intellectual Property

Understanding how to protect a company's Intellectual Property through the use of trade secrets, patents, trademarks and copyrights is reviewed. The protection afforded by these devices and the costs associated with filing and mounting a legal defense are discussed. Typically, the overall budget for filing a US & International patent is approximately $100K. The process of writing a patent disclosure and the journey from application to final acceptance by the examiner and granting of a US patent are studied. Key elements of any patent include 1) describing the best method for practicing the invention, 2) describing alternative embodiments and advantages

for the new invention, 3) reporting experimental results that validate the concept(s), 4) reviewing and disclosing prior art, 5) properly documenting the invention date and 6) deciding who are the inventors [5]. The students learn to use the USPTO website and investigate patents held by their adopted Companies; they then identify the legal claims of the patent and discuss their impact as a blocking or fundamental concept patent. Strategies for licensing or blocking competitors are discussed and summarized in a memo that each student writes to the CEO of their team's company.

Business Plans

Understanding the basic financial language of industry is important for any engineer. With most US Company's placing an emphasis on productivity and profitability, every employee must understand their impact to the bottom line. Most corporations develop an annual operating plan (AOP) which outlines the company's strategy to achieve revenue and profitability goals for the current fiscal year. Each business unit of the company can then formulate a tactical product line plan detailing revenue, cost of goods (COG), operating expenses (marketing, engineering & administration) and capital investments. A 3-5 year plan will show net income (profits or losses) for each quarter along with cash flow requirements. From this a return on investment (ROI) analysis can be completed which will determine if the investors (stockholders) will launch, continue or terminate a new product line.

A typical product line business plan model with realistic numbers and percentages for a high technology product is given to the students in each company team. They study the impact of several typical scenarios such as 1) a 10% increase in the COG, 2) product introduction delay of 6-months, 3) average sale price (ASP) is reduced by 10% due to competition and 4) the impact of a 10% cut in operating expenses through a reduction in force (RIF). The direct impact that each engineer can have on the success or failure of the corporation is discussed.

HOW CAN WE MEASURE SUCCESS

We hope the impact of this course on the success of undergraduate engineers entering the industrial work force will be significant, but it will be difficult to quantify. There are several metrics that we plan to utilize to evaluate our progress:

1. The IAB interviews our senior students each Spring and provides feedback to the faculty on the strengths and weaknesses of our program, along with suggestions for improving the curriculum.
2. The impact of utilizing project management techniques and design reviews should lead to a higher percentage of senior projects being completed on-time. In addition, the overall quality of the presentations should improve (senior projects are presented to a review panel including IAB members and faculty).
3. Feedback from alumni 1, 3 and 5 years after graduation, will be polled through a survey.

Ultimately, the success of this course will be measured by our ability to continue to attract top level engineering students to Cal Poly, their ability to find employment in their field of study and an increase in the number of Companies recruiting on our campus.

CONCLUSIONS

As we enter the Nanotechnology era, the skills required by undergraduate engineering students to succeed in industry are growing. Companies can no longer afford 9-12 month new graduate orientation and training programs. Time-to-market for new product introductions are decreasing. The traditional engineering curricula provide an excellent foundation of science and technology but we believe courses of this nature can supplement this with the skills necessary to practice applied engineering in the corporate environment.

REFERENCES

1. ASEE Profiles of Engineering and Engineering Technology Colleges, 2002 (website www.asee.org) p. 30.
2. J. Ross, presented at the 1997 IEEE Computer Society International Conference on Microelectronic Systems Education, Arlington, VA, 1997 (unpublished).
3. T. J. Peters and R. H. Waterman, in *In Search of Excellence – Lessons from America's Best-Run Companies* (Harper & Row, New York, 1982) pp. 13-15.
4. *National Nanotechnology Initiative Report: Research and Development Supporting the Next Industrial Revolution*, Supplement to the President's FY2004 Budget, (National Nanotechnology Coordination Office) p. 6.
5. *Intellectual Property: Guide for Engineers*, edited by M. Goldsmith (ASME Press & SPIE, New York, 2001) pp. 5-12.