AC 2007-1307: A CULMINATING EXPERIENCE MODEL FOR MASTER'S STUDENTS

Ahmad Sarfaraz, California State University-Northridge

Tarek Shraibati, California State University-Northridge

A Culminating Experience Model for Master's Students in Engineering Management

Abstract

Most graduate schools that offer Master's Degrees require some sort of culminating experience. These culminating experiences usually consist of a thesis or project, or an examination based on certain core courses. Department of Manufacturing Systems Engineering and Management (MSEM) at California State University, Northridge (CSUN) offers Master's Degrees in Engineering Management. The program is offered both in residential mode and online mode. Students in both programs must satisfy the same admission requirements and must fulfill a culminating experience course. This culminating experience is individually designed between each student and his/her faculty advisor. Each student selects two case studies from a pool of developed case studies. These case studies have been designed to allow students to demonstrate their ability to utilize and apply the knowledge and skills gained throughout the Master of Science in Engineering Management degree program. This paper describes the process that students go through during the culminating experience course and expresses how the case studies were developed. It explains a set of underlying beliefs that give life to courses and guide program implementation. Finally it presents a set of issues important in transferring the experience to other graduate schools who offer engineering management programs. This culminating experience model replaces a comprehensive exam.

Introduction

Engineering Management as a discipline is relatively new and well-represented by its own professional society, the American Society for Engineering Management. The first program was established in 1915, but by the mid-1970s, only 22 universities were offering this program. The American Society for Engineering Management (ASEM) reported that there are over one hundred universities offering Engineering Management masters programs[1]. As the value of these programs became apparent, their number began to increase rapidly.

Engineering Management, as a discipline, evolved from the need to provide a link between the managers and engineers of all types. A quick review of master program descriptions describes EM programs as providing a strong engineering core with additional studies in management, technology and business related courses. Hicks et. al.[2] classified Engineering Management masters programs into three groups. One group focused on traditional management concepts such as planning, marketing, accounting, etc. The second group focused on mathematical concepts including operations research, probabilistic models, and risk/decision analysis, etc. and the third one focused on behavioral management comprising motivation, project management, leadership, engineering management, etc.

The department of Manufacturing Systems Engineering and Management (MSEM) at California State University, Northridge (CSUN) has a unique role in southern California. The Engineering Management program at Cal State Northridge offers courses in Engineering Management, Decision/Risk Analysis, Statistical Analysis, Operations Research, Economic Analysis, Financial

and Cost Analysis, Management of Engineering Professionals, Quality Management, and other Engineering Management courses.

This paper describes the Engineering Management curriculum at the CSUN, and shows how the sequencing of courses enhances students' abilities as problem solvers using the culminating experience course. It also presents a set of issues important in transferring the experience to other graduate schools who offer engineering management programs.

Importance of Engineering Management Program

Because the practice of every engineering discipline is advancing so rapidly, engineers are required to maintain currency in their fields of employment. A master's degree is an effective way of obtaining that knowledge in a short time. The latest business practices include corporate downsizing, global market pressures, shorter product life cycle, and rapidly expanding technology, which require a new type of engineering discipline. This requirement produces the need for the engineering management.

Program Flexibility and Students' Background

More than two-thirds of all engineers will move into management positions during their professional careers for which their technical background has not prepared them. Currently, more than 95% of our students are working professionals who attend CSUN on a part time or full time basis, taking two or three evening courses per semester. To accommodate the schedules of employed students, the courses are taught in the evening hours, Monday through Thursday. Each course is normally offered in a 3-hour once a week for the entire semester, from 7:00 p.m. to 10:00 p.m. The classes are enriched by the diverse industry experience and disciplinary backgrounds of the students. Computer scientists, scientists, industrial designers, engineers in all discipline areas, and others involved in science and technology, bring their experiences with them to the classroom in areas including biomedical, aerospace, entertainment, utilities, manufacturing, construction and other industries. The popularity of the program with international students yields first-hand expertise in global issues pertaining to technology management.

The Engineering Management Curriculum at CSUN

The MSEM department offers a Master's degree that requires a minimum of 30-semester credit hours of graduate study plus a culminating experience course. The principal objective of the Engineering Management is to prepare students with undergraduate engineering degrees for positions in middle and upper management. Thus, a total of 18 credit hours are required of all students as illustrated in Table 1. The student is then required to select 12 credit hours from a list of elective courses as shown in Table 2. The descriptions of these courses are relevant to understanding of case study outlines that will be presented later. Finally, each graduate student must complete a comprehensive examination given by a committee consisting of the main advisor and two other faculty members. It is note worthy that core courses, as shown in Table 1, are supported by two financial analysis skills (Engineering Economic analysis and Engineering Financial and Cost Analysis). The main reason for including these two financial courses is

because many students select engineering management programs in lieu of alternative business related programs such as the MBA. Therefore, the program provides a high degree of the "business sense" that is critical to personal financial success. The elective courses shown in Table 2 are selected in consultation with a faculty advisor. These courses are selected to meet individual student needs. The descriptions of these courses are relevant to understanding of designing case studies that will be presented later. Elective courses can be also included numerous engineering disciplines (e.g., Civil, Automation, Manufacturing, Materials, Mechanical, Quality, and Electrical), as well as computer science or additional engineering management courses and some non-technical courses.

Course	Title	Course Description
MSE 601	ENGINEERING STATISTICS	Comprehensive statistical estimation, design and hypothesis testing methods, and their application to selected problems in engineering.
MSE 602	ADVANCED ENGINEERING MANAGEMENT	Starting, organizing, and managing engineering and technology research, design, and production. Technology and innovation, technological strategy and forecasting, technical entrepreneurship and entrepreneurship, evolving organizations, capitalization, and intellectual property.
MSE 604	ECONOMIC ANALYSES OF ENGINEERING	Evaluation of economic feasibility of large scale engineering systems. Projections of future economic environment, growth of demand, planned expansion of the system, use of resources, levels of confidence in projections, risk evaluation and profitability analysis.
MSE 606A	ENGINEERING OPERATIONS RESEARCH I	Systems methodology and mathematical bases in industry. Selected approaches in optimization methods, such as linear, integer, and dynamic programming; assignment and transportation as well as game and network approaches. Emphasis is placed on the modeling and formulation of problems and the economic interpretation of results. Examples of these methods to obtain practical solutions to real-world problems are presented and analyzed.
MSE 608B	MANAGEMENT OF ENGINEERING PROFESSIONALS	Study of special considerations in the management of engineering professionals, including selection, performance, termination, and conflict situations. Course consists in part of the study of selected current publications.
MSE 608C	ENGINEERING FINANCIAL AND COST ANALYSIS	Fundamental concepts and methods of engineering financial and cost analysis. Understanding the relevance of financial and managerial accounting to the effective management of engineering and technology projects.

Table 1. Engineering Management Core Course

Course	Title	Course Description
MSE 504	ENGINEERING MANAGEMENT	Principles and applications for effective management of technology projects, people, budgets and schedules. Organizing and motivating people, and controlling activities. Managing research, development, design, marketing and production functions in engineering and technology. Ethical considerations in engineering and technology management.
MSE 505	ENGINEERING DECISION/RISK ANALYSIS	Introduction to decision and risk analysis methods in the context of engineering. Organizing frameworks for the synthesis, analysis, and evaluation of complex unstructured engineering problems and situations.
MSE 606B	ENGINEERING OPERATIONS RESEARCH II	Continuation of selected approaches in systems optimization methods, such as stochastic, probabilistic, and waiting line models, with emphasis on applications to real-world problems.
MSE 607B	SYSTEMS ENGINEERING AND MANAGEMENT	Overview of concepts and methods of systems engineering and management. Considerations of life cycles, requirements, and configuration and cost management. Standards, metrics, architectures, integration, and evaluation. Survey of relevant tools and techniques and their relationships to effective systems engineering management.
MSE 608A	SEMINAR IN ENGINEERING MANAGEMENT	Advanced studies of topics of current interest in the field of Engineering Management. Course consists in part of an intensive study of selected papers from current literature.
MSE 617	SEMINAR IN QUALITY MANAGEMENT	Discussion and analysis of current theory, practices, and state-of-the-art developments applicable to quality management in engineering and technology.
MSE 618	SIX SIGMA QUALITY ENGINEERING	Overview and evolution of continuous improvement methodologies. Comparison of product-related and process-related six sigma methodologies. Integration of operating philosophies, applied statistics, and project management in continuous improvement deployment. Phases of six sigma methodology and application of computing technologies to quality engineering projects. Advanced topics in six sigma continuous improvement design.

Table 2. Engineering Management Elective Course

Culminating Experience Course

Most graduate schools that offer Master's Degrees require some sort of culminating experience. These culminating experiences usually consist of a thesis or project, or an examination based on certain core courses. For example, students at California State University, Easy Bay require passing a comprehensive examination and completing an additional 4-unit elective course[3]. As a culminating experience for our students at CSUN, we were interested in having our students exercise and tie together knowledge from earlier coursework, particularly from the core courses. Therefore, a course on culminating experience was developed by the authors. To fulfill this requirement, we developed a process through which each student would select two case studies from a pool of developed case studies. These case studies have been designed to allow students to demonstrate their ability to utilize and apply some of the knowledge and skills gained throughout the Master of Science in Engineering Management degree program. Implementing these case studies ensure the program integrates the curriculum with real-world application.

MSE 697, Directed Comprehensive Studies, is the culminating experience that has been selected and approved by the university for the Master of Science in Engineering Management. The specific requirements have evolved over several years, reflecting in part suggestions provided by program alumni. The culminating experience course or directed comprehensive course may not be undertaken until the last semester of program enrollment. The student's committee chairman is involved with the student on a regular basis and is in a position to assess the students overall performance.

Case Studies

MSE 697 is comprised of individualized integrative case studies. These case studies have been designed to allow students to demonstrate their ability to utilize and apply some of the knowledge and skills gained throughout the Master of Science in Engineering Management degree program. Students are required to choose two of the three case studies for their grades. Each of the case studies addresses certain courses as follows:

- Case study#1: MSE 606A, MSE 608C, and MSE 604
- Case study#2: MSE 505, MSE 601, and MSE 604
- Case study#3: MSE 504 and MSE 602

Case Study #1: MSE 606A, MSE 608C, and MSE 604

In this integrative case study, students demonstrate their ability to utilize and apply some of the knowledge and skills gained in MSE 606A, MSE 608C, and MSE 604. Engineering Operations Research, MSE 606A, course builds on some of the optimization methods and provide students specific linear programming applications useful for engineering managers. Fundamental concepts and methods of engineering financial and cost analysis are addressed in MSE 608C, Engineering Financial and Cost Analysis. In MSE 604, Engineering Economy, economic principles and techniques used in making decisions involving the acquisition and retirement of capital goods by government and industry; time value of money; computer solutions for rates of return, and capital expenditures are addressed.

Students are required first to formulate and solve a linear programming problem to maximize total contribution margins given the production, resource, and demand constraints for fifteen product lines. To formulate the problem, students need to compute the unit contribution margin for each of the products. The calculated unit contribution will be used for the coefficient of the decision variables of the LP model. After solving the problem, an optimized production plan will be determined. This production plan will be used in the subsequent parts including interpreting the computer solution, sensitivity analysis, shadow prices, and distinguishing the binding from non-binding resources.

To integrate the computer results with the financial and cost analysis, students are required to determine the income statement for certain period using the traditional cost accounting concept. To accomplish this task, students need to assume all products determined in previous part will be sold in the market. If an item is not determined by the LP model, it means that it will not be produced. Using the traditional cost accounting method, students are required to perform profit analysis for all produced items.

Since some of the items are not competitive in the market, students are then required to use the Activity-based costing method to calculate the actual unit profit using given cost drivers and activities. If a product is excluded by the LP solution, the corresponding activities for that item needs to be adjusted for a product family. Finally, students are required to perform a financial/economic analysis for the parts using the traditional cost accounting and the activity-based costing method.

Case Study#2: MSE 505, MSE 601, and MSE 604

In this integrative case study, students demonstrate their ability to utilize and apply some of the knowledge and skills gained in MSE 505, MSE 601, and MSE 604. Introduction to decision and risk analysis methods in the context of engineering are addressed in MSE 505, Engineering Decision/Risk Analysis. Engineering statistics, MSE 601, provides students the basic tools and techniques for the statistical analysis. The engineering economy and finance courses provide students a framework for applying cost-benefit analysis in comparing alternatives using time value of money. For this case study, students will be expected to bring disparate pieces of knowledge that a student have gained throughout ones studies.

For this case study, students are required to select the best alternative using the decision tree analysis. This is accomplished given a minimum attractive rate of return, study period, and the expected value of the present worth as a decision criterion. After constructing the decision tree, students are required to determine the expected value of perfect information for the problem. Given additional information about the future and the conditional probabilities, students are then required to develop a two-stage decision tree and to consequently determine the preferred alternative.

Using concept of the variables of random and the probability distribution function gained in MSE 601 and the Monte Carlo simulation technique learnt in MSE 604, students are asked to

develop a simulation of 100 sample points of the Annual Worth (AW) and to ultimately choose the best alternative.

Case Study#3: MSE 504 and MSE 602

In this integrative case study, students demonstrate their ability to utilize and apply some of the knowledge and skills gained in MSE 504 and MSE 602. The Engineering Management course, MSE 504, gives students the principles and applications for effective management of technology projects, people, budgets and schedules. Students in this course will be exposed to organizing, motivating people, and controlling activities. Managing research, development, design, marketing and production functions in engineering and technology, and ethical considerations in engineering and technology are the other topics that students learn in this course. The Advanced Engineering Management, MSE 602, provides students the basic tools and techniques for managing engineering and technology research, design, and production. Technology and innovation, technological strategy and forecasting, technical entrepreneurship and entrepreneurship, evolving organizations, capitalization, and intellectual property are the other concepts that students learn in this course.

For this case study, students are required to use their personal on-the-job experience to foresee the effects that may occur in a promotion or transition process. It should be noted that the transitional examples include taking becoming a manager for the first time or moving from a lower to a higher level managerial position. Students are then asked to use theories that serve to help explain the topic of "Motivating & Leading Technical People" that are covered in both courses.

Evaluation

A one-page Project Status Report for each case study is required by a certain date. The report should identify their selection about case studies and briefly describe the work that they have accomplished to date. The selected case studies are to be completed on an individual basis during the term. Each case study has its own instructions for completion and submission.

The completed case study reports are to be evaluated on a credit/no-credit by a three-member faculty committee that is chaired by the course instructor. The instructor accordingly submits a grade of CR (credit) or NC (no-credit) for the course. The report will be a formal report complete with a Title Page, Summary of Case Study, and Answer to Questions, and Appendixes. Appendixes are used to include the computer outputs.

Effectiveness of the New Model

A comparison of this culminating experience model with the previous model, which was a comprehensive exam, revealed that students were better able to integrate the material from various courses. Working students were better able to apply concepts to real life case studies. The comprehensive exam was based on numerous problems, each associated with a particular course. The exam did not require students to synthesize materials from different courses to solve the exam problems. It was also discovered that questions submitted by faculty for the

comprehensive exam were sometimes simply a duplication of final exam questions from the course. These shortcomings were avoided by using case studies.

Feedback from students and their employers has indicated that the students are better prepared using the case study approach to a culminating experience rather than a comprehensive exam. The effectiveness of the model was measured by contacting employers and alumni. Statistical data needed to address these results is lacking from the previous comprehensive exam approach.

Conclusion

The use of case studies as part of the culminating experience in the Masters of Science in Engineering Management at CSUN has been developed over several years by MSEM department faculty. Students pick two of three case studies, which are designed to tie together coursework taken in the MS Engineering Management program. Prior to the implementation of MSE 697, the culminating course in which the case studies are performed, coursework was simply taken as a series of requirements for the degree. Feedback from students in the program, most of who work in industry, led to the implementation and design of the use of case studies as a means to coalesce lessons learned in the various course in the curriculum. Feedback from working engineers and other in the program has shown the use of case studies has been effective in achieving this goal.

References

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Biographies

AHMAD SARFARAZ is a full time lecturer in the Department of Manufacturing Systems Engineering and Management at California State University, Northridge. He earned his Ph.D. degree are West Virginia University in Industrial Engineering. His research concerns operations research, AHP, economic analysis, and lean manufacturing. At the University, he teaches facilities planning and design, engineering economic, operations research, and engineering statistics. Prior joining to California State University, he taught at Amirkabir University of Technology over 10 years.

TAREK SHRAIBATI is a full time lecturer of the Manufacturing Systems Engineering and Management department at California State University at Northridge with 21 years of full-time teaching experience in engineering courses. He received his M.S. degree in Materials Science from USC. Prior joining to California State University, he worked at Rocketdyne.