Session: 2642

Engineering Management as the Fifth Year

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Abstract. Undergraduate engineering enrollments continue to be disappointing. Increased specialization in a forty year old format isn't working. A global economic world isn't reflected in our programs. Santa Clara has developed a Master's in Engineering Management to fill the knowledge gaps. This fifth year could become the capstone to a five year, first degree program leading directly to the master's degree. Technical and business systems are addressed, a multi-functional team experience is provided, plus room for more technical courses.

The Declining Influence of Engineering

Freshman enrollments in engineering have been relatively flat during the past 15 years, and have increased only 15% above 1955 levels.(1) In the meantime, the U.S. population has grown over 60%. For many, the computer has become a household appliance. Fielded by explosive growth at software companies, technology has mushroomed into the nation's second-largest private industry, behind only health care. (2) Is it possible that engineering is viewed as a second-tier career, with limited lifetime opportunities, and with a ceiling on corporate promotional opportunities. Engineering still draws the best and the brightest to the university. But many may ask, why pursue what is frequently viewed as the university's most difficult undergraduate program, when an undergraduate business degree is much less stressful, and is a good preparation for an MBA, and corporate careers.

This is a proposal that a master's degree, similar to that offered in Engineering Management at Santa Clara, become the terminal engineering degree awarded at the end of the fifth year. While the B.S. could be earned by those who wished to leave early, it would be viewed as only partial preparation for a lifetime career. A broader professional education would be the five-year goal. Four-year technical professionals will still remain in demand because their narrow

specialization will meet industry's immediate needs. High initial specialization and employability, does not necessarily meet the individual's long-term career needs, where there is a need for a better understanding of the cross-functional requirements of the profit seeking enterprise. To compound the problem, the primary responsibility for lifetime careers has moved from the firm to the individual. Individuals should anticipate a sequence of several employers in their longevity induced, fifty to sixty year careers. In this employer sequence, there must be congruence between the individual's value-added contribution, and the goals of the firm. A fifth year will help develop congruence.

A Fifth Year

There is declining room in the four-year degree program to accommodate all of the classical topics, plus the rapidly expanding pool of new knowledge. As a consequence, the engineering degree unit requirement generally exceeds that of the other colleges. An already difficult program is made longer. There have been earlier attempts to make the undergraduate engineering degree a five year program. Outstanding institutions such as Ohio State, Cornell, and Minnesota were among those who sought this goal. They encountered enrollment resistance from students who felt that they could earn a similar title, in four years, at a reduced personal cost. Now is the time to develop an attractive five-year package, and grant the master's degree as well. Recent data suggests that even though undergraduate enrollment is flat, graduate level enrollment continues to climb. (1) This change would therefore not be going against the tide. We have been developing a five year package at Santa Clara, and this is a report of our experience.

The Santa Clara Program.

The goal of the Santa Clara Engineering Management and Leadership program is to support the development of technical managers. We do not seek to compete with MBA programs that address general management. While their ultimate goal is to create CEO's, ours is the Chief Technology Officer assignment. To this end, we require that half of the Engineering Management degree units be devoted to a technical stem, drawn from the other engineering programs. The remaining units are in management-related studies. Our students are primarily full-time employees of Silicon Valley firms, who attend graduate courses from seven to nine in the morning, two or three days a week. We utilize a mix of full-time university faculty, and part-time industry adjuncts. There is no thesis requirement. Over a thousand students participate in the engineering graduate program which includes degrees in Applied Mathematics, and Electrical, Civil, Mechanical, and Computer Engineering. Two hundred of these students are in Engineering Management and Leadership.

Engineering Management or an MBA?

When developing the program, we took our cue from Lockheed Missles and Space Systems, a large employer in the Silicon Valley. For the first five years of employment as a technical professional, Lockheed would not pay the MBA tuition. They said that if you were hired as an engineer, they would prefer that you focus on your technical skills. This led to our concept of a unique program for engineers that would enhance their technical capabilities, and at the same time, would strengthen the candidate's ability to assume technical leadership roles.

MBA Classes for the Management Stem?

Santa Clara's Business School started its evening MBA program at the same time Engineering began morning graduate courses for the employed engineer. When considering the use of MBA courses for the Engineering Management stem, we encountered a number of constraints. The first difficulty was that the MBA students were granted enrollment priority, as you might expect. Engineers were placed on wait lists, and frequently no class openings occurred. A second, and more important hurdle, is the limited time engineers have available for electives. The MBA sequence frequently encourages study in some depth, accounting, for example. Engineers do not wish to spend too much time in one subject area. A sequence was therefore tailored for engineers. Finance, accounting and budgeting are included in two, two-quarter unit courses. This is much too concise for MBA students.

Content of the Engineering Management Stem

There appears to be no common course pattern for the over one hundred Engineering Management master's programs in the U.S. Each institution has different goals. At one end of the spectrum are those programs that seek to identify a new engineering specialty. Many of these have a strong operations research flavor. Other programs were developed from an Industrial Engineering base. Since Santa Clara's Applied Mathematics program includes modeling and optimization, and the statistics related to quality management, we chose the other end of the spectrum, to focus on management, leadership, and the expansion of business system understanding. We seek to enhance the ability of technical professionals to assume leadership positions. This includes self-leadership for career development, and group leadership for project implementation.

Business Systems Understanding.

Engineers are frequently accused of feature creep when they embellish a product beyond the markets' willingness to pay. In a turnaround situation at Telex, a manufacturer of heavy, off-the-road trucks, CEO Ronald DeFeo fired half of the engineering department in order to simplify the product line. Sales rose immediately as price-performance improved in the eyes of customers. (3) Our discussion of business systems at Santa Clara begins with multinational firms since they embody all of the forces that buffet today's organizations. The national and

regional economy is reviewed. Most of our students, who have attended engineering schools around the world, have not had formal economics courses in their undergraduate programs. The course in the marketing of technical systems attracts many who are considering redirecting their careers. Our goal is to increase each person's sensitivity to the breadth of forces that impact on even the most minor technical decision. We seek to reduce suboptimization. We seek to encourage the seamless organization that accommodates the needs of R&D, design, manufacturing, marketing, and the post-sales, service and support activities. This is really a focus on product life cycles and their influence on technical decisions.

Leadership.

We have added Leadership to the Engineering Management banner to reflect what is happening as organizations move from vertically structured hierarchies, to the horizontal structure of networks. This is a transition, with different firms occupying different positions on the hierarchy-network spectrum. Individuals must be aware of these differences as they develop a leadership style appropriate to their situation. As empowerment shifts responsibility lower in the organization, individuals must also assume greater responsibility for their own welfare. Self-leadership becomes increasingly critical. The growth of global firms, and global interconnectivity, means increased individual isolation in global networks. The other team members may be located in several other countries. Making a value-added contribution means not only contributing to the solution of technical problems, but also to optimize these decisions considering the enterprise as a whole.

Collaboration.

The need arose ten thousand years ago, when formal agriculture, and the establishment of villages, encouraged specialization of labor, and the trading of product and services. Increased interdependence was the result. To really make it work, cooperation, or better yet, productive collaboration, is required. Higher level synergy is then required to address problems of greater complexity. Individuals are simply unable to achieve innovative solutions, working entirely alone. If they do have the talent, they lack time. Shared expertise is the answer. We believe collaboration can be learned in Collaborative Action Learning groups, or COACTION. COACTION began as Action Learning when developed by Reginal Revans as a manager development program. (4) We have added collaboration to this title and we teach facilitated group problem solving, to provide the structure in which more effective collaboration can take place. In this approach, a group of 7 or 8 produces a fully integrated paper, a paper that reads as though it is written by one person. This is in contrast to the normal group production that reads like a handbook with seven or eight, non-integrated, chapters. The role of facilitator is rotated each week. The facilitator prepares the agenda for the following week. We had one group that was totally Internet wired for group collaboration by one of the members who worked in the collaboration industry. Collaboration was stressed. However, they had trouble getting members to answer their EMAIL. Finally, in desperation, they met live, at a dinner meeting, to accomplish in a few hours what six weeks of wired group activity had failed to

achieve. The output of these projects is graded, and each member of the group does an assessment of the contribution of the other group members. This includes written feedback sheets for each of the participants. The willingness to work in these groups appears to relate to what we have labeled "a coalition attitude".

A Coalition Attitude.

Our society has evolved through millions of years in which survival depended upon hunting and gathering of daily food. Communities and their interdependencies are only a few thousand years old. It is possible that we are still not naturally adapted to pulling together. Collaboration, however, is the basis for the higher standards of living we enjoy today. A coalition attitude recognizes that it is in the best interest of individuals to sublimate their individualistic attitudes, in favor of collaboration to reach higher level group achievement. "A rising tide raises all boats". In our courses, we select projects that no one person could possibly achieve in ten weeks. They find out that a group can. We hope that the need for a coalition attitude becomes more apparent by participating in successful achievement. To improve group interaction skills, we teach facilitated group problem solving.

Facilitated Group Problem Solving.

While most meetings are conducted by the person who calls them, often a manager, the Interaction Method of holding meetings uses a facilitator to orchestrate the meeting process. (5) One goal is to enhance innovation in the problem solving process by removing the strictures that a manager can place on a group. In addition to the facilitator, one person serve as a scribe, recording "public minutes" on sheets of paper, for all to see. These minutes become part of the facilitation process when the facilitator refers to them to check progress, and reduce duplication. The process objective is not only to make the meeting "more effective", but also to enlist participant ownership in the group achievement. In our normal two-hour course meetings, it is often possible to spend the final thirty minutes working on a real-time problem proposed by one of the class members. Collaboration to achieve synergy is that elusive realization of the human potential of experts supporting one another in a constructive manner. It is possible that effective collaboration is the limiting factor, in next level achievement, in a wide variety of activities.

The Santa Clara Management Stem

Over twenty years, the following courses have remained attractive to the students enrolled in the program:

Global Economic Systems and Multinational Firms
Self and Group Leadership
Project Management
COACTION: Facilitated Small Group Problem Solving

The Business Environment
Accounting and Cost Control
Marketing of Technical Systems
Finance and Budgeting
Project Planning--Risk Management
Management of R&D
New Product Development
Strategic Technical Management
Managing the Software Development Process

A Summary of Program Objectives.

Our first and primary objective is to broaden the perspectives of engineering graduates. Yes, they will have to sustain a technical competence in their careers, but their problem solutions must include the larger, ambient systems in which they will be nested.

We seek to do this without competing with MBA programs. We are not preparing for general management positions. Our graduates will retain their technical involvement, though they may aspire for some of the newer corporate positions such as Chief Technology Officer.

We seek to influence attitudes, such as adapting to continuous change, while creating new knowledge. Change cannot be resisted, and they must address greater complexity in organizations that are globally competitive.

We anticipate graduates working in networks as organizations must move from top-down, vertical hierarchies, to flatter, horizontal, relationships. This means working on multifunctional teams made of experts drawn together based on their potential contribution to the problem at hand.

COACTION, our name for Collaborative Action Learning, focuses on facilitated, small group problem solving process. It can be used in lab groups or any other kind of meeting. It also provides an opportunity for the facilitator to practice leadership, an opportunity that does not arise frequently, in our programs.

The four year/five year engineering degree program debate is not a new one. Previous five year attempts failed because they only offered a B.S. degree while requiring a year more of study. A fifth year leading to a master's, and added preparation for professional careers, is an attractive alternate.

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