Involving Industry in the Design of Courses, Programs, and A Systems Engineering and Engineering Management Department

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ABSTRACT

On July 1, 2000 Stevens Institute of Technology created a new Systems Engineering and Engineering Management (SEEM) department. Through a unique partnership with industry and selected government agencies in the area of short courses, graduate programs, and applied research, the department has grown to over 60 masters and 30 PhD students in one year. In terms of revenue from short courses and off campus programs, the department is now second within the school of engineering.

This paper will provide the details and lessons learned of how we designed, marketed, and executed three non traditional certificate and masters programs and two PhD degree granting programs centered on technology, engineering, systems, and management. Partnership with industry and government agencies within key market domains was the cornerstone of our strategy. At the strategic level we will discuss ideas on how to target market large employers of engineers, attracting faculty, balancing resource allocation for income activities versus break even or money losing activities such as research and undergraduate education, partnering with traditional engineering departments, the role of web based learning, and most importantly managing expectations for growth and income. Other seemingly trite yet important issues such as the naming of programs, how to best utilize web versus hard copy for marketing information, the role of an advisory board, and how to create the environment of mutual beneficial existence with the traditional engineering departments will also be discussed.

This paper, though hardly a road map for creating new programs or a department, will provide insight to the thought processes and steps needed to create modern and relevant programs to educate engineers in the 21st century.

INTRODUCTION

Few educators will argue that the face of engineering education is changing. In response to a number of socioeconomic factors, the number of engineering students is declining (see Figure 1). Furthermore, those that are remaining are entering computer/technology related programs, creating tremendous growth for these programs. Unfortunately, this has often been at the expense of the traditional engineering disciplines. Numerous traditional programs are being eliminated to free up resources to support the growth of technology and non-traditional programs.

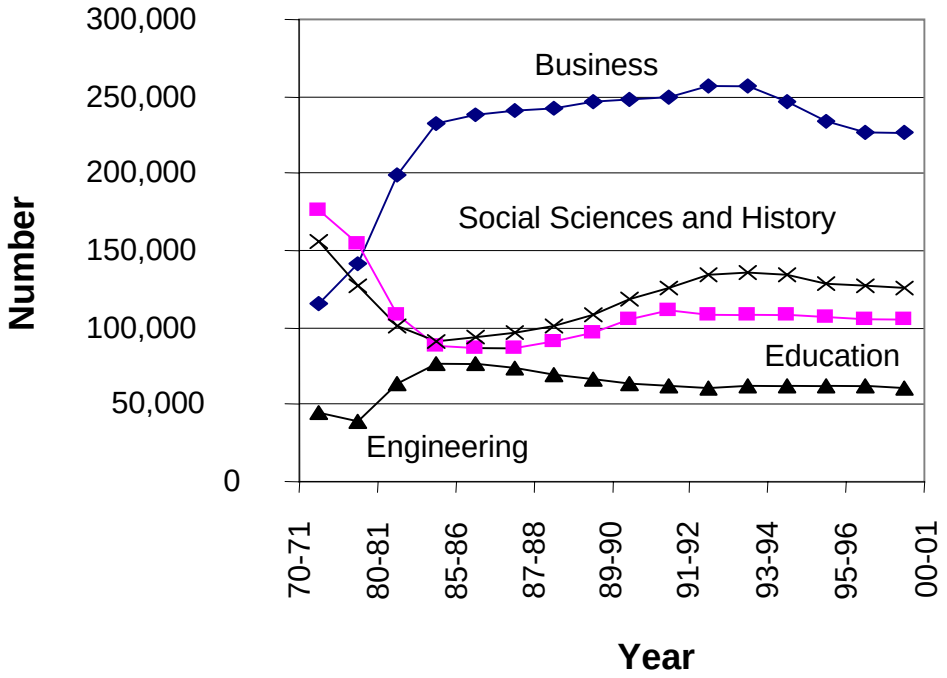

Figure 1. Four largest categories of degrees awarded since 1970 [1]

With exception of the large, usually state supported, Research I universities, many engineering schools are developing non traditional programs to compliment computer/technology related programs that are designed to:

- increase enrollments,
- compete with business schools,
- be more entrepreneurial in their focus,
- produce graduates who are strong in the "soft" skills and therefore more relevant to todays industry needs, and
- produce engineers who are employable in the growing service-based US economy.

Another important factor is that traditional engineering programs are resource intensive. Laboratory space, technicians, equipment, small class size requirements (especially for design classes) and supplies make the cost per student significantly greater than the typical business or humanities student. Most courses in management and systems can be taught to large classes, with minimal infrastructure, and are readily ported to distance learning platforms such as the web and DVD. Engineering management type programs are the largest group of these non-traditional programs and has experienced tremendous growth over the last 20 years.

According to Farr and Bowman[2], at least 84 universities have created graduate programs in Engineering Management. An IEEE paper[3] suggests that this number is closer to 150. Depending upon your interpretation of engineering management, the actual number could be approaching 200 engineering management type programs in the U.S. Combined with the growth of Systems Engineering programs, this explosion in sheer numbers can be attributed to many

complex factors. For example, the information age has produced problems that are increasing complex and distributed, interdisciplinary, and economically driven. As shown in Figure 2, the competitive global market and technology now requires that young engineers be able to work at the interface between engineering and management and serve as either managers of technical organizations or key systems integrators. To remain relevant and competitive, many schools are trying to reshape traditional engineering programs or start non-traditional programs to generate funding (mainly tuition based income), remain relevant, and respond to industry demands for engineers with stronger "soft" skills to complement the strong quantitative and analytical competencies[4,5]. Other key issues contributing to this growth is the diversity of the typical incoming freshman, zero true growth of most engineering salaries, and most importantly the perception that the type of work performed by an "engineer" has limited upward mobility when compared with business majors, lawyers, and other professions that are more applicable to the manufacturing, information technology, financial services, and consulting industries.

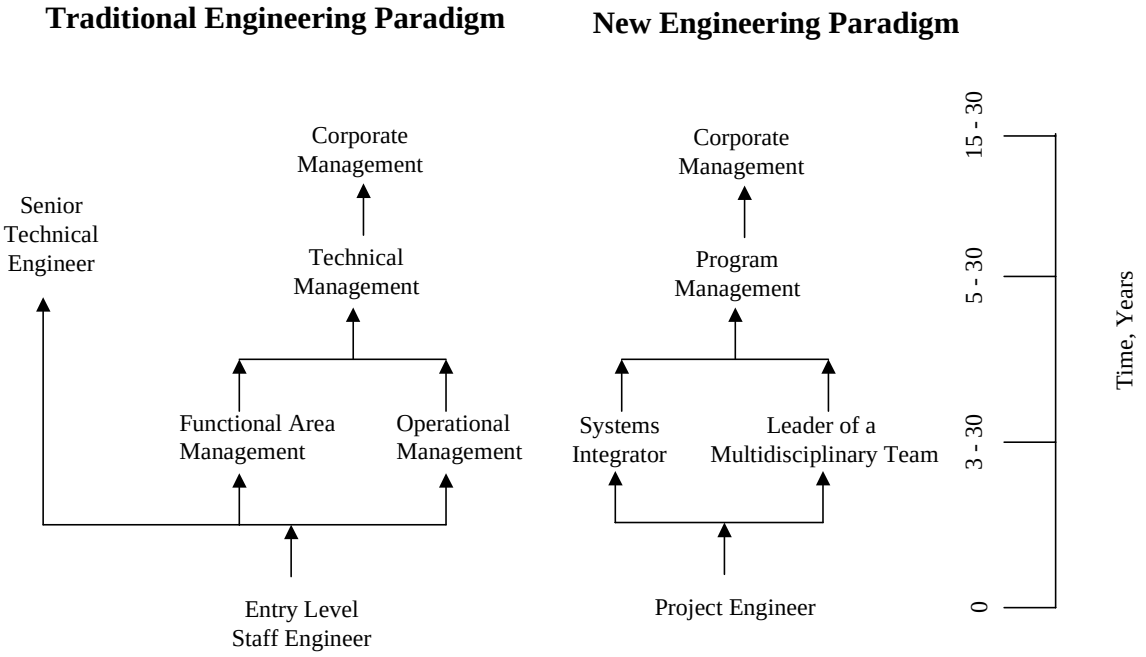

Figure 2. Traditional versus new engineering paradigm[6]

In July of 2000, Stevens created the Department of Systems Engineering and Engineering Management to respond to the changing customer needs for both undergraduate and graduate engineering education. This paper will provide the details and lessons learned of how we designed, marketed, and executed three non traditional certificate and masters programs and two PhD degree granting programs centered on technology, engineering systems, and management with industry partnership as the cornerstone.

WHY AND WHAT IS SYSTEMS ENGINEERING AND ENGINEERING MANAGEMENT?

Stevens Institute of Technology is a small private school located in Hoboken, New Jersey directly across the Hudson River from the financial district in lower Manhattan. Combined with the telecommunications and pharmaceutical centers located in New Jersey, Stevens was ideally suited to take advantage of the regional industries. More importantly, no other university in the area offered a systems engineering program and only one other regional university offers an engineering management program.

We chose to separate the department into two distinct but related disciplines: systems engineering (SE) and engineering management (EM). When the department was formed the university had a renowned undergraduate program in EM. However, no graduate programs existed. We chose to develop our graduate programs using the career model shown in Figure 2. In lieu of competing with the MBA programs, we chose to focus on the engineer who was 3 – 5 years out of their undergraduate program who was still actively engaged in some technical pursuits.

Systems Engineering and EM are complementary programs in that they appeal to varying audiences. Systems Engineering as a discipline offers significantly more research opportunities than EM. Yet EM is more marketable for continuing education than SE because of its strong management component. As will be a theme for this paper, research and revenue generation must occur simultaneously for a department to be successful. A well designed SE and EM program provides many synergies to include overlaps in content and complimentary research areas.

Each university has its own flavor of SE and EM. In a 1990 survey conducted by Virginia Tech, 78 graduate programs were identified as being listed in the "systems engineering" category[7]. Of these, 73 were in the U.S., with most programs addressing SE in the context of a functional discipline such as electrical, industrial, or manufacturing, and offer degrees with the nomenclature aligned with the functional discipline. Nineteen of the 73 graduate programs in the U. S. offered MS or ME degrees in SE and of these 11 had disciplinary affiliations, with 5 in Electrical Engineering and or Computer Science, 3 in Industrial Engineering, and 3 in other categories (Aeronautics, Information Systems, and Mechanical Engineering). According to this 1990 survey, only 8 programs in the U.S. appeared to offer an interdisciplinary education focused on systems engineering. While a subset of these 8 offered courses in design methodology, none offered significant focus on system reliability, maintainability, and supportability, or the related issues of system operation, maintenance, and logistics. Only two of the eight programs offered electives on subjects related to logistics support and supportability engineering. Using this study and input from numerous potential industry customers, we chose to develop an SE program that is rooted in complex system design methodologies, principles, and concepts. The objective of the program is to inculcate skills associated with abstract program solving to address design synthesis; and to address the quantitative modeling, simulation, and optimization techniques for design analysis and evaluation. Furthermore, the educational experience of the students includes an explicit and formal focus on system reliability, maintainability, and supportability in equal measure.

The content of EM programs also vary greatly. Many are simply management programs taught in conjunction with the business school using adjunct faculty. However, most have their roots in traditional industrial or manufacturing engineering and offer limited management content beyond project and operations management.

COMPONENTS OF A SUCCESSFUL DEPARTMENT

The First Step – Revenue Versus Research

Any EM department head will tell you his/her greatest challenge is to not be the "cash cow" for the university. There must be a balance between research initiatives and educational programs. Table 1 is a comparison of two types of department models. Most academicians would like to work in the traditional Research I type university because that leads to research funding and publishable research – the traditional performance metrics. Unfortunately, the education-focused department doesn't readily support these activities.

Table 1. Comparison of education versus research centric department

Traditional Research I Type Model	Continuing Education Focused
- Generates revenue from research	- Generates revenue from teaching
- Graduate programs focused on technical depth/teaching	- Graduate programs focused on continuing education for practitioners
- Full time students are research/teaching Assistants	- Students are mainly part time and work full time
- Delivered in a classroom environment	- Delivered using many methods

Demonstrated growth and potential are key for resource allocation within any university. Thus, we chose to initially pursue off campus programs to justify hiring more faculty and to grow the infrastructure. Because of our growth, our administration allowed us to hire four new faculty in 2000-2001. We plan to hire two more faculty in 2002. We have also received institutional funding for research laboratory facilities.

Other Lessons Learned

Below is a summary of other lessons learned during the last 1½ years in creating a new department.

- The promotion and tenure system does not support activities typical of the traditional EM faculty. Funding and refereed papers are still the performance paradigm for most (all?) universities. Because most SE/EM research grants do not need laboratory equipment, the funding is often significantly less than the traditional engineering programs. Also, since most SE/EM problems are applied in nature (all of our current funding at Stevens has come from private industry), writing refereed publications can be difficult.
- You must build alliances with the traditional engineering departments. Outside of computer and electrical engineering, few engineering schools are increasing the number of faculty. Any reallocation of resources to support growth in a non-traditional program is usually at the expense of another program/department. We are currently working jointly with our chemical engineering program to develop a master's degree for managers in the chemical processing industry.
- You need an undergraduate program to legitimize any SE/EM program. To be successful and an equal with the other engineering departments, you must have all of the traditional

components of an engineering department to include undergraduate program, research, laboratory facilities, a professional society, library, and an on campus masters and PhD program.

- You must have a distance learning master plan that stresses quality over quantity. Few will argue that this is the future of education. However, a poorly executed distance-learning program will negatively affect the perception of a program and the university.
- There is a tremendous difference in quality needed for corporate short courses versus the traditional graduate courses. However, to give creditability to your program this must be part of your department's capability.
- You must be flexible in the types of courses, program names, mixing delivery modes, and responsive to customer needs.
- You need a diverse faculty in terms of tenure and non-tenure track. The tenure track faculty should be focused on research and program content. Non-tenure faculty (usually from industry) can focus on teaching and cultivating off campus programs. However, there cannot be a class system where they are treated differently. Also, they must be paid commensurate with their experience. Adjuncts (we call ours, Industry Professors) must be motivated to provide a high quality educational experience. They must be integrated into the all aspects of a department.
- Develop a strong advisory committee. Industry champions are key to a successful program for not only students but content and adjuncts.
- Plan for an advertising and marketing budget. Brochures must be professionally written and designed. Resources must be planned for to develop meaningful potential customer databases for marketing. Databases from professional societies and the university's alumni association can be used.
- Invest in a professional web presence. We talked to numerous marketing and advertising professionals in how to market our program. For example, we made the decision to not develop a view book and instead spent our advertising budget on a professionally design web page based upon their recommendations.
- Negotiate a revenue sharing arrangement with your administration. Because you are spending a larger proportion of your resources on educational programs, you will initially have less discretionary funding typically derived from performing research.
- There is no substitute for corporate visits. Developing a professional briefing describing your program along with brochures that can be disseminated within a company are much more effective that mass mailings.
- To attract the quality of faculty needed, you must offer them opportunities for consulting and other avenues for professional growth. We are in the process of formalizing a "blue chip" consulting services under the auspices of the university.

SUMMARY AND RESULTS

In a period of two years, we created an international executive graduate program in SE (Fall 00), a regional graduate program for corporate and government clients (Fall 01), on campus programs in SE (Fall 01), an on campus program in EM (Fall 02), and plans call for an off campus program in EM (Spring 03). The results to date of our efforts are shown in Figure 3.

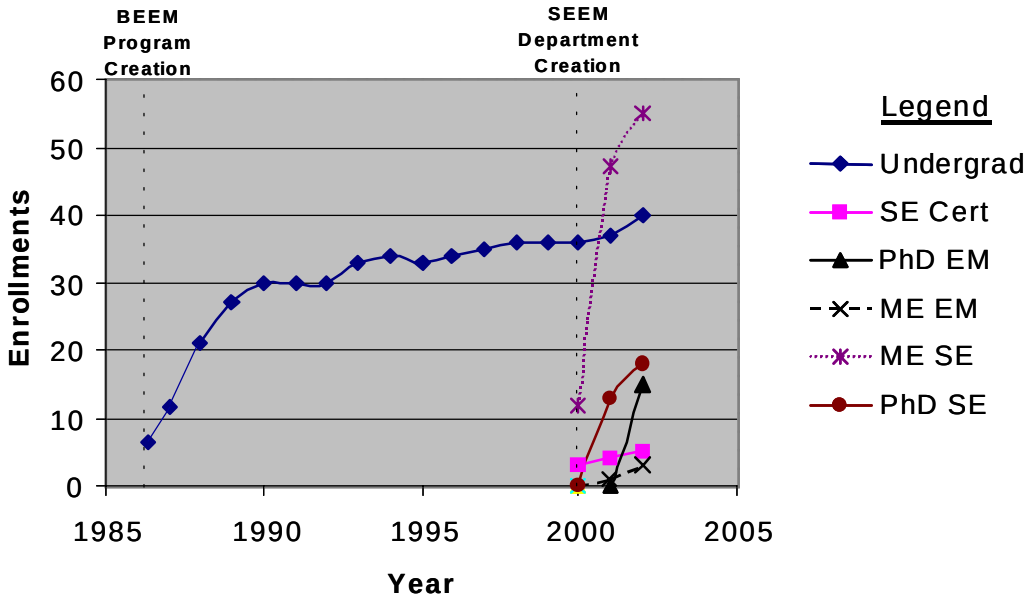

Figure 3. Undergraduate and graduate enrollments

As part of our strategic master plan, we plan to spend the next two years focusing on generate research funding to support our on-campus program to grow our professional reputation. Key elements of controlled growth for the next few years will be to improve our research facilities, train more adjuncts so our tenure/tenure track faculty can obtain load release using research funding, and encourage "blue chip" consulting by all elements of our faculty.

We were fortunate in that we had the full support of the Dean, a competitive market advantage because of our location, and were a small private university who could respond quickly. Like any university, our biggest challenges have been in the resource allocation arena and developing new business processes.

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BIOGRAPHICAL INFORMATION

JOHN V. FARR currently serves as Professor and Founding Director, Department of Systems Engineering and Engineering Management. He received his Ph.D. from the University of Michigan in 1986. Previously, he was Director of Engineering Management Program at the United States Military Academy. He teaches engineering economics, modeling and simulation, and data analysis. His research interests are in physical infrastructure protection, data mining, and modeling and simulation.

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