SUCCESS STORIES IN PARTNERING FOR ENGINEERING EDUCATION

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Abstract: The George Washington University, with an Engineering Management Department that dates back to the fifties, and now one of the largest in the country, has developed and implemented new collaborative programs in engineering management and related areas. These programs have involved partnering with both Industry and Government in the fields of systems engineering and engineering management. The former has been determined to be a critical core competency and the latter a required skill, especially for engineers that have transitioned, or are transitioning, into management positions. Going beyond the open enrollment model, cohort-based programs have been established with three large industrial firms and one important government agency, all with major offices in the Washington DC metropolitan area. A cohort is a group of from 25 to 45 students that stay together in lock-step through a prescribed sequence of courses. Initial programs led to Graduate Certificates in Systems Engineering. Later implementations resulted in Masters degrees in Systems Engineering as well as a distance learning mode of delivery. These have constituted significant success stories and are described in some detail in this paper.

Introduction

The Engineering Management Department within the School of Engineering and Applied Science (SEAS) at The George Washington University (GWU) has been in operation since the fifties, providing education programs leading to degrees at the master's level as well as doctor of science degrees. These programs, by-and-large, have focused upon the engineer and scientist who may be transitioning from a pure technical position to one that involves some degree of management responsibility. Further, they have tended to follow the open enrollment model whereby a variety of courses and programs are offered, and the students choose which courses suit their needs at any particular time and place.

The open enrollment model, upon re-examination, is both expensive and difficult to administer. One is continuously advertising and holding orientation sessions in order to guide and attract students. Such sessions are often held in several locations, depending upon the degree and nature of outreach beyond what might be called the "main campus". Administration of this approach has significant problems since it is difficult to predict how many students will actually sign up for the various classes at the different locations. Thus, concurrent with the initiation of each semester, a non-trivial juggling exercise involving students, locations and instructors becomes the norm.

Some five years ago, the above model as well as the needs of our "clients" were examined in some detail to see if another approach might be more effective for all concerned parties.

New Focus

The results of our exploration of other alternatives, in its short form, led to two very important new approaches that were added to supplement existing programs and approaches:

a. the introduction of cohort-based programs, and
b. an examination of the needs of local industries and government agencies

For each client, a cohort of from 25 to 45 students is formed. These students proceed through the same sequence of courses, in lock-step. Forming these cohorts of students turned out to be a very powerful and cost-effective approach. Under the right implementations, one is able to predict class size and composition with great accuracy, and a single plan can serve for several years. Instructor assignments can be made with long lead times, and the overall cost of attracting students drops precipitously. These are enormous benefits, if indeed the formation of these cohorts can be achieved efficiently. This leads to the second point cited above.

It became clear that both industry and government (especially in the Washington DC area) were in a position to support cohort-based programs. However, it was necessary to establish such programs that were clearly responsive to their needs, and also congruent with the charter and offerings of the Department. Without a great deal of study or fanfare, it appeared that the field of "systems engineering" (SE) was one for which both industry and government had a substantial need. This was reinforced through several face-to-face meetings that confirmed the fact that systems engineering represented a core competency that was (and still is) essential to carrying out large and even small scale systems integration (SI) projects. Indeed, it became clear that many of our largest companies operating in the Washington metropolitan area viewed systems integration as their main-line business and that a deep understanding of systems engineering was crucial to their success in that and related business arenas.

Specific Program Design

The first programs that were offered responded to the perceived needs through a curriculum leading to a Graduate Certificate in Systems Engineering (GCSE). The programs were structured so that the GCSE was issued to all students who successfully completed a prescribed sequence of six 3-credit courses, all integral to the theory and practice of systems engineering. These courses, with some minor variations, were (and still are):

a. Systems Engineering I
b. Systems Engineering II
c. Systems Analysis and Management I
d. Project/Program Management
e. Survey of Finance and Engineering Economics
f. Elements of Problem Solving and Decision Making for Managers

The above courses were scheduled for completion over a two year period. The selection of these six courses was based largely upon two factors. The first was that we had years of successful history with each and every one of them, including some fine-tuning over a period of not less than five years. The second was that feedback from students appeared to confirm that these courses were critical to a deep understanding of the fields of systems engineering and integration.

The first course in systems engineering addresses the full scope of systems engineering, but necessarily sacrificing depth. The second course provided the depth, concentrating on key areas such as system architecting. The systems analysis and management course provided specific analytic tools and techniques that supported the quantitative analysis of the behavior of large-scale systems. The course in project/program management put systems engineering and integration into a project management context. The survey of finance and engineering economics emphasized the life cycle cost analysis and modeling that is critical to making choices regarding overall system architecture and construction. Finally, the last course focused upon how the engineering manager might approach problem solving as well as decision making on a firmer quantitative foundation.

On the basis of the above program design, with each course syllabus defined historically and in great detail, three large and successful companies were approached to determine their interest in such a program. Typically, the courses would be taught at their facility from 6 to 9 PM, one night a week. Twelve sessions made up each semester, and the courses themselves were approximately identical to those offered under our more conventional programs provided by means of open enrollment. We sought cohorts of students that would move through the program, one course at a time, in lock step. No new students were to be added in the middle of the program since the cohort idea was accepted as a strong foundation for the program. New separate cohorts could be started a year later if the company felt that (a) the program was proving its success, and (b) there were

sufficient students so that, in effect, a "pipeline" was being established. Of the three companies with which we had early discussions of this program, two decided that it had a great deal of merit and wished to proceed with implementation. That, in fact, is what occurred.

A particularly important part of the program design was that the above six courses were selected so as to be exactly one half of the requirement for a master's degree in systems engineering. Thus, if the company and the students wished to proceed after the GCSE into the master's program, we were all prepared to do so, with all necessary adminstrative and academic machinery already approved and in place. In short, the GCSE could be both a terminal program as well as one that led to a master's degree. The company and the University signed a Memorandum of Agreement (MoA) that cited all of the necessary particulars regarding both the GCSE as well as the master's degree program, giving the company the option to proceed with sponsoring the cohorts that completed the GCSE into and through the master's degree. Typically, the six additional courses for the master's degree, beyond the GCSE, were:

a. Systems Analysis and Management II
b. Organizational Behavior for the Technical Manager
c. The Management of Technical Organizations
d. Information Management and Information Systems
e. Survey of Operations Research
f. Problems in Engineering Management

The various features of the overall program, therefore, can be summarized as follows:

a. target area was (and still is) the field of systems engineering
b. sign-ups by cohorts of approximately 30 students
c. successful completion of six 3-credit courses in order to be awarded a Graduate Certificate in Systems Engineering (GCSE)
d. courses provided at facility of sponsoring company once a week, for 12 weeks, nominally from 6 - 9PM
e. the initial six courses and GCSE could be followed by an additional six courses leading to a master's degree in systems engineering
f. terms and conditions of the program delineated in a Memorandum of Agreement (MoA) between the company and the University

The above program has been running for approximately 5 years with the two companies that initially signed on to it. Several cohorts have received Graduate Certificates in systems engineering, and also graduated with master's degrees in systems engineering. Both the University as well as these two companies consider the program as representing significant success stories. Based upon student evaluations at the completion of each course, both the instructors and the courses have consistently scored at the level of 3.5 or

higher on a scale with a maximum score of 4.0.

Program Expansion

Only after more than two years of experience with refinement of the above program did the University begin to expand its conception as well as its implementation. This was done slowly so as to ensure quality at each step along the way. The expansion ultimately proceeded in three directions:

a. expanding the number of partnering organizations
b. establishing a cohort-based executive master's degree program
c. eventually moving into a "distance learning" mode of delivery

In the last 2-3 years, the program described above was expanded to one additional company and one government agency. The same basic design was utilized and University assets were augmented in order to accommodate the increased numbers of courses and cohorts of students. With two-plus years of history, it was not a difficult matter to achieve this expansion while maintaining the high quality that all parties desired. This does not mean that no new problems appeared. Rather, we all were in a good position to solve such problems expeditiously and with uniformly good results. Most of these problems turned out to be administrative in nature.

The cohort-based executive master's degree program was constructed so as to respond to perceived needs of more senior personnel in local companies and government agencies. Two types of such programs were offered, both of which are listed below together with the specific courses for each:

1. Executive Master's in Systems Engineering
    - o Organizational Behavior for the Engineering Manager
    - o The Management of Technical Organizations
    - o Program and Project Management
    - o Information Management and Information Systems
    - o Survey of Finance and Engineering Economics
    - o Elements fo Problem Solving and Decision Making for Managers
    - o Systems Analysis and Management I
    - o Systems Analysis and Management II
    - o Systems Engineering I
    - o Systems Engineering II
    - o Problems in Engineering Management
    - o Survey of Operations Research
2. Executive Master's in Software and Information Systems Management
    - o Organizational Behavior for the Engineering Manager
    - o The Management of Technical Organizations
    - o Management of Information and Systems Security

- o Information and Software Engineering
- o Information Management and Information Systems
- o Survey of Finance and Engineering Economics
- o Elements of Problem Solving and Decision Making for Managers
- o Systems Engineering I
- o Database Design and Database Management Systems
- o Software Project Development with CASE
- o Problems in Engineering Management
- o Data Communications and Networks

The expansion into a distance learning venue was achieved by means of a partnering effort between the University and one of the companies that first sponsored this program some five years ago. With approximately one and a half years of experience with this implementation at this time, we have seen and tackled new problems that have been associated mostly with:

a. the regular use of video teleconferencing (VTC) and recording facilities
b. increased class size, and
c. some participating students located on the other side of the planet.

As anticipated, not all VTC and video recording equipment was up and running at all times. As a backup for problems of this type, every session was video recorded on site and copies of the tapes were sent the next day to all participating sites, of which there were nine. Even this video recording was carried out with two cameras so as to maintain a high level of availability. This helped students without a VTC capability and those that, for one reason or another, missed the VTC class that particular week.

The distance learning implementation was also supported by the use of materials through an on-line capability at the University known as Prometheus. This consistently took the form of slides (viewgraphs) that supplemented the texts for the courses. In general, these slides were accessible to the students from day one, and were used extensively as a way to support each three-hour class session. This meant that the students knew in advance what would be covered in considerable detail for each session. In a distance learning delivery mode, students appreciated the “no surprises” approach that we adopted.

Student evaluations for the distance learning delivery yielded an overall rating for both the instructor and the course at above 3.6, with 4.0 being the maximum score. Other selected factors that were measured included:

- o workload represented by the course
- o utility of assigned materials
- o acquisition of useful knowledge
- o appropriateness of exams and papers

- o clarity and organization of class presentations
- o pace of course
- o ability to impart knowledge

Results with respect to these metrics were consistently in the range of good to excellent.

Management of the expansion from conventional classroom to distance learning delivery went very well as a result of the detailed planning and the provision of back-ups, especially in the event of failures in the VTC and related equipment. Excluding the cost of this equipment, which was borne by the sponsoring company, additional costs in order to provide the distance learning capability were in the vicinity of ten percent. This was considered to be a rather cost-effective solution for all concerned parties.

In summary, this distance learning initiative was characterized by:

a. interactive and synchronous VTC-based courses at multiple sites
b. some sites on the other side of the planet (eg., Germany), without VTC capability
c. extensive use of slides that were available on-line and in advance
d. proctored exams, in most cases, with results sent via conventional express mail
e. double back-up video tape recording and prompt conveyance to all remote sites
f. graduate student assistance, mainly with administrative matters
g. an MoA that set forth the terms and conditions of this partnering relationship
h. detailed contingency planning to manage the overall expansion and minimize the expenditure of new resources
i. a continuing focus on the field of systems engineering.

Summary

This paper described three basic success stories, all of which were predicated upon establishing new cohort-based programs that significantly expanded the delivery mode of the Department's areas of study.

The first of these involved a 6-course Graduate Certificate in Systems Engineering (GCSE), followed by a 6-course program, all of which led to a master's degree in systems engineering. The second was an executive master's program, leading to degrees in (a) systems engineering, and (b) software and information systems management. The third was a distance learning implementation of the GCSE. These programs have been significant successes, as represented by such measures as:

a. rapid increase in numbers of graduate students
b. very high level of satisfaction of these students
c. a large percent of GCSE students moving on to the master's degree in systems engineering

d. achievement of new core competency levels in systems engineering
e. satisfaction of needs and goals of the partnering companies and agencies
f. reduced recruitment as well as overall program costs per student
g. one hundred percent renewal rates of the participating companies and agencies
h. relationships established between students in each cohort
i. relationships established between the University and partnering entities
j. interest shown on the part of these students in our doctoral program leading, at this time, to five active doctoral students

This author has served as faculty advisor for the above programs as well as professor for several of the courses within the programs. Judging from these experiences, we see new opportunities to partner for success in systems engineering as well as other fields. Such opportunities are being continuously explored by this author and his colleagues. These partnerships have proven their value to all concerned parties and serve as a model for the development and delivery of future graduate programs at the University.

HOWARD EISNER serves as Distinguished Research Professor and Professor of Engineering Management and Systems Engineering at The George Washington University. He spent 30 years in industry, working mainly in command, control, communications and intelligence applications. Dr. Eisner is a Life Fellow of the IEEE and came to the University in 1989 in order to pursue education and research interests.