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 \textsuperscript{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 \textsuperscript{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 \textsuperscript{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
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. 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**

<table>
<thead>
<tr>
<th>Major Topic/Field Subtopic</th>
<th>Core</th>
<th>Specialty</th>
<th>Support-ing.</th>
<th>Consistent w/ABET</th>
<th>Consistent w/ASEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Qualitative / Conceptual Courses, A. Individual People orientated</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1. Qualitative / Conceptual Courses, B. Organization or Group orientated</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Quantitative / Methodological Courses A. Quantitative</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Quantitative / Methodological Courses B. Methodical</td>
<td>YES</td>
<td>Maybe</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Accounting / Financial &amp; Economics A. Accounting / Finance</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Accounting / Financial &amp; Economics B. Economics</td>
<td>YES</td>
<td>Maybe</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Project Related Courses A. Project Management</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Project Related Courses B. Capstone</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Functional Courses A. Functional Technical Management</td>
<td>Some</td>
<td>YES</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Functional Courses B. Functional Business Management</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Engineering and Science Courses A. Engineering Courses</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Engineering and Science Courses</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>


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

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

### 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.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Previous Paper</th>
<th>Current Paper</th>
<th>Difference</th>
<th>Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A and 1B</td>
<td>20</td>
<td>18</td>
<td>-2</td>
<td>Yes</td>
</tr>
<tr>
<td>2A and 2B</td>
<td>27</td>
<td>28</td>
<td>+1</td>
<td>Yes</td>
</tr>
<tr>
<td>3A and 3B</td>
<td>20</td>
<td>21</td>
<td>+1</td>
<td>Yes</td>
</tr>
<tr>
<td>4A and 4B</td>
<td>18</td>
<td>17</td>
<td>-1</td>
<td>Yes</td>
</tr>
<tr>
<td>5A</td>
<td>15</td>
<td>16</td>
<td>+1</td>
<td>Yes</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**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.
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    2005 ASEM Annual Conference Proceedings