

2006-176: DETERMINING THE WEIGHTS OF ENGINEERING MANAGEMENT (EM) TOPICS FOR AN EM MANAGER'S CERTIFICATION TEST

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Determining the Relative Weights of Engineering Management (EM) Topics for an EM Managers Certification Test

Abstract

The purpose of this paper is to determine the relative weights of Engineering Management (EM) topics/courses based on recognized graduate and undergraduate EM programs. The graduate EM programs examined are those certified by the American Society of Engineering Management (ASEM) and undergraduate EM programs those which have been accredited by the Accreditation Board for Engineering and Technology (ABET). The topics and their relative weights can be used in testing for EM Managers' certification.

Four years ago, ASEM established a certification process for graduate EM programs. The objective was to provide common standards to help schools evaluate their programs. Since this work began, four schools and six programs have been ASEM certified. EM graduate masters programs that are ASEM certified are: University of Missouri at Rolla, Old Dominion University, Stevens Institute of Technology and George Washington University.

ABET is the acknowledged standard for engineering schools. While ABET criteria have changed from more detailed criteria to outcomes assessment there is still a definable body of knowledge by discipline. EM programs which are ABET accredited are at the University of Missouri at Rolla, Stevens Institute of Technology and United States Military Academy at West Point. ABET lists other schools under EM but they combine other disciplines like Industrial Engineering, etc. Two newly ABET accredited programs will be added in a later analysis.

The above analysis was sent to the various schools for peer review. The results are reported in this paper. Analyses of these topics and the weight they occupy in the curriculum are used as a guide in establishing an EM Body of Knowledge. They can also be used to help determine the weight of test questions to certify engineering managers.

Overview of Paper

In a previous paper ¹ proposed an Engineering Management Body of Knowledge (EM BoK). One use of an EM BoK is to help decide the topics and their relative weights in developing a test to certify EM practitioners. This paper also proposed topics and weights (see Table 2, Merino, 2005). An analysis of ASEM certified EM Masters programs and ABET accredited EM undergraduates programs were used to validate the topics and weights chosen. The previous study was revised based on feedback from the schools involved.

First, ASEM Masters Graduate programs are analyzed and then ABET undergraduate programs. Next, the graduate and undergraduate weights will be combined and then compared to the EMBoK weights previously proposed.

EM Masters Graduate Programs Certified by ASEM

As of this writing there are six ASEM certified EM Masters Graduate programs. They are:

- George Washington University: MSEM and MEM Programs
- Old Dominion University: MSEM and MEM Programs
- Stevens Institute of Technology: MEEM
- University of Missouri – Rolla: MSEM

EM Masters Program Structures

All of the programs analyzed have a core plus an elective set of courses. The core is separately analyzed to determine how these weights compare with the proposed EMBoK.

Exhibit 1. Number of Core and Elective Courses for EM Masters programs

EM Masters Programs		# Core Courses	# Elective Courses	Total # Courses
George Washington Univ.	MSEM	9	3	12
George Washington Univ.	MEM	9	3	12
Old Dominion Univ.	MSEM	9	4	13
Old Dominion Univ.	MEM	8	4	13
Stevens Institute	MEEM	6	4	10
Univ. of Missouri- Rolla	MSEM	4 (6)*	6	10

Exhibit 2. Number of Core and Elective Credits for EM Masters programs

EM Masters Graduate Programs		# Core Credits	# Elective Credits	Total # Credits
George Washington Univ.	MSEM	27	9	36
George Washington Univ.	MEM	27	9	36
Old Dominion Univ.	MSEM	25	9	34
Old Dominion Univ.	MEM	22	9	31
Stevens Institute	MEM	18	12	30
Univ. of Missouri- Rolla	MSEM	18	12	30

*UMR's prerequisites were counted as core.

As Exhibit 1 and 2 indicate the size of the EM core varies among the programs. Some of this variation is due to how the programs specify their core and elective courses. For this analysis we included all the courses included in the basic core and those courses leading to an EM concentration.

In an effort to achieve consistency, UMR's Statistics and Engineering Economics prerequisites were counted as core courses.

Analysis of Masters Programs by EM BoK Categories

Appendix 1 refers the reader to the ASEM Conference article that contains the detailed analysis for the graduate programs. This analysis contained the course titles. Note that there is no uniform

set of course titles used in EM. One needs to read the course description to determine which category the course fits in. Because of this variation, different researchers may come to different conclusions about how to categorize the course. This article along with the proposed EMBoK was sent to the various program directors or Department Heads to verify the analysis.

Summary of EM Topics and How They Compare with EMBoK Weights.

Exhibit 3 summarizes the topic weights by program and computes an average. The average is compared to the recommended weights in the proposed EMBoK ¹ to see if these weights were consistent with those proposed.

Overall there was a good comparison between the program average and the recommended weights.

The range was noted to determine the consistency across programs. For seven of the categories there was one program that did not have the topic as core. If that one program was not included the range would have been close to normal. For two topics the range was about normal.

Exhibit 3. EM Topics by ASEM Certified Graduate Masters Programs; and Consistency w/ EMBoK Weights

Schools – Programs >>> Major Topic/Field – Subtopic √	GWU MSEM	GWU MEM	ODU MSEM	ODU MEM	SIT MEEM	UMR MSEM	Range	Average	EM BoK	Consistent
<u>1. Qualitative / Conceptual</u> <i>A. Individual People Orient.</i>	0%	0%	0%	0%	0%	0%	0	0%	0%	Yes
<u>1. Qualitative / Conceptual</u> <i>B. Organization or Group</i>	11%	22%	24%	14%	17%	17%	11-24	17%	18%	Yes
<u>2. Quantitative / Methodical</u> <i>A. Quantitative</i>	11%	11%	12%	14%	0%	17%	0-17	16%	18%	Yes
<u>2. Quantitative / Methodical</u> <i>B. Methodical</i>	22%	11%	12%	14%	17%	0%	0-22	13%	10%	Yes
<u>3. Accounting/Finance/Econ.</u> <i>A. Accounting / Finance</i>	11%	11%	0%	0%	34%	17%	0-17	7%	9%	Yes
<u>3. Accounting/Finance/Econ.</u> <i>B. Economics</i>	11%	11%	12%	14%	17%	17%	11-17	14%	12%	Yes
<u>4. Project Related Courses</u> <i>A. Project Management</i>	11%	11%	12%	14%	17%	0%	0-14	14%	10%	Yes
<u>4. Project Related Courses</u> <i>B. Capstone</i>	11%	11%	4%	4%	0%	17%	0-17	5%	7%	Yes
<u>5. Functional Courses</u> <i>A. Functional Technical.</i>	11%	11%	24%	28%	0%	17%	0-22	15%	16%	Yes
Totals %	100	100	100	100	100	100		100	100	

Note: Totals may not agree with individual % due to rounding. An excel spreadsheet with one significant digit was used to calculate the average.

EM Undergraduate Programs Accredited by ABET

There have been three ABET accredited EM undergraduate programs for a number of years. They are:

- Stevens Institute of Technology: BEEM
- University of Missouri – Rolla: BSEM
- United States Military Academy at West Point: EM Major

There are two other EM undergraduate programs that have been ABET accredited and will be added to this analysis by the time of the conference.

EM Undergraduate Program Structures

All of the programs analyzed have a core plus an elective set of courses. The core is separately analyzed to determine how these weights compare with the proposed EMBoK.

Exhibit 4. Number of Core and Elective Courses for EM Undergraduate programs

EM Undergraduate Programs	Total # Courses	# Credits
Stevens Institute BEEM	17	51
Univ. of Missouri – Rolla BSEM	15	44
USMA at West Point EM Major	13	39.5

*UMR's prerequisites were counted as core.

As Exhibit 4 indicates, the size of the EM core varies among the programs. Some of this variation is due to how the programs specify their core and elective courses. For this analysis an attempt was made to list all courses that EM would take. To accomplish this, some engineering core courses, all courses listed as EM and some of the core courses were included.

USMA courses were selected based on what most EM students take. This involved deciding which of the electives were most likely to be taken. This analysis relied on a former USMA EM Department Chair for guidance.

For Stevens' core engineering courses like statistics, engineering economy and senior design labs were included as well as Micro and Macroeconomics which is a Humanities core. Stevens has a large design thread for all engineering students, including EMs, and that was counted.

For UMR all the core courses were included plus the Management of Technology major because it was the closest to the EM topics.

Analysis of Undergraduate Programs by EM BoK Categories

Appendix 2 refers the reader to the ASEM Conference article that contains the detailed analysis for the under graduate programs. Note that there is no uniform set of course titles used in EM. One needs to read the course description to determine which category the course fits in.

Because of this variation, different researchers may come to different conclusions about how to categorize the courses. This article along with the proposed EMBoK was sent to the various program directors or Department Heads to verify the analysis.

Summary of EM Topics and How They Compare with EMBoK Weights.

Exhibit 5 summarizes the topic weights by program and computes an average. The EM undergraduate averages are compared to the recommended weights in the proposed EMBoK ¹.

The range was noted to determine the consistency across programs. Three categories had at least one program that did not have the topic as core. Otherwise the ranges were close to normal.

Exhibit 5. EM Topics by ABET Accredited EM Undergraduate Programs: and Consistency w/ EMBoK Weights

Schools – Programs >> Major Topic/Field – Subtopic √	USMA EM Major	SIT BEEM	UMR BSEM	Range	UnderGrad Average	EM BoK	Undergrad Vs EM BoK
<u>1. Qualitative / Conceptual.</u> <i>A. Individual People Orient.</i>	0%	0%	7%	0-7	2%	0%	Ok
<u>1. Qualitative / Conceptual</u> <i>B. Organization or Group</i>	8%	0%	7%	0-8	5%	18%	Low
<u>2. Quantitative / Methodical</u> <i>A. Quantitative</i>	23%	30%	14%	14-30	22%	18%	High
<u>2. Quantitative / Methodical</u> <i>B. Methodical</i>	15%	0%	0%	0-15	5%	10%	Low
<u>3. Accounting/Finance/Econ.</u> <i>A. Accounting / Finance</i>	15%	8%	14%	8-15	12%	9%	High
<u>3. Accounting/Finance/Econ.</u> <i>B. Economics</i>	8%	23%	14%	8-23	15%	12%	High
<u>4. Project Related Courses</u> <i>A. Project Management</i>	9%	6%	7%	6-9	7%	10%	Low
<u>4. Project Related Courses</u> <i>B. Capstone</i>	15%	15%	7%	7-15	13%	7%	High
<u>5. Functional Courses</u> <i>A. Functional Technical Mgt</i>	8%	18%	32%	8-32	19%	16%	Ok
Totals %	100	100	100	-	100%	100	

Note: Totals may not agree with individual % due to rounding. An excel spreadsheet with one significant digit was used to calculate the average.

Four categories (2.A. Quantitative; 3.A. and 3.B. Accounting /Financial/Economics; and 4. B. Capstone) the average weight for these EM programs was higher than the proposed EMBoK. This is not surprising since all these topics are basic topics usually taught in undergraduate programs. Capstones are a feature of and more prevalent in undergraduate programs.

The three categories (1.B. Organizations; 2.B. Quantitative/Methodical; and 4.A. Project Mgt.) that were low are also not surprising since these topics are more advanced and taught in graduate programs.

Combining EM Graduate and Undergraduate Topic Weights.

Exhibit 6 combines the graduate and undergraduate averages and then compares them to the weights suggested in the EM BoK paper.

A simple average of graduate and undergraduate percentages was chosen to compare with the recommended weights. This gives greater weight to the graduate course topics since there are fewer credits in graduate than undergraduate programs. This seemed appropriate since the graduate programs concentrate on EM and assume that the students have the appropriate prerequisites from their undergraduate programs. It is also appropriate given that these weights will be used to construct an EM Managers’ certification test.

On an individual subcategory basis the combined weights are consistent with the proposed weights except for 1.B (Organization or Group Oriented). This category was weighed higher in the proposed EM BoK because it is more consistent with the graduate weighting.

Exhibit 6. EM Combined Averages by Topics; Consistency w/ EMBoK Weights

Schools – Programs >> Major Topic/Field – Subtopic √	Graduate Aver	UnderGrad Average	Comb Aver	EM BoK	Consistent?
<u>1. Qualitative / Conceptual</u> <i>A. Individual People Orient.</i>	0%	2%	1%	0%	Ok
<u>1. Qualitative / Conceptual</u> <i>B. Organization or Group</i>	17%	5%	11%	18%	Low
<u>2. Quantitative / Methodical</u> <i>A. Quantitative</i>	16%	22%	19%	18%	Ok
<u>2. Quantitative / Methodical</u> <i>B. Methodical</i>	13%	5%	9%	10%	Ok
<u>3. Accounting/Finance/Econ.</u> <i>A. Accounting / Finance</i>	7%	12%	10%	9%	Ok
<u>3. Accounting/Finance/Econ.</u> <i>B. Economics</i>	14%	15%	10%	12%	Ok
<u>4. Project Related Courses</u> <i>A. Project Management</i>	14%	7%	11%	10%	Ok
<u>4. Project Related Courses</u> <i>B. Capstone</i>	5%	13%	9%	7%	Ok
<u>5. Functional Courses</u> <i>A. Functional Technical Mgt</i>	15%	19%	17%	16%	Ok
Totals	100	100%	-	100%	

Reconciliation of Weights with Previous Study

Exhibit 7: 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	100.0	100	0	

Exhibit 7 is the analysis if the categories are combined. Combining the categories resulted in a variation of 1% for most of the categories and 2% for category A. 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 and caused by 1.B. (See above for this difference).

As stated previously, it is expected that these weights will change over time as the EM BoK evolves. In the previous paper (Merino, 2005) it was stated that the weights would be adjusted based on the feedback from the schools and based on combining the graduate and undergraduate results. Based on this feedback and analysis the weights changed only slightly.

Given that this was an initial attempt to determine how consistent the topics were among recognized EM programs the results are encouraging. As the data and analysis indicates there was a relative degree of consistency.

Observations and Future Work

Given that EM and the ASEM are relatively new it would not be surprising if changes occur over time. In any case, ASEM should reanalyze this topic on a periodic basis – probably every three or four years as EM curricula are updated and certified.

Future work needs to highlight the prerequisites and the most commonly chosen electives for EM programs. Also, additional work in defining the course content would be helpful. It is speculated that these analyses will show similar results as this analysis. That is, there will be a consistent pattern in EM courses.

Bibliography:

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

2. 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

3. 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

Appendix 1. Detailed Course listings for Graduate Masters – ASEM

See Tables in reference above Merino, Donald, 2005 – Benchmark Grad programs

GWU – MSEM: http://www.emse.gwu.edu/concentration_etm.html

GWU – MEM: http://www.emse.gwu.edu/concentration_etm.html

ODU – MSEM: <http://www.eng.odu.edu/enma/academics/promaster.shtml>

ODU – MEM: <http://www.eng.odu.edu/enma/academics/promaster.shtml>

SIT – MEEM: 2004 Catalog; URL: <http://www.stevens.edu/engineering/seem/>

Appendix 2. Detailed Course listings for Undergraduate Masters – ABET

See Tables in reference above Merino, Donald, 2005 – Benchmark Under grad programs