

Engineering Management: The Practical Discipline

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A headline in *USA Today* caught my eye: "Education gaps leave graduates ill-prepared." ¹ The lead stated: "College graduates enter the work force with strong technical skills but aren't very good at communicating, being part of a team or accepting ambiguity, among other things." The "other things" included ethics and global awareness. The report was the result of a study done by the Task Force on High-Performance Work and Workers, sponsored by the Business-Higher Education Forum, affiliated with the American Council on Education. ² This sentiment was expressed earlier in the halls of The American Society for Engineering Education (ASEE) via the 1995 National Science Foundation report *Restructuring Engineering Education*, as well as a *Prism* article on Pennsylvania State University. The university's Leonhard Center for the Innovation and Enhancement of Engineering Education has funded a new leadership minor, which Director Jack Matson described: "There are five basic things the world tells us we need to do to radically improve engineering education: . . . to enhance communication skills, increase international outlook, broaden understanding of business, encourage creativity, and call attention to ethical concerns regarding technology and society." ³

Is the study of engineering management including these improvements? To answer this question and to look at the "differences" in the discipline of engineering management (EM), I polled an assortment of practitioners familiar with field literature to find the most well-known programs. I then asked representatives from the programs to send their most recent plans of study. In this paper I will look for similarities and differences in course requirements for popular programs in engineering management. The search theme is to discover the subject areas important in the preparation of our discipline's graduates, especially the five areas of communication, business, creativity, teamwork, ethics, and international concerns.

Brief History of Engineering Management

Dr. Dundar F. Kocaoglu, Director of Engineering Management at Portland State University, has made a longitudinal study of the discipline and has written extensively. His paper, "Education for Leadership in Management of Engineering and Technology," ⁴ describes the origins of the field as an industrial management program at Massachusetts Institute of Technology in 1913. The field grew slowly in terms of developing coursework and in becoming established as a professional area of expertise until the oil crisis of the 1970s. Apparently, so long as conditions remained static, traditional education sufficed; however, when international forces created a changing American business environment *and* changing technology, engineering management came into its own as an important discipline. Former technical specialists had to become technical managers of people, as well as projects and technology. In short, simply having cutting-edge technology was not enough to keep America on the forefront of business and industry; *managing* that technology and the resources required to maintain it became important--

thus, an increased attention to engineering management.

"Engineering and Technology Management is the discipline addressed to making and implementing decisions for leadership in existing and emerging technologies and their impacts on interrelated systems. Its focus is placed on issues both at the strategic and the operational levels" (p. 79). Dr. Kocaoglu further stated that the foci of different programs varied with the region being served, but generalized that "they all reflect on a discipline starting where Industrial Engineering stops, and going up to a point where Public Policy starts."

The Scope of Engineering Management

In detailing the dimensions of the field, Dr. Kocaoglu said that EM included basic and applied research, developing, designing, and implementing the transfer of technology, as well as testing, marketing, and maintaining the technological life cycle, all of which seem to represent the engineering side of the EM house. A second area concerned the subsystems of people, projects, organizations, resources, innovation, and strategy, which seem to represent the managerial side of the EM house. (p. 80)

In a 1991 overview of core and elective EM courses in 80 United States universities, Dr. Kocaoglu lists:

<u>Most frequently offered core courses</u>		<u>Most frequently offered electives</u>	
Operations research	43	Engineering (CE, EE, ME, etc.)	43
Accounting	38	MIS	37
Economic theory	35	AI/expert systems	35
Financial management	31	Project management	34
Behavioral science	29	Personnel management	34
Project management	22	Quality management	33
Strategic planning	17	Operations research	32
Projects (group, individual)	16	Database management	30
Technology management	15	Economic theory	29
Quality management	13	Financial management	29
R & D management	13	Manufacturing management	28
Indus/organ. psychology	12	CAD/CAM	27
Manufacturing management	12	Indus/organ. psychology	27
Case studies	11	Accounting	26
Communication	11	Entrepreneurship	24
Engineering (CE,EE,ME,)	10	Behavioral science	23
MIS	10	Forecasting	23
Personnel management	10	Industrial relations	23
Productivity management	10	Productivity management	22

(p. 81)

One "difference," then, in engineering management education is that the study of engineering itself is not paramount, but is balanced by the study of various aspects of business, such as finances, personnel, productivity, as well as psychology, entrepreneurship, and behavioral science. Thus, some of the original concerns of this paper are addressed: engineering management broadens understanding of business, and offers education in teamwork, creativity, and global awareness. This education focus is further corroborated by two other well-known engineering management leaders.

Drs. Daniel L. Babcock and Bernard R. Sarchet, University of Missouri-Rolla, in their article, "Is Engineering Management a Profession," questioned the way EM differed from other *management* specialties.⁵

"The engineering manager is distinguished from other managers by the fact that he possesses both an ability to apply engineering principles and a skill in organizing and directing people and projects. He is uniquely qualified for two types of jobs: the management of technical functions (such as design or production) in almost any enterprise, or the management of broader functions (such as marketing or top management) in a high-technology enterprise." (p. 240)

Engineering Management Programs

In a 1994-5 study, Dr. Kocaoglu noted that of the 166 EM programs identified, 77 were called *Engineering Management*, 46 were *Management of Technology*, 17 were *Industrial Management*, 8 were *Manufacturing Management*, and 5 were an *MBA with Technology Management*. (13 others were titled variously.)⁶ Ninety-two EM programs were located in engineering schools, 29 were in business schools, and 33 were in joint engineering- business schools. Sixty-five percent of EM faculty come from engineering and physical science backgrounds, while 29% come from business and management, and 6% come from social sciences and other areas of study.

To arrive at coursework descriptions for well-known EM programs, I asked practitioners who had had the opportunity to read field literature over time. These were Dr. Ted Eschenbach, Editor of *Engineering Management Journal*; Dr. Dunder Kocaoglu, chronicler of EM curricula; and Dr. Jerome Lavelle, whom I am following through the "chairs" of the ASEE EM Division and who knows everything. What follows is a coursework overview.

Old Dominion University **Engineering Management, College of Engineering and Technology, Norfolk, Virginia**

Core Program

ENMA420/520	Statistical Concepts in Engineering Management
ENMA600	Monetary Concepts in Engineering Management
ENMA601	Behavioral Concepts in Engineering Management
ENMA602	Technological Data Analysis
ENMA603	Deterministic Decision Methods
ENMA604	Project Management
ENMA605	Project Research
ENMA607	Stochastic Decision Methods
ENMA614	Quality Assurance Management

Elective Courses

Organizational Analysis and Design	Organizational Communication
Sociotechnical Systems Design	Inter-Cultural Issues in Organizations
Language, Design, and Management	Reliability and Maintainability
Robust Engineering Design	Parametric Cost Engineering
Risk Analysis	Discrete Event Simulation
Computer Methods and Models	Systems Theory and Cybernetics
Knowledge Engineering	Applications of Neural Networks
Production Systems Management	Computer Integrated Manufacturing
Contemporary Manufacturing Technology	Human Factors Engineering
Technology Policy	Policy Modeling
Architecture of Knowledge and Quality	Quantitative Research Design
Qualitative Research	(Electives in other Colleges may be selected.)

Degree Concentrations/Fields of Study

Master of Engineering Management (M.E.M.)	M.S. in Engineering Management
M.E. in Operations Research & Systems Analysis	Ph.D. in Engineering Management
Certificate of Professional Study in Engineering Management (post-masters' certificate) ⁷	

Portland State University
Engineering Management, School of Engineering and Applied Science, Portland, Oregon

Core Program

EMgt 520	Management of Engineering and Technology
EMgt 530	Decision Making in Engineering and Technology Management
EMgt 540	Operations Research in Engineering and Technology Management
EMgt 545	Project Management in Engineering and Technology
EMgt 555	Technology Marketing
EMgt 510	Communication and Team Building <i>or</i> Mgmt 550 Organizational Management
EMgt 535	Engineering Economic Analysis <i>or</i> Actg 511 Financial Accounting
EMgt 590	Engineering Management Synthesis <i>or</i> M.S. Thesis <i>or</i> Special Projects ⁸

Elective Courses

Unit Operations in Environmental Engineering	Engineering Statistics
Computer Simulations of Industrial Facilities	International Financial Management
Strategic Planning in Engineering Management	Productivity Analysis
Project Scheduling & Network Analysis	Manufacturing Systems Engineering
Manufacturing Systems Management	Intelligent Manufacturing Systems
Manufacturing Systems Simulation	TQM: Total Quality Management
Reengineering the Technical Enterprise	Expert Systems in Engineering
Research Methods for Engineering Management	(24 credits from 107 electives allowed)

	Degree Concentrations/Fields of Study	
M.S. Engineering Management	Ph.D. in Systems Science--Engineering Management	
	Technology Management	Decision Theory
	Operations Research	Project Management
	Manufacturing Management	Technology Planning
	Technological Innovations	Knowledge-based Systems

Stevens Institute of Technology
Engineering Management, Castlepoint on the Hudson, Hoboken, New Jersey

Core Courses

EM 301/302/303	Management of Design I/II/III
EM 365	Statistics for Engineers
EM 350	Production/Operations Management
EM 357	Elements of Operations Research
EM 380	Engineering Management Lab
EM 415	Engineering Management Design Project
EM 460	Quality Management
EM 466	Statistical Quality Control
EM 470	Engineering Management
EM 485	Human Factors
	(Required courses from E, EE, CH, CE, Math, ME, PE, PEP)

	Elective Courses
Group Dynamics	Transport
MIS/Computer Applications	Materials Processing
Introduction to Individual Psychology	Microeconomics
Microeconomics	Humanities (18 credits)

	Degree Concentrations/Fields of Study	
B.E. in Engineering Management	M.S. in Concurrent Engineering	M.S. in Management
M.S. in Applied Psychology	Ph.D. in Information Management	
Ph.D. in Concurrent Engineering	Ph.D. in Applied Psychology	

**University of Missouri-Rolla
Engineering Management, Rolla, Missouri**

Core Courses

Emgt 209	Engineering Economy and Management
Emgt 230	Management Accounting Systems
Emgt 251	Marketing Management
Emgt 252	Financial Management
Emgt 260	General Management-Design and Integration
Emgt 282	Production Management
	(Required courses in CH, PHY, Math, Hmnt (24 cr.), E, EG, BE, ME, EE, + emphasis areas: manufacturing, packaging, industry, quality, management)

Elective courses

Plant Layout	Computer-integrated Manufacturing Systems
Solid Waste	Total Quality Management
Value Analysis	Package Machinery, Management, Materials, System Design
Neural Networks	Interdisciplinary Problems in Manufacturing Automation
Total Quality Management	Production Planning and Scheduling
Project Management	Methods of Industrial Engineering
Statistical Process Control	Human Relations in Engineering
Experimentation in EM	Management & Methods in Reliability
Management for Engineers	Managing Engineering & Technology
Technical Enterprise	Government Regulations/Business & Industry
Legal Environment	Business Logistics Systems Analysis
Work Design	Expert Systems in Manufacturing & Engineering
Safety Engineering Management	
(20 other Emgt courses available in catalog) ⁹	

	Degree Concentrations/Fields of Study	
B.S., M.S. and Ph. D. in Engineering Management		
	Emphasis Areas: Manufacturing Engineering, Packaging Engineering, Industrial Engineering, Quality Engineering, Management of Technology	

Conclusions and Recommendations

The original query of this paper concerned whether engineering management programs were enhancing communication skills, increasing international outlook, broadening understanding of business, encouraging creativity, encouraging teamwork, and calling attention to ethical concerns regarding technology and society, since traditional engineering education seems not to be addressing these areas. I think the answer is: the curricular opportunity is there. Different programs seem to emphasize different strengths: Old Dominion offers graduate degrees from a panoply of course offerings taught within the department; Portland State offers the most latitude in coursework (107 electives) networking throughout the university; Stevens also networks with other departments and schools to offer an engineering-oriented program; and UMR looks as though it should have 100 faculty just to teach their undergraduate courses. My thanks to Larry Richards (Old Dominion), Dundar Kocaoglu (Portland State), Don Merino (Stevens), and Steve Raper (UMR) for sending the material for this paper.

My final thought is this: if engineering management is the discipline for the 21st century, how can we as practitioners best get the message out? My recommendation is a compilation of the best programs we have, much in the manner of The Fiske Guide to Colleges, making engineering management a subject to discuss among high school and college counselors, as well as university consortia world wide.

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⁹ University of Missouri-Rolla. (1996-97). The University of Missouri Undergraduate Catalog 1996-97, pp. 55-57, 120-123.

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