

## **A GRADUATE CURRICULUM FOCUSED UPON MANUFACTURING & INTEGRATING ENGINEERING & BUSINESS**

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### **Abstract**

A unique, new graduate program, Quality and Manufacturing Management (QMM), has been introduced at Penn State. The QMM program is an integrated two-semester academic program created jointly by the Colleges of Engineering and Business with cooperation and stimulation from industry. The courses are all required and taken in lock-step by each class cohort. Faculty members from both colleges teach in the program, often with both being present in the classroom to provide continuous integration of course material. The students have backgrounds in business, engineering, science, and industry and are selected to provide diversity in each cohort class. The first year has been successful beyond expectations and has met or exceeded all of the parameters selected for its evaluation. In terms of acceptance of the new, unknown Master's in Manufacturing Management (MMM) degree by employers, all but one of the graduates had accepted a suitable employment position or elected to continue his/her education by graduation day. In terms of interest from prospective students, applications increased nearly three fold from the first to the second year.

### **Introduction**

Manufacturing today not only refers to the making of hard goods, but also to enterprises that “produce” information, transportation, health care, etc. Manufacturing is not simply the cutting, shaping, grinding, and assembling of materials; it includes product design, materials and processes, plant design, capacity management, product distribution, product costing, performance measurement, plant scheduling, quality management, workforce organization, equipment maintenance, strategic planning, supply chain management, interplant coordination, and direct production. This is sometimes referred to as “Big M”. All of the activities typically included in “Big M” manufacturing are part of the unique new integrated Engineering/Business graduate program at Penn State called Quality and Manufacturing Management (QMM).

Industry is driving for a competitive edge through quality, cost, speed, and flexibility. Corporations are streamlining, asking not for specialists, but for personnel with the ability to integrate and work across traditional boundaries. These forces have combined to create an emerging need for a new breed of professional: women and men who can think broadly as business people, engineers, and technologists, and who have the skills needed to bring new products to the marketplace in the most cost-efficient way possible.

Penn State's one-year QMM program helps prepare professionals as leaders capable of bringing together collaborative teams of engineers, scientists, and business managers whose common aim is developing and delivering a quality product to the customer for a profit.

Departing from traditional patterns in the academic world, Penn State's QMM program was developed while listening to the voice of industry. The result was synthesized with the best thinking of one of the country's leading engineering colleges with one of America's top business schools.

### **Development**

Penn State's QMM program was conceived in 1991 by Mike Hottenstein from the Smeal College of Business Administration and Allan Soyster from the College of Engineering. From 1991 until the first class was welcomed in August of 1996, an intense development activity occurred involving faculty, industry, and administration. This included bench marking of joint Business/Engineering graduate programs at other universities, surveying industry needs, conducting Voice of Industry workshops in cooperation with twelve other universities, obtaining faculty endorsement from both colleges involved, and finally approval of the graduate faculty council and the administration.

### **Goals and Objectives**

The SME<sup>1</sup> reported that at the Manufacturing Education Congress on June 19, 1997, the following skills were identified as lacking in B.S. graduates entering manufacturing.

- |                              |                           |
|------------------------------|---------------------------|
| * communication              | * materials               |
| * teamwork                   | * reliability             |
| * personal attributes        | * project management      |
| * manufacturing principals   | * manufacturing processes |
| * quality concepts           | * business                |
| * statistics and probability | * change management       |
|                              | • ergonomics              |

In the development of the QMM program those skills listed above, preceded by an asterix, were identified as needed, and the program designed to introduce, enforce, and/or provide practicum in them.

### **Program**

Penn State's QMM program is an integrated one-year academic program leading to a Master of Manufacturing Management (MMM). The degree is conferred by both the College of Engineering and Smeal College of Business Administration. Faculty members from both colleges serve as QMM instructors, often both being present in the classroom to provide continuous integration of course materials. Enrollment is limited to forty-five students; combining individuals with backgrounds in business, engineering, science, and industry. The

program theme is diversity and this includes student academic, ethnic, national, and experienced background. The prerequisites are a B.S. degree and certain mathematics and statistics courses.

Work experience is a key in preparation for QMM studies at Penn State and for the careers of its graduates. While students may enter the QMM program immediately after completing a bachelor's degree in engineering, science, or business, they must take an internship with a manufacturing company in the summer before entering the program if they have no industrial experience.

Upon entering the academic year in the fall, students with an engineering or science background are required to take an introductory core course in business principles, and students with a business background are required to take an introductory core course in engineering principles. The introductory business and engineering courses, together with the nine remaining core courses are all 3-credit courses to be completed over a normal two-semester period. All core courses have been specifically designed for this program and integrate engineering and business concepts. All QMM students take the ten core courses together. They are organized into interdisciplinary teams for project exercises and encouraged to apply teamwork in their studies. The diversity of the students, specifically selected from differing backgrounds, facilitates the development and refinement of team-building skills and enriches their learning.

The core courses for the program are as follows:

*QMM 491 Introduction to Business Concepts for Manufacturing (3.0)*

Introduction to business, topics in accounting and finance for non-business students in manufacturing management.

*QMM 492 Introduction to Engineering Design Principles (3.0)*

Engineering principles including different engineering fields, graphics, design, solid modeling, and failure analysis.

*QMM 551 Quality Management (3.0)*

Concepts of design, assessment, and improvement of quality systems; customer needs analysis, identification of opportunities for application of measurement techniques.

*QMM 552 Applied Statistical Process Control and Experimental Design (3.0)*

Concepts and techniques of statistical process control and the design of experiments.

*QMM 561 Manufacturing Systems Planning and Control I (3.0)*

Systems, components, and configurations, flow of material and information in a manufacturing system.

*QMM 562 Manufacturing Systems Planning and Control II (3.0)*

Flow of material and information in a manufacturing system. Emphasis on systems integration.

*QMM 571 Design Practice for Manufacturing I (3.0)*

Contemporary concepts in design and practice with emphasis on engineering, business, and human strategy issues.

*QMM 572 Design Practice for Manufacturing II (3.0)*

Contemporary concepts in design and design practice with emphasis on logistics, risk, design and manufacturing readiness, and production.

*QMM 581 Manufacturing Processes and Materials (3.0)*

Characteristics of materials with respect to their properties and associated choices of processing to create a range of products.

*QMM 582 Manufacturing Strategy and Organization (3.0)*

Strategic decision context of manufacturing and linkage with corporate and business strategy. Includes cost drivers, organizational structure, and human relations.

*QMM 597 Communication and Leadership Skills for Managers (3.0)*

Comprehensive applied communications instruction including oral, written, and media communication.

Table 1 shows the course structure of the program.

Table 1 Curricular Structure of QMM program

Summer	Fall (16 credits)	Spring (14 credits)
Internship	Intro. to Business Concepts for Manufacturing (3) QMM 491 or Intro. to Engineering Design Principles (3) QMM 492	
	Quality Management (3) QMM 551	Statistical Process Control and Experimental Design (3) QMM 552
	Manufacturing Systems Planning and Control I (3) QMM 561	Manufacturing Systems Planning and Control II (3) QMM 562
	Design Practice for Manufacturing I (3) QMM 571	Design Practice for Manufacturing II (3) QMM 572

	Manufacturing Processes and Materials (3) QMM 581	Manufacturing Strategy (3) QMM 582
	Communication and Leadership Skills for Managers (1) QMM 597	Communication and Leadership Skills for Managers (2) QMM 597

## Results

The Quality and Manufacturing Management (QMM) Program completed its inaugural academic year in May 1997. The first year was successful beyond expectations and met or exceeded all of the parameters selected to evaluate this new program. These measures included: class size, student quality, visitors, plant trips, educational experience, industrial interaction and support, placement, and applications for the second class.

The inaugural year student enrollment of 31 exceeded the optimistic goal of 30 students. About half the incoming students had sufficient work experience to be exempted from the internship requirement. The educational experience was enriched by thirteen guest speakers and by visits to fourteen plant and/or industrial research sites. The student body participated in the Quality Expo and the Advanced Manufacturing Forum at Penn State. Major team projects were completed in the Quality Management course, the Design Practice course, and the Manufacturing Strategy course all in concert with the Communications course.

The QMM industrial partnership was initiated with nine companies participating in at least four of the following activities: advisory board, financial support, guest speakers, field trips, internships, and field projects. Table 2 lists the inaugural year industrial partnership activities.

Table 2 Quality and Manufacturing Management Program Sustained Partnerships Formed with Industry

Company Partner	Advisory Board	Financial Support	Guest Speakers	Field Trips	Internships	Field Projects
AlliedSignal	X	X	X		X	
Atotech USA	X	X	X		X	X
Austin-Hunt	X					
Belleville-Casting				X		
C-Cor Electronics					X	X
Cargill Nutrena Feeds					X	
Carpenter Tech	X		X	X	X	
Compaq Computer	X		X		X	

Corning-Asahi	X	X	X	X	X	
Eaton Cutler-Hammer	X					
Ford Motor Company	X	X	X	X	X	
IBM		X	X		X	
Ingersoll-Rand	X	X	X	X	X	
Intel			X		X	
Kodak	X	X	X	X		
Lucent Technologies	X			X		
Murata Electronics	X	X	X		X	X
New Holland	X	X	X		X	X
Neoplan					X	
Osram-Sylvania	X	X		X		
Overhead Door					X	
Ruetgers-Nease						X
Supelco						X
Veeder-Root				X		
Xerox				X		

In terms of acceptance of the new, unknown master's degree by employers, all but one of the graduates had accepted a professional position, or elected to seek further education by graduation day. The offers averaged \$52,000; over ten thousand dollars more than the graduates would have received with their baccalaureate degrees alone and exceeds that of most two year M.S. degrees. It should be noted that the program offers no assistantships and very few fellowships, most of the students are self supporting. The number of applications for the second class, Class of '98, were nearly three times that of the Class of '97. Their GRE and GMAT scores were significantly over 100 and 50, respectively higher than that of the previous class and most have industrial experience after their B.S. degree. The QMM Class of '98 is composed of about 20% international, 30% women, and 20% minority students, which provides the diversity needed to reflect manufacturing enterprise.

The evaluation criteria established by the faculty was to be based upon the interest and participation of industry and the quality of students that enrolled in the program. The response of industry and student applicants as described in the previous paragraph is a practical evaluation. The next level of criteria will be indicated by the professional success of our graduates a few years after graduation.

**Conclusions:**

1. Industry has demonstrated their approval of the program by their demand for QMM graduates.
2. The quality and quantity of students applying to the QMM program has increased significantly from the first to the second year.

**References:**

1. SME, "Education Plan in High Gear," The SME News. pp 1-2, July/August 1997

**Biographical Information:**

CLAYTON O. RUUD, Ph.D., P.E., Professor of Industrial and Manufacturing Engineering, Co-Director of The Quality and Manufacturing Management Program. Ten years of manufacturing experience in the basic metals, aerospace and heavy machinery industries. Twenty-eight years in research and academia.

MICHAEL P. HOTTENSTEIN, D.B.A., Professor of Operations Management in the Smeal College of Business Administration, Associate Director of the Center for the Management of Technological and Organizational Change, and Co-director of the Quality and Manufacturing Management Program. He has over thirty-five years experience at Penn State including service as department head, MBA Program Director, and Graduate Dean.