What is Engineering Management? A New Look at an Old Question

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Throughout my academic career in Engineering Management education (EMGT) I have often been asked, "What is engineering management?" People interested in a combination of technical and managerial career would be naturally attracted to the title of this discipline, but would have no idea what it is or how it may be similar to other more familiar or descriptive disciplines such as industrial engineering or business administration at the graduate or undergraduate levels.

Depending on the inquirer's level of interest in the topic these questions would be answered in some detail; comparisons and contrasts would be provided with examples from the actual world of work, based on my many years of experience in industry and the academe. Once answered in detail, the inquiring person usually ended up with a very positive attitude toward this relatively new discipline in engineering education.

In the following pages I will try to provide a background on the discipline of engineering management, and hopefully provide a helpful starting point for anyone who is interested in this discipline for study or professional pursuit.

It is my firm belief that engineering management is a new, broadly integrative and synthesis-focused enterprise engineering discipline. Functionally, I believe that managerial engineering is what these engineers do; that is, they do engineering in the managerial realm. In that sense EMGT is similar to other classical engineering disciplines that are concerned with the mechanical, electrical, civil, chemical, industrial, and other areas of technical problems in which design and synthesis are essential elements of the engineering work. EMGT professionals do engineering work in the managerial realm of a technological enterprise.

Anchored in science, mathematics, and engineering principles, and reaching into managerial areas, EMGT graduates can design and integrate the total enterprise system with its technical, financial, operational, organizational, marketing, and human aspects within the global competitive environment. EMGT graduates can design, establish, operate, optimize, and continuously improve a technological enterprise, public or private, for profit or not for profit. In summary they are enterprise engineers doing managerial engineering work.

A Brief History of EMGT at MIT (1)

The fundamental ideas of EMGT go back to antiquity. As a field of study these ideas were formalized within the academic environment at Massachusetts Institute of Technology (MIT). An academic program began there in 1914 as the Course Number XV Engineering Administration, in the department of Economics and Statistics. A program "…specially designed to train men to be competent managers of businesses that have much to do with engineering problems…" is the way it was introduced to the public at the time of its launching.

In 1930 the Course XV became the Department of Business and Engineering Administration as part of the Engineering School at MIT. In 1931 a one year graduate study program was initiated with the backing of several influential industrialists of the time.

In 1950 the Sloan Foundation made a gift of over $5 million to establish a School of Industrial Management. The main objective of the Sloan School of Industrial Management as stated in their charter documents was "… to correlate managerial problems with science, engineering and research…".

In 1964 MIT the School of Industrial Management was renamed the Alfred P. Sloan School of Management and administratively became independent of the School of Engineering, while maintaining close association with its engineering roots.

In 1981 the Management of Technology program (MOT) was established as a 12-month, full time MS program jointly developed by faculty of MIT's Alfred P. Sloan School of Management and the MIT School of Engineering. The MOT program was designed for "...engineers and scientists to prepare them for senior roles in industry and government where they would generate and manage technology based endeavors...".

In 1995 MIT Alfred P. Sloan School of Management began offering for the first time a non-thesis Masters degree, the MBA, along with the original MS in Management that had a required thesis component. Thus the MIT Course XV, eight years after its inauguration, evolved away from an undergraduate program called Engineering Administration housed in the school of engineering into a graduate program in Management located in a school of management. While the MIT program was developing its roots in an engineering school environment and later growing into a comprehensive management education providing institution, it still kept some of its engineering characteristics by maintaining the MS degree with thesis and a strong mathematical foundation for the degree programs offered.

A Brief History of EMGT at the University of Missouri Rolla

One of the major players in the academic discipline of EMGT is the Missouri University of Science and Technology. It was established as the Missouri School of Mines (MSM) as part of the University of Missouri main campus (located in Columbia, Missouri) following the passage of the Morrill Act of Land Grant Colleges of Agriculture and Mechanic Arts. MSM was established as a technical branch of the University of Missouri as part of the Land Grant tradition due to the existence at the time of many mining companies, especially lead mining, in south central Missouri. It was located in Rolla due to the availability of a new school building (Rolla Building) that the city was willing to dedicate to the new school. By the mid-1950s MSM had grown

to be one of the largest engineering schools in the country with a distinguished reputation as a technical campus.

In 1964 the Rolla campus was separated from Columbia to become the University of Missouri-Rolla (UMR) under a visionary leader – Chancellor Merl Baker. Among the academic programs added in 1965 to expand and enrich the offerings of this new university was a BS degree in engineering administration under the program in economics. This program was quite similar to the MIT Course XV in content and orientation. Chancellor Baker's interest in broadening the technical dimensions of UMR befitting a full-fledged university and his knowledge about the MIT program in engineering administration may have played a significant role in the development of this program at Rolla. In addition there was a need to create a softer, alternative path for students enrolling in the classical engineering disciplines who were finding them to be unmanageably demanding. I have heard from the administrators who were in charge of the university at the time that one reason they started the program under the name of "Engineering Administration" was that several business schools in Missouri objected to UMR starting a business administration program and the industrial engineering programs likewise did not want an IE program to start in Rolla. Eventually the name combination of "Engineering Administration" seemed to be acceptable to all.

In 1967 Bernard R. Sarchet, a chemical engineer with significant experience as a technical and corporate manager, was hired as the department head. Sarchet changed the name of the program to EMGT and moved it into the School of Engineering and away from the program in economics, similar to what happened at MIT. His replacement of the word "Administration" in the title of the program with the more appealing "Management" may have been simply due to his desire to project a brighter and more attractive image to prospective students and employers of the graduates of EMGT programs. Perhaps one may speculate that if Sarchet had to re-name the program now he may have used the word "Leadership" instead!

Sarchet also expanded the program offerings to St. Louis at the MS level while keeping the BS and MS degree offerings in Rolla. He frequently referred to the BS degree program in EMGT as "...a blend of three years of engineering and one year of management...". The Curriculum was made up of three years of one of the classical engineering disciplines offered on campus plus some statistics, optimization, and typical business courses such as finance, marketing, cost accounting, etc. The BS-EMGT degree would not have been ABET accreditable as it was designed at the time without engineering design and some other aspects being strengthened. The MS curriculum content at the time may best be described as approximately 30% technical and 70% management.

From the beginning, however, the typical business classes such as finance and marketing were taught with a technological orientation and by professors who had considerable industrial experience and at least one engineering degree. Main functional areas of an enterprise were covered in the programs of study with a lot of case studies and group projects.

On the UMR campus, the BS-EMGT program was seen as a "safety net" for students who for one reason or another dropped out of the classical engineering disciplines and switched to EMGT instead of leaving the campus. Many of these students ultimately returned to their intended majors once they overcame the academic difficulties they were having, but many more stayed in the EMGT program to complete the non-ABET accredited BS degree in EMGT. Large companies such as Proctor & Gamble and IBM recruiting graduate engineers on campus for technical sales and supervision of production operations quickly discovered that BS-EMGT graduates were well suited for these jobs. This emerging demand caused significant growth in enrollments of the BS-EMGT degree program on campus shortly after its inauguration

The MS-EMGT program also found a very receptive customer base among graduate engineers from classical disciplines who were looking for an alternative to the traditional MBA in the St. Louis market and other industrial environments. UMR's MS-EMGT program that was 30-33 credits long provided a competitive advantage for students considering the 45-60 credit MBA programs. Applicants liked the fact that in the MS-EMGT program, management would be taught by former engineers who had achieved significant management success in industry. Also the fact that they would be in classes populated with other technical people provided an additional incentive for selecting the MS-EMGT degree provided by UMR on the campus of the University of Missouri-St Louis.

ABET accreditation was seriously sought after Dean James Halligan insisted that all engineering departments in the school of engineering at UMR must be accredited by ABET. After the EMGT curriculum was modified appropriately, accreditation was achieved for the BS degree in 1979. This was followed by the U.S. Military Academy (USMA) and Stevens Institute of Technology EMGT programs. Southern Methodist University also had a BS program in EMGT within its industrial engineering department but it quickly got away from teaching EMGT at the undergraduate level and hence abandoned their aspirations for ABET accreditation in EMGT.

I believe that during my time at UMR, the program transitioned into a true engineering program – from the "...blend of three years of engineering plus one year of management..." to an engineering synthesis of the hard engineering and soft managerial content. The design element of engineering was internalized in many management-based courses where the essence of engineering design was applied to the design of marketing, financial, organizational, and strategic management systems. Also the research output measured in externally funded research dollars and the number of MS theses and PhD dissertations produced was greatly enhanced. New areas with more technical flavor such as artificial neural networks, quality engineering, robotics, etc., were also developed. The concept of the Learning Factory, an industrial grade comprehensive manufacturing systems laboratory and horizontal integration of such an enterprise as part of the curriculum were implemented making our PhD graduates sought after by other universities.

EMGT Education in Numbers (2)(3)

As of October 1, 2008, there were five ABET accredited BS degree programs in the U.S. in this discipline: UMR -1979, USMA - 1985, Stevens - 1992, University of the Pacific - 2004, and Arizona - 2005. Another similar program that was accredited under EMGT guidelines is available at the University of Connecticut under the name of Management and Engineering for Manufacturing. The Air Force Institute of Technology (AFIT) offers an ABET accredited MS program in EMGT since 2004.

According to ASEE sources, the total numbers of EMGT degrees granted in 2006-07 were 274 BS, 2114 MS and 37 PhD. Out of the total of 274 BS degrees, 153 were from ABET accredited programs. There are 17 BS degree awarding and 67 MS degree

awarding universities in the U.S. in EMGT as listed in the ASEE Profiles of Engineering Colleges 2007 Edition.

With the degree programs not listed in the ASEE sources and the ones under industrial engineering as a track in EMGT, it is estimated that over 150 such programs exist at U.S. colleges and universities offering an MS degree in EMGT. Added to these numbers may be another 100-plus programs in business schools offered under various names such as management of technology, technology management, or technical MBA.

The BS programs in EMGT are usually independent programs or departments within the schools of engineering directly reporting to the dean of engineering. IE departments are the most common academic home for the EMGT programs at the MS level.

What is Design in EMGT?

Analysis and design define engineering disciplines. At the BS level, the design element in EMGT may be found in the complete design of a technological enterprise similar to the plant design in industrial engineering. At Rolla the design element was accomplished by integrated technical case studies. At the MS level the design component usually comes from the students' undergraduate backgrounds and thus the curriculum is more analysis and management oriented, and less focused on engineering design. In this sense a BS graduate of an ABET accredited EMGT program would have similar skill sets as a graduate from a classical engineering discipline who also has an MBA.

Many BS programs do a good job of providing the design component in their curricula. One of the best such programs I was privileged to work with is the one at Istanbul Technical University. In their engineering management program they have a three course sequence that covers the design of a physical product or a service (Course 1), design of a production facility for a physical product including suppliers and distribution channels (Course 2), and the design of a comprehensive technical enterprise providing a service including a business plan that is suitable for seeking venture capital for its implementation (Course 3).

EMGT vs. IE, MBA and MOT

Comparing and contrasting these degree programs are often highly dependent on the orientations of the degree-granting institutions making some of the programs quite similar and almost interchangeable. Here I will attempt to provide some of the most likely differences among these programs.

IE graduates at the BS level seem to be prepared to solve problems as staff analysts to support operational managers. At the MS level, IEs specializes in the staff expert role to solve problems and make recommendations to higher level executives. IEs as other engineers can also serve as line managers after some on the job experience.

EMGT graduates, on the other hand, at the BS and MS levels are prepared for line functions as well as staff work. Many EMGT graduates are hired for technical marketing and operations management roles requiring analytical skills and optimization capability. EMGT education combines staff and line capabilities in one person thus making the graduates more flexible and efficient in their careers. Their area of weakness compared to most classical engineering including the IE degree graduates would be in high level engineering analysis and design unless they cultivated a special interest in it such as machine design; however, for many small to medium size companies employing only a few graduate engineers, the BS-EMGT graduates will do a good job in design work in support of the manufacturing and sales functions.

An engineer with a BS degree in a classical engineering discipline who has an MBA from a leading school of business may perform better compared to an EMGT or IE graduate in higher corporate levels of management especially after ten or more years of managerial experience at the lower levels. The source of the MBA degree may also play a role in the degree of success for such professionals. An MS in EMGT is more efficient and effective for one's technical career especially in its earlier years. An MBA from a good school may be a better choice for an engineer if one plans to leave the technical work environment entirely.

MOT and similar degree programs are also effective career enhancers but they are not considered engineering degrees as they are often associated with business school degree offerings along with the most popular MBA.

Summary

In general we may conclude that the EMGT education provides a competitive advantage in the job market for engineers, especially in the earlier part of their careers, compared to those who do not have the enterprise integrating skills and credentials provided by the EMGT education. Mastering the enterprise analysis and design as well as management skills built upon a sound foundation in engineering as provided efficiently by the EMGT education at the BS and MS levels will usually lead to challenging and satisfying careers.

At the BS and MS levels, the EMGT degree can be an ABET-EAC accredited engineering degree with all the privileges such a degree imply. The BS degree bridges the gap between hard engineering based on realist philosophy (science) and soft management mostly based on idealist philosophy (art). A BS in EMGT is an efficient route to obtain in four years a combination of the fundamental skill sets offered by engineering and the MBA degrees. As a result the BS-EMGT degree graduates have a broader and more flexible employability compared to most classical engineering degree holders.

Students who inquire about the MS degree in EMGT and eventually enroll in it appear to seek either depth in an area or breadth linking several areas of the technological enterprise in which they are involved. They expect the study and the degree in EMGT to broaden their career options or increase their rate of progress within the ranks in their work environments. They believe that the EMGT degree will make them better and more effective leaders in their organizations. They expect to become more effective in dealing with people related problems, team work, and interpersonal communications which would lead to overcoming various organizational barriers to achieve rapid career growth. MS degree recipients also expect and often receive a salary increase as a result of this achievement alone.

The MS in EMGT is a degree well received by industry. It provides the graduate broader career options. It is a more efficient path for an engineer seeking management skills and credentials. MBA and MOT are not considered engineering degrees.

Conclusion and Recommendations

I believe that most EMGT programs, if left alone, will end up like the MIT program, gradually evolving into a management program, or under the tutelage of the IIE within the ABET they will evolve into IE departments. EMGT educators must work hard on the horizontal integration of all aspects of a technological

enterprise and establish a new school concept that serves as an umbrella to both the technical/engineering and the managerial disciplines. After all, in the real world problems seldom appear as simply a technical problem requiring an engineering degree or a management problem requiring a management education. Real world problems we face everyday are complex and contain technical and management dimensions. People trained in EMGT may be the best general practitioners to deal effectively with such problems for the benefit of all.

The future schools of engineering management which offer both the ABET accredited EMGT degrees with its many tracks from management of technology to manufacturing systems as was done in Rolla, and management information systems, financial engineering, technology marketing, and organization design and development and human factors in management and other programs usually found in AACSB accredited business schools might be the ideal bridge building that we need for such a bright future in EMGT education.

References

(1) MIT Sloan School of Management Web site
(2) ABET web site
(3) ASEE 2007, Profiles of Engineering and Engineering Technology Colleges, Published in 2008 by the American Society for Engineering Education (ASEE). Washington DC.

About the Author

Bill Omurtag received his BS in mechanical engineering from Iowa State University in 1962, his MS in mechanical engineering from Middle East Technical University, Ankara, Turkey, in 1968, and his Ph.D. in industrial engineering from Iowa State University in 1971. He currently serves as a professor of engineering and science in the School of Engineering, Mathematics and Science at Robert Morris University where he was the Founding Dean of the School of Engineering, Mathematics and Science. His previous academic service includes the University of Missouri-Rolla, asst-full prof and head of engineering management department; The Wichita State University, head of the industrial engineering department; California State University-Sacramento School of Business and the Middle East Technical University co-founder of the Department of Industrial Engineering and department chair. He is ASEM founding member number 19.

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