2006-174: A PROPOSED ENGINEERING MANAGEMENT BODY OF KNOWLEDGE (EMBOK)

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An Engineering Management Body of Knowledge (EMBoK)

Abstract

An Engineering Management Body of Knowledge (EMBoK) is proposed and then used to develop topics and their relative weights which could be used for an Engineering Manager's certification test.

There have been a number of articles over the last 25 years which analyzed Engineering Management curricula and helped define an EM body of knowledge. The most prominent author was Dr. Dundar Kocaoglu [1,2,3,4]. The major categories used in this article are consistent with Dr. Kocaoglu's functional definitions. To better define the fields, subcategories were added and the order changed to reflect most EM curricula.

An EMBoK is proposed using these functional definitions and subcategories. Typical courses that appear in EM accredited undergraduate and graduate programs, consistent with the definitions, are listed.

The EMBoK definitions are compared to the Accreditation Board for Engineering and Technology (ABET) and the American Society of Engineering Management (ASEM) criteria for EM programs to determine if there is consistency. ABET is primarily used for undergraduate and ASEM for graduate programs.

Lastly, the EMBoK developed was used to help decide the fields and typical courses which could be used to test the competence of engineering managers. The topics were weighed based on the ABET and ASEM criteria. These weights will be verified by analyzing undergraduate EM programs accredited by ABET and graduate programs accredited by ASEM.

Previous Research / Literature Search

Engineering Management is a relatively new discipline which combines a knowledge of both academic and practice topics. Also required is expertise in several areas (frequently with more depth in one area) and a working knowledge of several more [5, 6, 7].

Over the last 25 years, there have been a number of articles which analyzed Engineering Management curricula and helped define an EM body of knowledge. The most prominent of these authors was Dr. Dundar Kocaoglu [1,2,3,4] who analyzed virtually all the EM related undergraduate and graduate programs using a consistent set of categories.

Definition of Engineering Management Fields:

The following major categories are consistent with Dr. Kocaoglu's definitions. This should be familiar to researchers in the field. To better define the fields, subcategories were added and the order changed to reflect most EM curricula. The example fields represent a typical course name and/or related field.

The result is summarized as follows:

 # The Major Category – Functional Definition
A. .. Sub Category – Field or Topic
Typical Course Names/Field Names

This set of definitions can be used to analyze most undergraduate and graduate EM curricula as well as define the field of Engineering Management. However, not all the fields or topics listed define EM, but a subset will.

Major Functional Definitions; Sub Fields; Typical Course Names

1. Qualitative / Conceptual Courses
A. Individual People oriented
Typical Course Names: Individual Psychology; Personnel Management
B. Organization or Group oriented
Typical Course Names: Organizational Behavior; Management Theory; Teaming

2. Quantitative / Methodical Courses
A. Quantitative
Typical Course Names: Statistics; Operations Research; Decision Theory; Simulation
B. Methodical
Typical Course Names: Systems Engineering

3. Accounting / Financial and Economics Courses
A. Accounting / Finance
Typical Course Names: Managerial Accounting; Financial Accounting; Cost Accounting; Eng. Accounting; Financial Management; Managerial Finance
B. Economics
Typical Course Names: Eng. Economics; Macro or Micro or Managerial Economics

4. Project Related Courses
A. Project Management
Typical Course Name: Project Management
B. Capstone
Typical Course Names: Capstone; Special Projects

Major Functional Definitions; Sub Fields; Typical Course Names – cont.

5. Functional Courses

A. Functional Technical Management

Typical Course Names: Operations Management; Quality Management; Engineering Management; R&D Management; Marketing Management

B. Functional Business Management

Typical Course Names: Marketing; Engineering Law; Mgt. Information Systems

6. Engineering and Science Courses

A. Engineering Courses

Typical Course Names: any with "engineering" in title – except for Engineering Management; Systems Engineering and Industrial Engineering

B. Science Courses

Typical Course Names: Mathematics, Chemistry or Physics courses

Engineering Management Major Functional Definition; Sub Fields; Typical Course Names: Exhibit 1.

Engineering Management programs (undergraduate or graduate) could be categorized by the above set of definitions. However, only a subset of the fields or areas represents EM's contribution to a student's or practitioner's education. In addition, the topics/ fields chosen need to be consistent with already established accreditation criteria.

Exhibit 1 summarizes the relevance of the topic to the EM Body of Knowledge. The Core category represents the topics/fields that every EM student should know and master. Specialties are those topics/fields where a student benefits from more in-depth knowledge. Lastly, supporting topics/fields are those that help a student understand the content of which EM is a part.

The ABET and ASEM column indicates whether the Core, Specialty and Supporting categories are consistent with these accreditation criteria.

The ABET criteria is listed in Appendix A and is the criteria used to define EM programs. This set of criteria is used primarily for undergraduate programs.

The ASEM criteria are listed in Appendix B and are to certify graduate programs in EM.

Obviously, this is a "snap shot" in time and will change as engineering, technology and management knowledge evolves. A good example of this is the merging of Systems Engineering and Engineering Management departments in some of the ABET accredited schools. As these trends continue they will influence the EM BoK. Thus, this should be considered a work in progress and

be revisited at regular intervals, just as we do with our EM undergraduate and graduate curricula. Currently those cycles are 5 to 7 years.

Engineering Management BoK Testing / Certification: Exhibit 2

One of the uses of the EMBoK is to help decide how to test students/practitioners to determine if they have mastered the topics and fields. Exhibit 2 summarizes a possible test weight and typical courses.

This is a first draft based on the accreditation criteria (ABET and ASEM) and on the number of courses in accredited programs. These weights need to be adjusted periodically based on surveys of EM faculty and practitioners and continued analysis of accredited programs.

Exhibit 2 will be used as a guide to evaluate accredited (ABET) undergraduate EM programs and certified (ASEM) graduate programs [7]. Based on this empirical evidence the weight will be adjusted. As the EMBoK evolves over time periodic reevaluations need to be conducted.

Exhibit 1: Importance of Fields/Topics to EM BoK; Consistency w/ ABET, ASEM

Major Topic/Field Subtopic	Core	Spec-ialty	Support-ing.	Consistent w/ABET	Consistent w/ASEM
1. Qualitative / Conceptual Courses. *A. Individual People orientated*	YES	NO	NO	Yes	Yes
1. Qualitative / Conceptual Courses. *B. Organization or Group orientated*	YES	NO	NO	Yes	Yes
2. Quantitative / Methodolical Courses *A. Quantitative*	YES	NO	NO	Yes	Yes
2. Quantitative / Methodical Courses *B. Methodical*	YES	Maybe	NO	Yes	Yes
3. Accounting / Financial & Economics *A. Accounting / Finance*	YES	NO	NO	Yes	Yes
3. Accounting / Financial & Economics *B. Economics*	YES	Maybe	NO	Yes	Yes
4. Project Related Courses *A. Project Management*	YES	NO	NO	Yes	Yes
4. Project Related Courses *B. Capstone*	YES	NO	NO	Yes	Yes
5. Functional Courses *A. Functional Technical Management*	Some	YES	NO	Yes	Yes
5. Functional Courses *B. Functional Business Management*	NO	YES	NO	Yes	Yes
6. Engineering and Science Courses *A. Engineering Courses*	NO	NO	YES	Yes	Yes
6. Engineering and Science Courses	NO	NO	YES	Yes	Yes

B. Science Courses					

Exhibit 2: Importance of Fields / Topics to EM BoK; Test Weights; Typical Courses

Major Topic/Field Subtopic	Importance To EM	Weight	Typical Courses
1. Qualitative / Conceptual Courses. *A. Individual People orientated*	Core	0%	Ind. Psychology
1. Qualitative / Conceptual Courses. *B. Organization or Group orientated*	Core	18%	Management Theory Org. Behavior
2. Quantitative / Methodical Courses *A. Quantitative*	Core	18%	Statistics ; Operations Research; Simulation
2. Quantitative / Methodical Courses *B. Methodical*	Core	10%	Systems Engineering
3. Accounting / Financial and Economics *A. Accounting / Finance*	Core	9%	Accounting
3. Accounting / Financial and Economics *B. Economics*	Core	12%	Engineering Economics
4. Project Related Courses *A. Project Management*	Core	10%	Project Management
4. Project Related Courses *B. Capstone*	Core	7%	Integrative Problems
5. Functional Courses *A. Functional Technical Management*	Core	16%	Engineering Mgt., Operations Mgt., Quality Mgt
Totals		100%	
5. Functional Courses *B. Functional Business Management*	Specialty		--
6. Engineering and Science Courses *A. Engineering Courses*	Supporting	0%	--
6. Engineering and Science Courses *B. Science Courses*	Supporting	0%	--

Reconciliation of Weights with Previous Study

In previous papers [8, 9, 10]. it was stated that the weights will be adjusted based on the feedback from the schools and based on combining the graduate and undergraduate results. Because of this feedback and analysis the weights slightly changed. Exhibit 3 provides a comparison of the previous paper and this one.

The feedback caused only a slight change in weights as indicated in Exhibit 3. Consistency was judged as the difference between the estimates. A difference of 1% was judged to be well within the variation of the various programs. A 2% deviation was acceptable.

While the categories were combined for this comparison the deviation among the individual subcategories did not vary by more than 2%. As stated previously, it is expected that these weights change over time as the EM BoK evolves.

Exhibit 3: Comparison of Previous with Current Study.

Categories	Previous Paper %	Current Paper %	Difference %	Consistency
1A and 1B	20	18	- 2	Yes
2A and 2B	27	28	+ 1	Yes
3A and 3B	20	21	+ 1	Yes
4A and 4B	18	17	-1	Yes
5A	15	16	+1	Yes
Total	100	100	0	

Appendix A. ABET Criteria for EM programs

Source: ABET:
Criteria for Accrediting Programs in Engineering in the US, 2003 -04
Program Criteria for Engineering Management and Similarly Named Engineering Programs

1. Curriculum.

The program must demonstrate that graduates have: an understanding of the engineering relationships between the tasks of planning, organization, leadership, control, and the human element in production, research, and service organizations; an understanding of and dealing with the stochastic nature of management systems. They must also be capable of demonstrating the integration of management systems into a series of different technological environments.

Appendix B. ASEM Criteria for EM Graduate Programs

Source: ASEM Website: Certification Academic Standards: Graduate Programs

B. Curriculum Requirements

1. A balance between qualitative and quantitative courses
2. At least one third of the curriculum will be management and management related courses.
3. Courses designated "Engineering Management" are in the academic catalog.
4. Course material must be directly related to technology driven organizations.
5. The curriculum must require each student to demonstrate a command of written and oral communication skills in English.
6. Courses must relate to knowledge workers in a global environment.
7. Each student is required to perform a capstone project or thesis using analysis and integration of Engineering Management concepts.
8. A minimum of one course in probability and statistics
9. A minimum of one course in engineering economy
10. Two courses in quantitative analysis courses are required.

Bibliography:

1. Kocaoglu, Dundar F.,
"Educating Engineering Managers for the Future",
ASEE Annual Conference Proceedings; (1983) pp. 794-798.

2. Kocaoglu, Dundar F.
"Engineering Management Education and Research"*;*
*IEEE; (*1984) pp.341-342.

3. Kocaoglu, Dundar F.
"The Emergence of Engineering Management Discipline";
ASEE Conference Proceedings (1986); pp. 240-247.

4. Kocaoglu, Dundar F.
"Education for Leadership in Management of Engineering and Technology",
IEEE 1992; pp. 78-83.

5. Farr, John v., and Bowman, Bruce A.
"Engineering Management Programs: Contemporary and Future Issues"
Engineering Management Journal, Vol. 11 no. 4. December 1999

6. Peterson, William R. and Collin, Terry
"Engineering Management Body of Knowledge"
Unpublished position paper presented to ASEM Board, 2004

7. Westbrook, Jerry D. (2005),
"ASEM'S Effort to Recognize Quality in Engineering Management Master's Programs"
Engineering Management Journal, Vol. 17. No. 1, March 2005, pg. 33-38

8. Merino, Donald
"A Proposed Engineering Management Body of Knowledge"
2005 ASEM Annual Conference Proceedings

9. Merino, Donald, Rana, Vishwajeet, Ganguly, Anirban
"Benchmarking ASEM Graduate Engineering Management (EM)
Programs using a Proposed EM Body of Knowledge"
2005 ASEM Annual Conference Proceedings

10. Merino, Donald, Rana, Vishwajeet, Ganguly, Anirban
"Benchmarking ABET Undergraduate Engineering Management (EM)
Programs using a Proposed EM Body of Knowledge"
2005 ASEM Annual Conference Proceedings