

Perhaps a Shift in Direction in Engineering Management Education: A Discussion and Work in Progress of Adding Data Modeling Topics to the Foundation of an EM Curriculum

Dr. Kate D. Abel, Stevens Institute of Technology (School of Engineering and Science)

Kate Abel serves as the as the Director of the Bachelor of Engineering in Engineering Management Program in the School of Systems and Enterprises at Stevens Institute of Technology. She holds a Ph.D. in Technology Management and Applied Psychology. She has held several professional service positions, including the President of the Engineering Management Division of the American Society for Engineering Education and the President of Epsilon Mu Eta, the Engineering Management Honor Society. She teaches courses in Total Quality Management, Engineering Economics, Entrepreneurial Analysis of Engineering Design, Statistics for Engineering Managers, Management of Engineering and Technology, and Senior Design. Her research areas include knowledge engineering, as well as knowledge and information management. She is a member of the Board of Advisors at West Point for the Department of Systems Engineering. She is also a member of several professional societies, including ASEE, ASEM, ASME, and EMH.

Perhaps a Shift in Direction in Engineering Management Education: A Discussion and Work in Progress of Adding Data Modeling Topics to the Foundation of an EM Curriculum

Abstract

Traditionally, the Engineering Management body of knowledge contains topics such as project management, financial resource planning, and the management of technology, etc. But are these traditional tools enough to prepare an Engineering Management student for the ever more technologically complex and data driven corporate world of the 2020's? More recently systems engineering concepts have been added to the Engineering Management Body of Knowledge. Is this now enough? Stevens Institute of Technology thinks not. Over the past few semesters, Stevens incorporated more concepts on informatics and other data analytics, modeling and visualization topics beyond Operations Research into its' curriculum. Recent alumni, and cooperative education students alike, have been impressed with the quality and quantity of employment prospects. Should other Engineering Management programs consider the addition of such topics to the foundation of their curriculums? This article will discuss the pros and the pushbacks to making what others call an 'area of emphasis', core to a traditional Engineering Management curriculum.

Introduction

The Engineering Management Body of Knowledge (EMBoK) contains Engineering Management principles and practices over 11 different knowledge domains¹. (See Table 1 below which summarizes the domain areas in the 2012 edition of the EM Body of Knowledge.) The content of those domains details the standard principles and practices generally accepted and applicable in the field of engineering management. It represents the best information available collected from various content areas such as published books and studies on Engineering Management, as well as, feedback from subject matter experts from across industry, government and academia. Whether a practicing engineer, an engineering manager, or a trainer or educator of engineers, the EMBoK is an indispensable resource about what constitutes the knowledge, skills and abilities expected in Engineering Management education and practice.

Table 1 – EMBoK domains

General Engineering Management
Leadership and Organizational Management
Strategic Planning
Financial Resource Planning
Project Management
Operations and Supply Chain Management
Marketing and Sales Management
Management of Technology, Research and Development
Systems Engineering
Legal Issues in Engineering Management
Professional Codes of Conduct and Ethics

Originally there were eight domains in the EMBoK. But in the 2012 edition, the domain areas were expanded to 11 with the addition of domains such as Operations and Supply Chain Management, and Systems Engineering. Interestingly, Stevens had Supply Chain Management in its curriculum since 2009 (and Logistics and Operations Management for years before that), as well as Innovative Systems Design since 2007 and Introduction to Systems Architecture and Design since 2011.

There are only a handful of universities that have had an Engineering Management program for as long as, or longer than, Stevens. These long standing Engineering Management programs have similar sounding courses, and have had them for a similar number of years. For example, USMA at West Point's Engineering Management program has a "Supply Chain Engineering and Information Management" course as well as a "Fundamentals of Systems Engineering Course"². Similarly, Clarkson University's Engineering Management program has an "Operations and Supply Chain Management" course³ and Missouri Science and Technology's EM program has an "Introduction to Complex Systems Engineering"⁴ course.

Looking further into these school's Engineering Management programs shows that WestPoint has an "area of emphasis" in both "Information and Decision Systems" and "Simulation" while MS&T has an "emphasis area" in "Industrial Engineering". These emphasis areas may be similar to the areas being proposed in this paper. That is not being argued. However, the focus of this paper is in the question of if these areas should be core to the EM discipline to ensure the success of our graduates.

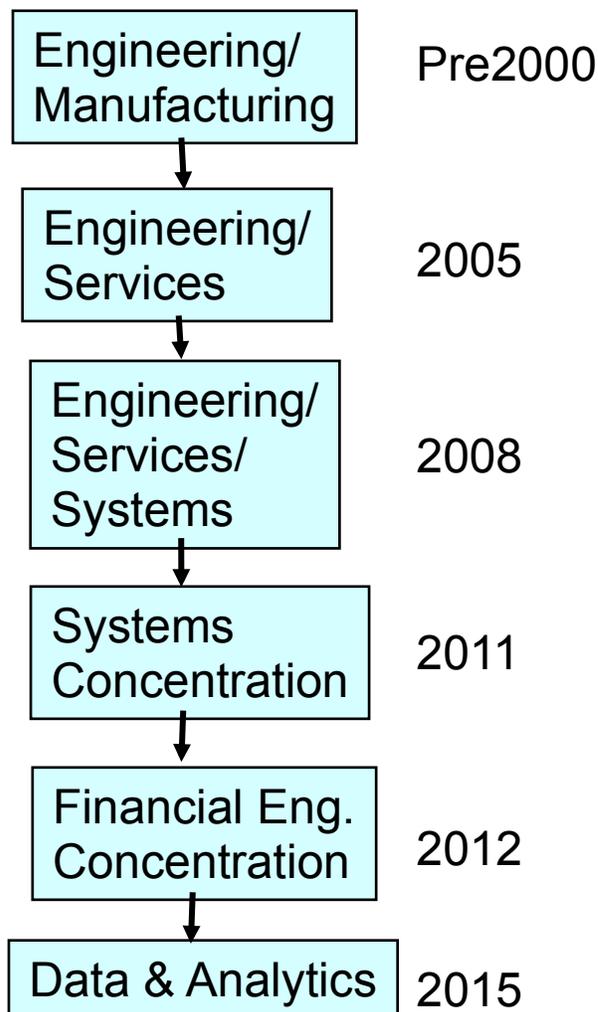
Population

Stevens Institute of Technology is a small, private, urban campus across the Hudson River from Manhattan in New Jersey. Approximately 3000 undergraduate students are enrolled, of whom about 2000 are engineering students. The Engineering Management Program housed in the School of Systems and Enterprises at Stevens has been ABET accredited since the early 1990's and has about 125 students in the program in any given year.

Curriculum Change

Academic curriculums usually change over time as the world and business change, and Steven's curriculum is no different. Back in the 1990's, the EM curriculum at Stevens was mainly manufacturing based. Over time, the focus shifted to more services based topics. Subsequent to that, there was another shift toward including Systems Engineering in the Engineering Management curriculum. See Figure 1 for a graphical representation of the Engineering Management curriculum shift at Stevens over the past two decades.

Figure 1 – Decades Transition of the Engineering Management Program at Stevens



As mentioned above, times changed and in addition to curriculum change at Stevens, there was an update to the EMBoK in 2012 as well. The question begs to be asked if the domain areas listed in Table 1 are enough in 2016? Do they convey the topics that are necessary for today's engineering manager to succeed? What about the education of

tomorrow's engineering manager? Will the EM graduates of 2020 succeed with the topics being taught in the EM curriculum today?

A few years ago, students, alumni and employers were speaking to the EM Program faculty of the changing landscape of the work they were being asked to do which lay beyond the EMBoK. Anecdotal data from these constituents was discussed at faculty meetings. Over time and much discussion, some faculty at Stevens began to believe the topics in the 2012 EMBoK were not enough. During these same several years, members of the Stevens' EM senior class were surveyed on their opinions of what topics they felt should be added to the EM curriculum, and what topics they felt should be merged or have less focus. Again and again for several years in a row, student data from these surveys pointed in the same direction as the anecdotal employer, alumni and faculty statements. Concurrently each year, the outcome from this data was shared with the Board of Advisors (representing employers, external and internal academia, students and alumni) to get their feedback as well. Eventually proposals for specific courses were created, and for the merging of others, based on the feedback, were brought to the Board of Advisors. The Board of Advisors had overwhelming support for the implementation of the new material into the core of the Engineering Management curriculum at Stevens. However, as many academics are well aware, adding material to a curriculum is tough to do given the lack of wiggle room in adding credits. Additionally, some faculty can be very hard set against changing curriculum that has been tried and true. However over some complaint, new topics were added to the Engineering Management curriculum at Stevens, and existing topics were combined and /or integrated into existing courses to do it. As example, the two separate courses of "Business Process Reengineering" and "Total Quality Management" were combined to create "Operations Management and Process Engineering" freeing up a space for a new course. Additionally, "Introduction to Engineering Management" which had been very much an introductory survey course, was eliminated and the crucial aspects of it integrated into the existing "Project Management" Course.

After the usual assessment processes of determination of need, and understanding of the necessary topics to fill the need, courses were discussed, proposed, edited, approved and added to the curriculum. First came "Analysis of Networks and Strategies" and "Data Mining and Risk Assessment" in the fall 2014 and then "Informatics and Software Development" in 2015.

These new courses were seen as critical to an engineering managers' career success given the countless systems producing massive amounts of data in today's business environment. Engineering professionals are necessary who can analyze complex data, extract knowledge from it, and deploy management strategies based on their insight to give or maintain a competitive advantage to their company.⁵ The business world has already made known that there will be a dire need in the next decade for professionals who can harness data into meaningful information that can be used in the making of critical decisions.⁶ As such, the Engineering Management program at Stevens believed that EMs' would be at a disadvantage if they were not provided this skill set needed in today's data driven business world.

Catalog descriptions of each of the new courses are included in Table 2 to assist readers in knowing the content of the new courses as well as in what stage of student learning in the curriculum such courses were added.

Table 2 – New Data Modeling Courses

Course Number and Name	Catalog Description
EM 224 – Informatics and Software Development	This course deals with the challenges associated with the variety and volume of information encountered in today's workplace, and working with others in a software development environment. Students will analyze and work with both structured and semi-structured data, using the python programming language. Students will learn about the types of software development environments they are likely to encounter in their careers. The capstone of the course is a small-group project that analyzes real-world data to answer a business or research question.
EM 451 – Analysis of Networks and Strategies	This course is designed to help with understanding the complexity, structure and dynamics of a highly connected world. It takes an interdisciplinary look at economics, sociology, information science and applied mathematics to discuss some of the fundamental features of networks and their behavior. The course is designed to equip students with a modeling lens to analyze, quantify and reason about structures, dynamics and evolution of complex networks. Key topics that are covered in the course are mathematical description of complex networks, fundamental measures of network structure, diffusion and cascading, voting and economic and market implications. The course will also have a particular emphasis on game theory as the method to model resource allocation in networks in the presence of autonomous agents.
EM 489 – Data Mining and Risk Assessment	This course will use tools and techniques, which have proven to be of value in recognizing patterns, making predictions, and evaluation of risk from both large data sets (using data-mining techniques), and small data sets (using networks constructed from problem definition and discovery). Both approaches are critical to today's engineers and managers, because they span a range of possible data availability and reliability. Using these tools and techniques, the student will survey applications, and have hands-on experimentation with both data mining and network construction, using real-world examples and situations.

Results and Future Directions

Stevens has had only one Engineering Management class graduate since the overhaul in the curriculum. However, many of these students were too far along in their academic career to partake in the new courses. Though the seniors of the class of 2015 had a deep desire to take the new classes, alas many of them could not fit them in their schedule. As such, at this point there is mostly anecdotal evidence regarding the impact of this significant change to the Stevens's core Engineering Management curriculum and there is no formal assessment methodology yet to conclude about the effectiveness of introducing these new courses.

Since only one class has graduated, at this point it is difficult to quantify the effectiveness of the new courses. However, for those few students who did get to take the new classes, feedback from seniors was that the new courses were phenomenal and provided knowledge they could see using immediately in the job they accepted upon graduation. Although data only exists for one semester, it is none-the-less provided below as an example of the type of feedback Stevens is receiving on the new core courses. See Table 3 – Course Assessment Feedback. Please note sample size is only for one course each, so approximately 25 students per course listed below.

Table 3 - Course Assessment Feedback on Overall Evaluation of the Course

Course Number	Rating out of 4.0
EM 224 - Informatics	3.8 out of 4
EM 451 – Networks and Strategies	3.4 out of 4
EM 489 – Data Mining	3.6 out of 4

Anecdotal student feedback has been positive and in large supply. It was already mentioned that seniors of the class of 2015 wanted to take these new courses, even though they did not need them to graduate. Similarly, those who are graduating in 2016 and who thus overlap both old and new curriculum, also requested to be allowed to take the new courses though some do not need them to graduate. Additionally, alumni who have interacted with faculty over the past year and a half are thrilled and excited to hear about the new topics in the EM curriculum, and are offering co-ops and internships to those students who had taken the new courses (but not so much to those who have not).

Time will tell if these courses in data topics and data modeling will become core to the next generation of Engineering Manager in the work place. Given immediate anecdotal and assessment feedback among Stevens' engineering management undergraduates and recent alumni, evidence is strong that it will. Interestingly, a new phenomenon occurred in spring of 2016. Suddenly the new EM courses were filling up and reaching their enrollment cap with EM students still needing to be enrolled. Upon close inspection it was discovered that students in other majors were enrolling into these new EM courses

because they think they are “interesting” and “useful” and will “help them in the workplace”. The anecdotal evidence is getting stronger regarding the need for these topics!

As we move to the future, Stevens hopes to gather feedback from other universities as to their opinion about the addition of data modeling topics into the core of Engineering Management programs. Additionally, Stevens hopes the change in curriculum will lead to quantifiable changes in its senior surveys and well as improvement in Engineering Management outcomes, graduate starting salary, satisfaction, etc that coordinates with this change in the EM curriculum.

Bibliography

- 1) Shah, Hiral, Editor, “Guide to Engineering Management Body of Knowledge”, American Society for Engineering Management, 2012.
- 2) <http://www.usma.edu/se/SiteAssets/SitePages/Engineering%20Management/Department%20of%20Systems%20Engineering%20Class%20of%202018%20Engineering%20Management%20Brochure.pdf>
- 3) <http://www.clarkson.edu/em/curriculum/index.html>
- 4) <http://catalog.mst.edu/undergraduate/degreeprogramsandcourses/engineeringmanagement/#bachelorstext>
- 5) McAfee, Andrew and Brynjolfsson, “Big Data: The Management Revolution, Harvard Business Review, October 2012.
- 6) Davenport, Thomas H. and Patil, D.J, “Data Scientist: The Sexiest Job of the 21st Century”, Harvard Business Review, October 2012.