AC 2007-116: FINDING APPROPRIATE DATA FOR ABET SELF-STUDY SECTIONS B2 AND B3 FOR ENGINEERING PROGRAMS

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Abstract
ABET accreditation is an established benchmark for undergraduate engineering programs in the United States and ensures the quality of education college engineering students receive. As such, ABET is the recognized U.S. accreditor of engineering college and university programs. ABET outlines the criteria for each engineering program and the key elements of what is required in each engineering program's Self Study. However, ABET leaves up to the interpretation of each engineering program the details of how to present the findings of its hopefully successful defense of its own program. This apparent paradox results from the many elements, characteristics and factors that can contribute to successful accreditation. This paper gives a summary of types of data that can be used in the ABET accreditation process. Specifically the data presented was used in the 2004 ABET accreditation of the Engineering Management program at Stevens Institute of Technology. Examples of types of data leading toward accreditation and recommendations of how colleges and universities can implement similar data assessment processes are discussed.

Introduction
ABET accreditation provides endorsement of curricula, facilitates university and external funding and, in general, adds credibility to an engineering program. However, achieving ABET accreditation can be a daunting task. This paper provides guidance to engineering programs considering accreditation or undergoing re-accreditation, by examining the experiences and data processes at an accredited Engineering Management Program at Stevens Institute of Technology.

The paper first provides background on the EM programs at Stevens. This is followed by a description of ABET and the accreditation process. The experiences of data discovery and assessment by the Stevens Engineering Management program are next discussed. The paper concludes with suggestions for successfully accrediting an engineering program.

Population
Stevens Institute of Technology is a private university located across the Hudson River from Manhattan in Hoboken, New Jersey. Stevens Institute of Technology has a relatively large, well established Engineering Management (EM) Program. Its success is evidenced by the size of its faculty (15 full time faculty) and external recognition (four awards from the American Society of Engineering Management, ASEM, over the past 15 years). The EM Program at Stevens was first ABET accredited in 1992, and successfully re-accredited in 1998 and 2004. There are currently 15 faculty in the EM department, of which 10 teach in the undergraduate program. Several of the faculty have been members of the American Society for Engineering Management (ASEM) for over 5 to 15 years.

Stevens has approximately 1400 undergraduate students, of which about 100 designated Engineering Management (EM) as their preferred discipline in the 2005 – 2006 academic year. Approximately 50% of Engineering Management students choose to participate in the five year Cooperative Education program. Stevens graduates between 20 and 30 Engineering Management students a year with a Bachelor of Engineering Degree. Approximately 75% of these EM graduates have a job prior to graduation with an average starting salary of $47,700.

ABET: History and Role

The Engineers' Council for Professional Development (ECPD) first formed ABET in 1932. ABET's original task was to fill the recognized need for a "joint program for upbuilding engineering as a profession" (ABET 2004) and by 1936, ECPD had evaluated its first engineering programs. In early 1980, ECPD was renamed the Accreditation Board of Engineering and Technology (ABET) and in 1997, ABET adopted the Engineering Criteria 2000 (EC2000). This new format of accreditation was an evaluation based on a continuous improvement process focusing on engineering program outcomes.

Thus, for over 50 years and in cooperation with both the engineering academic and practitioner community, ECPD/ABET has been the recognized accreditation body for undergraduate engineering programs in the United States. Their accreditation criteria have molded engineering education and guided engineering educators to endeavor for ABET's vision of providing "world leadership in assuring quality and in stimulating innovation in applied science, computing, engineering, and technology education" (ABET 2004).

The U.S. Council for Higher Education Accreditation recognizes ABET as the agency responsible for evaluating and certifying the quality of engineering education in the United States (ABET 2004). This recognition by the Council adds to the credentials of ABET accredited college programs. However, a significant reason for achieving accreditation is that many state licensing authorities recognize ABET accredited programs as satisfying the educational requirements for P.E. licensure. All states, except Michigan and New Hampshire, require graduation from an ABET accredited institution as a prerequisite to the FE/PE examination. Of the states requiring an ABET accredited degree, a small minority (15 states as of 2003) allow graduates with non-ABET accredited degrees to take the FE/PE exam as long as they have a given number of post-graduation engineering experience prior to the exam date (NCEES, 2005). Without an ABET accredited undergraduate engineering program, states may refuse to issue professional engineering licenses to individuals. Thus, many colleges choose to accredit their undergraduate programs to satisfy licensing requirements for their graduates. IN addition, accreditation inherently enhances the reputation of the Engineering professions overall and adds credibility to each university's individual engineering program.

Data Discovery and Assessment Data Examples

Ever since EC 2000, engineering colleges have been striving for ways to find a process of assessment, discover data, quantify assessments and then display the data in a meaningful and easy to read format for ABET accreditation. There are many ways to do this and many varied forms have been used seen since EC 2000 began. This paper shows some examples of the ways assessment concepts and data were used and implemented by the Engineering Management Program at Stevens Institute of Technology.

Stevens Institute of Technology adopted an online assessment method in the late 1990's in order to stream line the majority of its' data collection and display the majority of its data in one easily accessible location. However, how each department chose to mold this data into the requirements of ABET's Self Study differed from program to program. In the 2003 accreditation cycle, however, many Stevens' programs liked what Engineering Management was doing and chose to have their Self-Studies reflect much of the format and data used by the Engineering Management Program. Although similarities between programs can be noted for 2003, it should be stated that several of Stevens' programs also had individual data displays and analyses of their own as well.

As mentioned above, much of the data was collected through a university-wide online assessment system. This system consisted of surveys for students to assess their classes [outcomes], and alumni to assess their satisfaction with the quality of their education, as well as, employers to assess their satisfaction with the quality of their employees (the Program's alumni) [objectives]. However, this assessment produced only indirect data. Thus, in addition to this, direct measures were also necessary which required more of a manual collection process. The below sections outline the types of data collected and the methods used for the critical Self Study Sections of B2 and B3.

<u>ABET Self Study Section B2 – Objectives</u>

The first part of the ABET Self Study Section B2 asks for the educational objectives to be consistent with the mission, as well as, ABET criteria. Thus, this section should list the Engineering Program's objectives and how the program objectives are consistent with the mission of the program, as well as, the mission of the college or university and the ABET accreditation criteria.

Next the Self Study must demonstrate that there is a process in place to determine and periodically evaluate these objectives based on the needs of the program constituencies. Thus, this section should outline the constituents of the program. At a minimum the constituents should be the Students, the Employers of the alumni, the Alumni and the Faculty and Staff of the program. It is then the job of the Self Study to demonstrate how these constituents contribute to and benefit from the Program.

This demonstration can be done in several ways. For example, Engineering Program's should have Visiting Committees which critique, as well as, add value to Engineering Programs. By showing the varied and knowledgeable backgrounds of the members of the Visiting Committee and how the committee is made up of members from *all* of the constituent groups above, a program can demonstrate feedback loops to the program or other assessment data.

Another method to assess the Objectives of a program is through electronic or paper Alumni surveys. Similarly, Objectives can be assessed by Employer surveys through paper or online assessment forms as well. Although these methods of assessment are indirect for both alumni and employers, programs can achieve great volumes of quantifiable data on each of their objectives through this simple process. However, direct measures should also be taken. Some direct measures which can be used to demonstrate both the alumni and employer satisfaction of the education of the program's graduate are through average starting salary data and the comparison of this data to national averages. Similarly job placement data for the individual programs' graduates and the comparison of this data to national averages shows the quality of the program's graduates to employers as well as the satisfaction of the alumni with their education's ability to employ them.

Lastly, within the realm of objective assessment, a discussion of the school-wide curriculum development process, as well as the implementation of school-wide and program-wide faculty meeting discussions will add yet another layer of feedback to an engineering programs progress toward continual improvement in achieving its objectives.

<u>ABET Self Study Section B3 – Outcomes</u>

The first part of the ABET Self Study Section 3 asks for an assessment process with documented results to produce measured outcomes. Thus, this section should address the assessment system in place at the educational institution and or within the Program. Whether this system is electronic or paper, feedback loops ensuring a continuous learning process should be documented.

The next part of Section 3 asks for the Program Outcomes and their relationship to the Program Objectives and ABET criterion 3. Thus, this section should list the Engineering Program's outcomes and how these program outcomes relate to the program's objectives and ABET's a-k. See Tables 1 and 2 for examples of partial tables.

Table 1: School of Engineering (SoE) Curriculum Outcomes, Engineering Management Program Outcomes and their relationship to ABET Criterion a-k

ABET Crit 3	**SoE Curriculum Outcomes** ***By the time of graduation, our students will have:***	**Engineering Management Program Outcomes** ***By the time of graduation, our students will:***
	I. Broad Based Technical Expertise	
(a) an ability to apply knowledge of **mathematics, science and engineering**	1-A&B **Scientific foundations** – the ability to apply basic scientific knowledge	be able to use knowledge of relevant mathematics and computer science principles and parameters in engineering management, especially an ability to use various simulations models, probability applications and sampling techniques, and quality improvement methods.
(e) an ability to identify, formulate, and solve	1-C **Engineering foundations** – the ability to apply engineering	be able to analyze systems using an engineering management approach.

engineering problems	science knowledge	
(b) an ability to design and conduct **experiments**, as well as to analyze and interpret **data**	2 **Experimentation** – the ability to design experiments, conduct experiments, and analyze experimental data	be able to design, conduct and analyze experiments through the use of engineering economics analysis, statistical, life cycle and IPPD models, sampling tables and techniques, probability applications and word problems that use examples from manufacturing or service applications.
(k) an ability to use the techniques, skills, and modern engineering **tools** necessary for engineering practice	3 **Tools** – an ability to use the relevant tools necessary for engineering practice	be able to use computational tools and management software and theories for finding graphical, statistical and analytical solutions to problems necessary for the practice of engineering management.
(c) an ability to **design** a system, component, or process to meet desired needs	4 **Technical design** – the technical ability to design a prescribed engineering subsystem	be able to determine the scientific and engineering management variables of interest and processes to manage engineering design alternatives and management planning.
(h) the **broad education** necessary to understand the impact of engineering solutions in a global and societal context	5 **Design assessment** – the ability to develop and assess alternative system designs based on technical and non-technical criteria	be able to assess the ergonomic, economic, social and environmental requirements, needs and constraints of the system and its impact on the global society.

Table 2: Stevens School of Engineering Curriculum Outcomes Related to EM Objectives

		Stevens EM Prog. Objectives				
ABET	**Stevens EM Outcomes**	1	2	3	4	5
a and e	1. (Scientific and engineering foundations) the ability to use applied scientific knowledge.	X	X	X		
b	2. (Experimentation) the ability to design experiments, conduct experiments, and analyze experimental data.			X		X
k	3. (Tools) an ability to use the relevant tools necessary for engineering practice.	X		X		X
c	4. (Technical design) the technical ability to design a prescribed engineering subsystem.	X			X	
h	5. (Design assessment) The ability to develop and assess alternative system designs based on technical and non-technical criteria.	X		X		
f	6. (Professionalism) the ability to recognize and achieve high levels of professionalism in their work.		X	X		

For further clarification, programs can include more detailed tables of where their outcomes are being assessed. See Table 3 for an example of a partial table.

Table 3: EM Detailed Outcomes Related to EM Courses and Activities

Stevens EM Program Outcome (ABET Criterion)	1A&B (a) Scientif. Found.	1C (e) Eng. Found.	2 (b) Experi-mental	3 (k) Eng. Tools	4 (c) Design	5 (h) Design Assess-ment	6 (f) Profess-ionalism	7 (d) Leader-ship	8 (d) Teamwork	9 (g) Communic-ation Skills	10 (f) Ethics	11 (j) Contem-porary issues	12 (i) Life-long Learning	13 Entrepren-eurship
COURSES														
E101 – Engineering Seminar							L				L	L	L	
E120 – Engineering Graphics				M	L	L			L					
E122 – Engineering Design II	L	L	L	L	M		M	L	M	L				L
E126 – Mechanics of Solids	L	M		L	L	L	M	L	M	L				
EM470 – Engineering Management				L		L	L			M	M		M	M
EM 475 – Project Management			L			H	M							
EM365 – Statistics for Engineering Mgrs	M								M	L				
EM380 – Engineering Management Lab.				M		L	M	M	M	M	L			
EM301 – Engineering Cost Management				L	L	L								L
EM345 - Modeling & Simulation	L		L	L		L								
EM322 - Engineering Design VI			M		L	M								
EM466 – Statistical Quality Control	M		L	L		L								
EM460 – Total Quality Management							M		L					H
EM423/424 - Design VII & VIII				M		H	M	M	M	M	M			
EM357 – Elements of Operations Research	L		L	L		L								
EM350 – Operations Management			L	M		L	L							
6-course Humanities sequence										H	L	H	M	
Writing Proficiency Exam										H				
ACTIVITIES														
Stevens Honor System							L				H			
ASEM Membership and Activities							L	L			L	L	L	

Next, the Self Study must demonstrate how the data is used to assess program outcome achievement within the undergraduate engineering program. Within this discussion, it should also be mentioned that there is both program level and course level feedback loops that need to fold into each other. In essence, the results of the course level assessment should be integrated into the program level assessment of the program outcomes.

This demonstration can be done in several ways. For the Engineering Management program, outcomes were established by the Program Assessment Committee in consultation with, and based on feedback from, various constituencies. Members of the constituencies including alumni, faculty, students, and employers were involved in the definition and periodic revision of the Program Outcomes.

To summarize, the Engineering Management Program gathered data from various sources to verify that the mechanism of assessment and feedback was working correctly. The constituencies are asked about our success in achieving our outcomes. Stevens' School of Engineering has Course Surveys at the end of each semester for all engineering students via the web about the outcomes in each of the engineering courses they have taken during the semester. This provides indirect electronically tallied feedback. Faculty are asked to review this data, as well as, provide direct measures and feedback on course improvements through a manual process called Instructor Course Assessment and Student Performance Assessment. Indirect measures such as the Senior Exit surveys and interviews of graduating seniors also inquire and provide information about outcomes. Finally, feedback from Cooperative Education employers and students provide an indication of how well the students achieve the outcomes which involve the Workplace and working with a client. This provides both indirect and direct measures of assessment of the program and therefore, continuous assessment and evaluation of Program Outcomes is thus accomplished.

Next, in the following portion of section 3, one must list the evidence that results are applied to the improvement of the program. This section states for each outcome approximately a half to one page worth of assessment types (as indicated above) and their actual data output and its impact on the program. See Table 4 for a partial example listing.

Table 4 – Evidence that Results are Applied to Improvement of the Program

Program Outcome 5 – (Design Assessment) Students will have the ability to develop and assess alternative system designs based on technical and non-technical criteria. **ABET Criteria 3h** – the broad education necessary to understand the impact of engineering solutions in a global and societal context
<u>**EVALUATION AND PLAN OF THE EM PROGRAM**</u> Electives contributing to this outcome include E 355, E 421, EM 301, EM 322, EM 345, EM 350, EM 357 and EM 380. **Senior Exit Survey**

ABET h: Rank of Stevens vs. "All School" comparison group stayed somewhat the same from 2000 to 2002.

Course-level
General – All items scored were adequate to high on the Student Performance Assessment Forms. Ranges from some to great and significant in learning were reported in the Student Surveys.
EM 345 – Propose adding more professional software to the Schacht Management Laboratory.
EM 357 – Change some exercises into cases.
E355 – SEED worksheets were revamped to more closely align with E 421.
Mgt 243 – The wording for this outcome was modified to more accurately reflect the content of the course.

Program-level
EM 322 will add energy conservation modules.
The EM program decided it would assess Mgt 243 in a paper format since electronic surveys were not yet available for classes outside to SoE.

Suggested changes to Outcomes or Assessment
No changes are proposed at this time.

In the remaining portion of section 3, one must list the evidence that changes have been implemented to improve the program. This can be accomplished through a cumulative listing of all of the improvements made to the program since the last ABET visit along with the impetus for each change that was made.

The last portion of section 3 is the listing of materials available for review beyond those provided in the Self Study itself. This is the program's opportunity to list reference documents such as the web based Student Assessments, Visiting Committee reports, Senior Exit Survey or Alumni survey data, etc.

Conclusion

In summary, the Engineering Management Program Outcomes provide appropriate coverage of the EM program's Objectives. In addition, Engineering Management Program Outcomes also provide adequate coverage of the ABET Criterion outcomes a through k. (See Table 2)

To ensure that graduates achieve the Engineering Management program's outcomes, we link courses to program outcomes. A review of Table 3 shows that each outcome is well covered when looking at the program as a whole. This deliberate process ensures that successful completion of the courses results in achievement of the desired program outcome. Since the program outcomes are directly related to the course outcomes, any deficiencies or adequate coverage of a course outcome within the survey data would indicate a deficiency or adequate coverage of its related program outcomes. Moreover, the assessment process described above provides the opportunity for annual feedback concerning the Program Outcomes to ensure that the Program Outcomes are continuously consistent with the needs of our constituencies.

This assessment system generates specific assessment data which are collected and evaluated at the course level by individual faculty, at the program level by the Program Curriculum Committee, and finally at the School of Engineering level by the SoE Education and Assessment committee. The cycle is completed annually and results are fed back into the long-term cycle of assessment. After completion of each cycle, the Program Assessment Committee and representative members of our constituency including representatives from the Students, the Workplace, Advisory Board and Alumni evaluate the data from the reports. The Committee then makes recommendations to the Department Faculty for maintaining, modifying, or otherwise improving the curricula, programs, and the assessment process including modifications to Program Objectives. The process iterates, resulting in continuous improvement of education and support processes.

Although improvements have been made to the system described here, and will be documented in the 2009 assessment cycle of the Engineering Management Program at Stevens Institute of Technology, the assessment process described in this paper was considered a good start and was acceptable to ABET. Other colleges can look over the basic outline of data collection and demonstration to get ideas for their own assessment cycles.

Bibliography

ABET, Accreditation Board of Engineering and Technology, (accessed October 2006) http://www.abet.org. Internet.

NCEES, National Council of Examiners for Engineering and Surveying (accessed January 2005), http://www.ncees.org/licensure/licensing_requirements.

Engineering Management Program Self Study (June 2003) Stevens Institute of Technology.