OUTCOMES AND QUALITY ASSURANCE AT THE HEART OF THE US ENGINEERING ACCREDITATION SYSTEM

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INTRODUCTION

Since the fall of 2001, educational institutions across the United States have had to assess and evaluate their undergraduate engineering programs to employ the philosophy and practice of continuous quality improvement based on new engineering criteria approved by the Accreditation Board for Engineering and Technology (ABET). The first step is to develop program educational objectives – statements describing expected achievements of graduates in the early years of their careers as a result of their educational preparation. Usually, educational objectives are expectations of graduates' performance after they have been in the workforce for three to five years. The second step requires a more specific definition of program outcomes – skills, knowledge and behavior that is expected of students when they graduate. Fulfilling these steps requires considerable time and effort, not only to clearly define the program educational objectives and outcomes, but also to develop proper and continuous assessment methods and tools, documentation, processes, and the necessary culture and philosophy changes that would be introduced as a consequence of the cyclical processes.

This paper presents an overview of ABET and the accreditation process in the US and the experiences the author has had in leading the accreditation strategy under new ABET criteria of the College of Engineering at the University of Puerto Rico Mayagüez Campus, which successfully led all engineering programs achieve accreditation in 2002.

ABET History

(Adapted from www.abet.org)

ABET was established in 1992 as the Engineers Council for Professional Development (ECPD). ECPD to fill the apparent need for a "joint program for upbuilding engineering as a profession," a need determined through surveys conducted by professional engineering societies in the 1920s. At the time, the ECPD's original focuses were in the following areas:

- Guidance – Supplying information to engineering students and potential students.
- Training – Developing plans for personal and professional development.
- Education – Appraising engineering curricula and maintaining a list of accredited curricula.
- Recognition – Developing methods where-by individuals could achieve recognition by the profession and the general public.

Seven engineering societies founded the organization and contributed to its original direction and focus: The American Society of Civil Engineers (ASCE), the American Institute of Mining and Metallurgical Engineers (now the American Institute of Mining, Metallurgical, and Petroleum Engineers), the American Society of Mechanical Engineers (ASME), the American Institute of Electrical Engineers (now IEEE), the Society for the Promotion of Engineering Education (now the American Society for Engineering Education), the American Institute of Chemical Engineers (AIChE), and the National Council of State Boards of Engineering Examiners (now NCEES).

Within its first year of existence, ECPD had begun developing itself as an accreditation agency; in 1936, ECPD evaluated its first engineering degree programs. Ten years later, the council began evaluating engineering technology degree programs. By its 15th year, ECPD had accredited 580 undergraduate engineering curricula at 133 institutions.

Producing guidance and training publications was a large part of ECPD operations. The council produced dozens of books, pamphlets, brochures, and even a couple of movies. Here are just a few of the many titles: "Reading List for Junior Engineers" (1945); "Speaking Can Be Easy... for Engineers Too" (1950); "WOMENGINEER" (1974); and "Minorities in Engineering" (1974).

In 1980, ECPD was renamed the Accreditation Board for Engineering and Technology (ABET) to more accurately describe its emphasis on accreditation. Three years later, ABET created the Related Accreditation Commission, now known as the Applied Science Accreditation Commission (ASAC).

In response to the anticipated boom in computer science education, ABET helped establish the Computing Sciences Accreditation Board (now CSAB) in 1985. CSAB is now one of ABET's largest member societies with more than 250 accredited programs.

In 2005, ABET formally changed its name from the "Accreditation Board for Engineering and Technology" to ABET, Inc. This allows the organization to continue its activities under the name that represents leadership and quality in accreditation for the public while reflecting its broadening into additional areas of technical education.

ABET's international activities, now a thriving area of the organization, initially launched in 1979 when ECPD signed its first mutual recognition agreement with the Canadian Engineering Accreditation Board. By 1989, ABET was a consultant to both fledgling and established international accreditation boards, a "substantial equivalence" evaluator of international programs, and a founding member of the multinational Washington Accord.

Currently, ABET accredits some 2,700 programs at more than 550 colleges and universities nationwide. Each year, over 1,500 volunteers from its now 28 member societies actively contribute to ABET's goals of leadership and quality assurance in applied science, computing, engineering, and technology education, serving as program evaluators, committee and council members, commissioners, and Board representatives.

ABET has been recognized by the US Council for Higher Education Accreditation (CHEA) since 1997.

OUTCOMES ASSESSMENT AND CONTINUOUS IMPROVEMENT

In 1997, following nearly a decade of development, ABET adopted Engineering Criteria 2000 (EC2000), considered at the time a revolutionary approach to accreditation criteria. The revolution of EC2000 was its focus on what is learned rather than what is taught. At its core was the call for a continuous improvement process informed by the specific mission and goals of individual institutions and programs. Lacking the inflexibility of earlier accreditation criteria, EC2000 meant that ABET could enable program innovation rather than stifling it, as well as encourage new assessment processes and subsequent program improvement.

Today, the spirit of EC2000 can be found in the evaluation criteria of all ABET disciplines, and several studies prove those criteria are having an impact on accredited programs. Internationally, ABET is extremely active in sharing that spirit with other accreditation boards and degree programs. It readily participates in global education and worker mobility through agreements like the Washington Accord. ABET also offers faculty workshops, outreach programs, and special events for institutional representatives, has an active industry advisory council, and is engaged in several important initiatives spurred by the visionary strategic planning of its Board.

ACCREDITATION BASICS

(Adapted from www.abet.org)

Accreditation Assures Quality

In the United States, accreditation is a non-governmental, peer-review process that assures the quality of the postsecondary education students receive. Educational institutions or programs volunteer to undergo this review periodically to determine if certain criteria are being met.

> Outside the United States, accreditation is not necessarily voluntary, nor non-governmental. Please visit the United Nations Educational, Scientific, and Cultural Organization (www.unesco.org) for more information on the world's postsecondary education systems and their quality assurance mechanisms.

It is important to understand, however, that accreditation is not a ranking system. It is simply assurance that a program or institution meets established quality standards. There are two types of accreditation: institutional and specialized.

Institutional accreditation evaluates overall institutional quality. One form of institutional accreditation is regional accreditation of colleges and universities. Specialized accreditation examines specific programs of study, rather than an institution as a whole. This type of accreditation is granted to specific programs at specific levels. Architecture, nursing, law, medicine, and engineering programs are often evaluated through specialized accreditation.

ABET, Inc., is responsible for the specialized accreditation of educational programs in applied science, computing, engineering, and technology. (More general information about accreditation is available at www.chea.org)

What Is ABET Accreditation?

ABET accreditation is assurance that a college or university program meets the quality standards established by the profession for which it prepares its students. For example, an accredited engineering program must meet the quality standards set by the engineering profession. An accredited computer science program must meet the quality standards set by the computing profession. ABET accredits postsecondary degree-granting programs housed within regionally accredited institutions. ABET accredits programs only, not degrees, departments, colleges, or institutions.

Who Sets the ABET Quality Standards?

The quality standards programs must meet to be ABET-accredited are set by the ABET professions themselves. This is made possible by the collaborative efforts of many different professional and technical societies. These societies and their members work together through ABET to develop the standards, and they provide the professionals who evaluate the programs to make sure they meet those standards.

Why Is ABET Accreditation Important?

Why should an engineering program seek accreditation? Accreditation helps students and their parents choose quality college programs and enables employers to recruit graduates they know are well-prepared. It is also used by registration, licensure, and certification boards to screen applicants. Finally, accreditation gives colleges and universities a structured mechanism to assess, evaluate, and improve the quality of their programs. Accreditation provides a means for student mobility in the globalized world.

The ABET Accreditation Process

Accreditation is a voluntary process on the part of an institution. The first step is that an institution requests an evaluation of its program(s). (Only programs that have produced at least one graduate are eligible for accreditation.) Each program then conducts an internal evaluation and completes a self-study questionnaire. The self-study documents whether students, curriculum, faculty, administration, facilities, and institutional support meet the established criteria.

While the program conducts its self-examination, the appropriate ABET commission (Applied Science, Computing, Engineering, or Technology Commission) forms an evaluation team to visit the campus. A team chair and one or more program evaluators make up the evaluation team. Team members are volunteers from academe, government, and industry, as well as private practice.

During the on-campus visit, the evaluation team reviews course materials, student projects, and sample assignments and interviews students, faculty, and administrators.

The team investigates whether the criteria are met and tackles any questions raised by the self-study.

Following its campus visit, the team provides the school with a written report of the evaluation. This allows the program to correct any misrepresentations or errors of fact, as well as address any shortcomings in a timely manner.

At a large annual meeting of all ABET commission members, the final evaluation report is presented by the evaluation team, along with its recommended accreditation action. Based on the findings of the report, the commission members vote on the action, and the school is notified of the decision. The information the school receives identifies strengths, concerns, weaknesses, deficiencies, and recommendations for improvements. Accreditation is granted for a maximum of six years. To renew accreditation, the institution must request another evaluation.

The University of Puerto Rico at Mayagüez (UPRM) Experience

Engineering education, as any dynamic process, as any engineering problem, needs to be clearly understood in all of its components in order that it can adequately address the needs of the community it serves. As with any engineering problem, the output, the input, its process variables as well as the ecosystem it exists within need to be clearly identified and assessed, so that appropriate changes are made and quality is enhanced as a continuous process. Thus, as a continuous process, it needs to be imbedded, ingrained in those that implement it. It is truly a culture, a way of life, not an isolated event that institutions or programs undergo just to simply comply with accreditation criteria. The true value of assessment and accreditation lies in the fact that it provides its most important constituents – students, faculty and employers – with the best possible engineering professional it can provide; a professional that possesses the skills, values and competencies that make him/her a valuable contributor in his/her country or as a member of a multinational engineering workforce. This culture takes time and resources to be developed, it does not come easy.

The University of Puerto Rico at Mayagüez (UPRM) realized the significance of EC 2000 early on and undertook planning and organizational steps fully four years prior to the actual site visit. All six of our undergraduate programs were evaluated during November 2002.

The following section outlines the planning and implementation processes/steps that the Campus undertook to undergo accreditation under the new ABET EC 2000 criteria. These include: educate the general populace, conduct industry-sponsored EC 2000 mock visits, the establishment of processes and respective offices with dedicated staff and working committees, in order to not only prepare for the ABET EC 2000 site visit, but also to develop an organizational structure which would sustain the process beyond the EC 2000 site visit for continuous quality enhancement.

As a result, the process of preparing for ABET EC 2000 accreditation became an agent and facilitator of the cultural change that needed to occur within and without UPRM's educational system to promote quality assurance in engineering education.

Brief description of UPRM

UPRM is one of the 11 campuses of the University of Puerto Rico System. The UPR System is a public institution, which was created by the Puerto Rico Legislative Assembly on March 12, 1903. It collectively enrolls about 67,000 students. The Mayaguez Campus (UPRM) is a land grant institution that began in 1911 with the College of Agricultural Sciences. Subsequently, other colleges were added as follows: College of Engineering (1913), College of Arts & Sciences (1943), and the College of Business

(1970). The student body consists of about 11,000 undergraduate and 970 graduate students. The College of Engineering counts on an undergraduate enrollment of 4458 students, of which, 36 percent are females, which is one of the highest in engineering among U.S. institutions. This enrollment results in UPRM as ranking 15th nationally in terms of the number of undergraduate degrees awarded (695) during 2000-2001 [1]. The strategic plan of the College of Engineering was approved by its faculty on October 13, 1998. The vision and mission statements, which are an integral part of the strategic plan, are well in consonance and they subscribe to preparing "best professionals in engineering" and "strong education in engineering." This commitment to excellence is reflected in the college's philosophy "to provide a firm educational foundation [2]." Undergraduate education is our strength. While emphasis on research and graduate education with newer doctoral programs is gaining increased attention, the fact remains that graduate degrees have consistently accounted for less than ten percent of the total undergraduate degrees conferred. The College of Engineering comprises six academic units or departments, which are: Electrical & Computer Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Civil Engineering & Surveying, and General Engineering. These collectively offer seven undergraduate degree programs, of which, six are in engineering with a separate program in surveying. All of the six undergraduate degree programs in Electrical, Computer, Mechanical, Industrial, Civil, and Chemical Engineering are accredited by the Accreditation Board for Engineering and Technology (ABET). The undergraduate degree programs at UPRM are of five-year duration as opposed to four years at most U.S. institutions. This provides both breadth and depth, along with ample opportunities for summer internships, undergraduate research, exchange programs, and a strong cooperative education program in partnership with industry. Approximately 27 percent of all undergraduate engineering students avail themselves of this cooperative education industry experience with bulk of the students, about 45 percent, coming from Mechanical and Chemical Engineering programs. The programs underwent a reaccreditation site visit during November 2002 as per ABET's new Engineering Criteria 2000.

The Learning Factory: a Seed is Planted [3]

In 1994, the author began participating in a university-industry partnership called the Manufacturing Engineering Education Partnership (MEEP). Its aim was to integrate design, manufacturing and business realities into the engineering curriculum. This was an opportunity to extend curriculum, and teaching and learning methodologies across the Atlantic.

The MEEP team developed the Learning Factory, a multi-disciplinary program that provides real (industry-driven) projects; a curriculum in product realization; and a state-of-the-art, hands-on learning laboratory, with strong industry participation and integrated outcomes assessment. The Learning Factory began as the result of a joint National Science Foundation/Defense Advanced Research Projects Agency grant, and was undertaken by Sandia National Labs and three universities: UPRM, Penn State University and the University of Washington. This program, which integrates an outcomes- and competency-based curriculum with assessment and industry partnership, has continued to grow over the decade since its inception [4,5,6].

The fundamental innovations of the Learning Factory that have made the greatest impact at the universities were:

Figure 1 - Learning Factory facilities at UPRM

- Facilities: The Learning Factory is an open-access, active-learning laboratory, where students, faculty and industry from all disciplines can practice real engineering. It provides practical training and modern facilities for design, prototyping, manufacturing, testing and re-design. These facilities support numerous student design projects and competitions, enabling faculty to integrate engineering practice into their courses.
- Industry interaction: The Learning Factory provides an efficient infrastructure for actively involving industry in the educational process through capstone design projects, curriculum improvement and engineers in the classroom.
- Curriculum: The product realization minor, or manufacturing certificate, is comprised of elective courses in product dissection, concurrent engineering and engineering entrepreneurship; and required courses in manufacturing processes, quality control and capstone design.

In 2006, Jens E. Jorgensen (University of Washington), John S. Lamancusa (Penn State University), Allen L. Soyster (then at Northeastern University), José Zayas-Castro (University of South Florida) and the present author received the National Academy of Engineering's Bernard M. Gordon Prize – a $500,000 annual award that recognizes innovation in engineering and technology education. These individuals won, the academy noted, "For creating the Learning Factory, where multidisciplinary student teams develop engineering leadership skills by working with industry to solve real-world problems."

REPLICATING AND EXPANDING THE LEARNING FACTORY MODEL

Based on the Learning Factory model and with funding from the National Aeronautics and Space Administration, in 1998 the present author led UPRM's team to start the Partnership for Spatial and Computational Research (PaSCoR), an innovative interdisciplinary curriculum whose goal was to strengthen academic programs and integrate research in remote sensing and geographical information systems (GIS), at the undergraduate level, in various SMET disciplines. This project followed the model of the Learning Factory, and focused on the student's learning, with strong emphasis on hands-on activities [7,8]. The Remote Sensing and GIS option was developed for over 10 engineering and science programs with hundreds of students now earning the certificate.

At UPRM, one of the most significant impacts of the Learning Factory was on accreditation and outcomes assessment. UPRM's College of Engineering ABET 2000 accreditation strategy was based on the Learning Factory experience. The strategy incorporated the outcomes assessment plan and tools developed under MEEP and PaSCoR. In order to institutionalize the assessment process as part of the various courses, the College of Engineering established an office called the System for the Evaluation of Education (SEED), with the goal of developing assessment strategies for the undergraduate engineering programs. In addition, the faculty involved industry and employers in its process, and conducted mock "accreditation visits" where industry members gave input about the programs. The UPRM ABET committee organized a series of one-day workshops that led to the development of a package of assessment tools and strategies. This was adopted for common use by all programs, with each one at liberty to modify or choose from among the recommended methods and tools. The package contains an outcomes assessment matrix; an assessment strategies matrix; and various assessment forms for integrating ethics, oral and written reports, teamwork, peer evaluation, course and project evaluations, internships, and a variety of surveys.

UPRM'S EARLY EFFORTS AND CHALLENGES

ABET's periodic review of engineering programs is well accepted as a form of program assessment and quality assurance. Since its enactment, Engineering Criteria 2000 have been well publicized in various sources, and effective Fall 2001, all programs coming up for accreditation review, are being evaluated for compliance against these criteria. These essentially consist of eight criteria with a goal of continuous program improvement as opposed to the earlier focus on rigid quantitative inputs. These criteria encompass: (1) students, (2) program educational objectives, (3) program outcomes and assessment, (4) professional component, (5) faculty, (6) facilities, (7) institutional support and financial resources, and (8) specific program criteria. George D. Peterson, ABET's Executive Director, states that at the core of these criteria "is an outcomes assessment component that requires each engineering program seeking accreditation or reaccreditation to establish its own internal assessment process, which in turn, will be assessed by ABET[9]." M. Dayne Aldridge and Larry D. Benefield point out that it is not sufficient to merely demonstrate the achievement of educational objectives (Criterion 2) and program outcomes (Criterion 3), but additionally, "a commitment to continuous improvement and the stability to continue its achievement record over the next six years [10]."

Unlike the earlier traditional accreditation-related efforts, where the crux of the effort was put into producing a self-study document and demonstrating that the minimum curricular requirements were met or exceeded, the leadership of the College of Engineering recognized the importance of EC 2000 as far back as November 1998, fully four years ahead of ABET's next review visit. This wasn't something that could be relegated to the last minute. It was a whole new approach that required early action and planning, and with which, not many of us were well conversant. It was a bold move on the part of the administrative leadership to encourage a team consisting of department heads to participate in the 2nd Working Symposium on Best Assessment Processes in Engineering Education at the Rose Hulman Institute of Technology in Terre Haute, Indiana. This was the start of our efforts, which was soon followed by the formal establishment of a Faculty ABET Committee with a lead coordinator within the College of Engineering. As John W. Meredith corroborated much later that, "The most important element in conducting a successful EC 2000 implementation is commitment at the highest level [11]." Some of the early challenges faced were: simply getting to understand and digest the implications of EC 2000, team composition and its stability, the holding of regular meetings to identify constituents, and discussion on possible assessment methods and tools. It was quite evident early on that Criterion 2 and Criterion 3 in particular would be the most demanding. Criterion 2 calls for a clear establishment of program educational objectives, with input from the key stakeholders or constituents. And these program educational objectives would need to have an embedded self-improvement process in place (the first loop) by establishing an assessment mechanism. Criterion 3 calls for the definition of program outcomes that should as a minimum, embrace the eleven (a-k) outcomes listed under the criterion; along with proper assessment methods, which would constitute the second loop of the self-improvement process. Criterion 3 could be viewed as a subset that had to map on to Criterion 2, which, up the ladder, was also required to satisfy the mission and vision of the College of Engineering, and eventually, that of the institution as a whole. All six programs were required to develop not only their own strategic plans, but also within these, their specific program educational objectives with input from their constituents and identify program outcomes. Consequently, this led to the establishment of each program's ABET sub-committee and the scheduling of numerous working retreats by each department. Each department chose its coordinator, which in turn, became member of the College of Engineering level Faculty ABET Committee.

ASSESSMENT METHODS AND TOOLS

Given the new accreditation paradigm that every engineering program establish an assessment process and document results, George D. Peterson was quite correct in his statement "No one expects that the outcomes assessment component of Engineering Criteria 2000 will be easy to implement. Establishing measurable objectives and evaluating their outcomes are sophisticated activities with which most engineering educators have had little or no experience [9]." Accreditation is really an ongoing process aimed at understanding and improving student learning.

The Faculty ABET Committee organized a series of one-day workshops in mid-year 2001 that led to the development of assessment tools and strategies package. This was adopted for common use by all programs with each one at liberty to modify or be selective about the recommended methods or tools. The package contained an outcomes assessment matrix, an assessment strategies matrix, and various assessment forms for integrating ethics, oral and written reports, teamwork, peer evaluation, course/project evaluations, exit survey, alumni survey, employer survey, and internships.

PRINCIPAL DRIVERS FOR CHANGE

Peggy L. Maki, Director of Assessment, AAHE, stated, "All too frequently higher education institutions view the commitment to assessing their students' learning and development as a periodic activity – most often driven by an impending accreditation visit [12]." While this would generally be the case with external drivers such as industry, or ABET, or Middle States Association, we, at the University of Puerto Rico at Mayaguez, had had some experience related with assessment in earlier educational projects, such as MEEP (Manufacturing Engineering Education Partnership) Learning Factory (funded by NSF, 1994) and PaSCoR (Partnership for Spatial and Computational Research), which was funded by NASA in 1998. And ideally, such should really be the case; institutional curiosity – an internal motivator, versus attempting to comply – an external motivator [12]. In order to institutionalize this assessment process as part of the various courses, the College of Engineering established a physical office called System for the Evaluation of Education (SEED) in mid-year 2001, with the goal of developing assessing strategies for the undergraduate engineering programs.

The principal goals of this office are to:

- Establish and facilitate a strategy for continuous evaluation of engineering programs and student learning outcomes assessment.
- Coordinate with engineering departments and accreditation committees (ABET EC2000 and the Middle States Association) the College of Engineering's activities regarding accreditation processes, including their implementation strategies.
- Assess outcomes of the College of Engineering's Strategic Plan.
- Become the College of Engineering's repository of assessment strategies, assessment instruments, and assessment results and reports.
- Coordinate professional development activities concerning evaluation and assessment.
- Disseminate assessment results to stakeholders and decision-makers for their information and decision-making.

The SEED Office counts on the services of a coordinator on a half-time basis, a person in-charge of database management and web page maintenance, and a full-time secretary. As an extension to this concept, similar offices were created in each of the six departments with names such as Continuous Improvement Center, The Curriculum Renewal Plan, and Center for Academic Research.

AWARENESS CAMPAIGN

A series of workshops and retreats were organized with guidance and support from industry and other U.S. universities, on the definition of outcomes and the development of outcomes based course syllabi, the development and re-definition of mission statements at individual program as well as faculty level, the mapping of outcomes to program educational objectives, the implications of ABET's EC 2000 criteria – not only to the faculty and staff in the College of Engineering, but also much later to the faculty and staff of the entire campus as part of a much wider awareness outreach. A number of one-day workshops were also organized on the integration of ethics across the curricula, which were well spread out throughout the period. There were also workshops on assessment and student mentoring which were given by faculty members representing the US NSF's SUCCEED and Foundation coalitions.

INDUSTRY SUPPORT

Criterion 4 (Professional Component) and Criterion 5 (Faculty) allude to interactions with industrial and professional practitioners as well as employers of students. Robert M. Laurenson from ASME stated, "A positive result of EC 2000 was the involvement of the program Advisory Boards. These groups have provided a very useful resource to the programs in establishing educational objectives and defining associated measurements of student outcomes [13]." The University of Puerto Rico at Mayaguez sought out industry partnership very early on in the process of preparing for the re-accreditation site visit in November 2002. For example, early in the process Hewlett Packard donated the server used to collect all data regarding the College's outcomes assessment and strategic plans. A college-wide ABET EC 2000 Retreat led by Raytheon engineers and quality improvement personnel, and co-sponsored by Microsoft, was organized in November 2000 to assist each program to define their Program Educational Objectives (Criterion 2) and Program Outcomes (Criterion 3). This retreat workshop enabled each program to develop or re-define their mission statement, to develop outcomes based course syllabi, and to map the outcomes to program educational objectives. This retreat led to an ABET EC 2000 Mock Visit sponsored by Raytheon Missile Systems, Microsoft, Hewlett Packard and Boeing in January 2002 with team members representing both academia and industry. The objectives of the Mock Visit were to visit the laboratory facilities, conduct interviews with faculty and students, evaluate the first draft of the individual EC 2000 self-study reports, and to offer candid comments and recommendations to incorporate assessment and continuous quality improvements within the programs. The results from the Mock Visit were an eye-opener for many of us and provided the vital external feedback on our status. This was followed by the formation of the first Industrial Advisory Board (IAB) of the College of Engineering in June 2002, although each of the departments had been interacting formally or informally with industry representatives. The college saw the need to form the IAB to receive direct feedback from their senior-level industry constituents. As an outcome of this IAB meeting, it was recommended to organize a second ABET Mock Visit in September 2002, fully two months prior to the actual ABET site visit. The second Mock Visit team was similarly composed of members representing both academia and industry like the team in January 2002, and had with them, prior to their arrival on campus, copies of the final self-study reports for all six programs that were submitted to ABET by the end of June 2002. This Mock Visit was sponsored by a much larger group of industries as Raytheon Missile Systems, Hamilton Sundstrand, Abbott, Microsoft, Boeing, Merck Sharp & Dohme, and Eli Lilly.

DOCUMENTATION AND CONTINUATION OF ACTIVITIES

Throughout the course of the preparatory efforts during the span of last four years, leading up to the ABET site visit, proper documentation was maintained. This included all reports as well as the minutes of all meetings conducted by the Faculty ABET Team which can be found in the website http://www.abet.uprm.edu. The website can also be accessed from the UPRM website http://www.uprm.edu and the College of Engineering website http://ing.uprm.edu. The SEED Office under the College of Engineering is expected to continue providing support to ensure the smooth functioning of such offices in each department. This would require conducting assessments on a regular basis, and by combining common assessment practices and methods. The experience gained from this effort is already being applied towards UPRM's accreditation efforts for a visit from the Middle States Council of Higher Education (MSCHE) in 2005.

IMPACT OF ABET EC 2000 ACCREDITATION ON CAMPUS AND BEYOND

UPRM's College of Engineering ABET 2000 accreditation strategy was based on the Learning Factory experience. The strategy incorporated the outcomes assessment plan and tools developed under MEEP and PaSCoR. In order to institutionalize the assessment process as part of the various courses, the College of Engineering established an office called the System for the Evaluation of Education (SEED), with the goal of developing assessment strategies for the undergraduate engineering programs. In addition, the faculty involved industry and employers in its process, and conducted mock "accreditation visits" where industry members gave input about the programs. The UPRM ABET committee organized a series of one-day workshops that led to the development of a package of assessment tools and strategies. This was adopted for common use by all programs, with each one at liberty to modify or choose from among the recommended methods and tools. The package contains an outcomes assessment matrix; an assessment strategies matrix; and various assessment forms for integrating ethics, oral and written reports, teamwork, peer evaluation, course and project evaluations, internships, and a variety of surveys.

As a result of the College of Engineering accreditation outcomes, UPRM has expanded the quality culture to all its functions, to use outcomes for effective decision making, thus therefore creating a quality culture.

SHARING WITH OTHERS: OUTREACH SMALL AND HEMISPHERIC

As the MEEP Learning Factory project was coming to an end, the UPRM team began working to share this model program with other faculty and institutions. Grants from the NSF, Raytheon Company, Microsoft and Hewlett-Packard have made it possible for UPRM to hold more than 40 workshops around the world for hundreds of faculty and deans, many of whom have adopted or adapted this model program. The program has had an outstanding impact in many cases. The most noteworthy example is Chile, where the Engineering Deans Council sponsored workshops for more than 130 participants nationwide, resulting in curricular reform supported by government grants. UPRM workshop leaders are assisting faculty at the Universidad Federico Santa Maria in Valparaiso, Universidad de Bio-Bio, and Universidad de la Frontera, in their implementation efforts. (Note: Some of the sites where this workshop has been offered include: 1998 & 1999 Frontiers in Education Conferences; 1999, 2000 ASEE Conferences; 2000 SUCCEED-GATEWAY conference in Greensboro, NC; UTEP; Tennessee State University; Southern University; North Carolina A&T; 1999 ICEE Conference; Texas A&M - Prairie View; Polytechnic University- Puerto Rico; University of P.R. at Bayamón; Worcester Polytechnic Institute; 2000 ADMI Conference; Hampton University, VA; University of Chile; Pontifical Catholic University of Chile; University of Buenos Aires; Universidad Tecnológica Nacional, Argentina; and Universidade Estadual de Campinas, Brazil; and more recently in 2005-2006 at Monterrey Tech and 2006 SEFI Conference in Uppsala, Sweden. Frank Stefan Becker, Director of Siemens Worldwide University Relations said of his experience in July 2006: "it is probably the best workshop in all the SEFI conference.")

Recently, the present author has had the opportunity to be involved in engineering education innovation and assessment that became the "Engineering for the Americas" initiative. It was developed after a Learning Factory workshop was held in Rio de Janeiro in 1998 during the International Conference on Engineering Education, ICEE-1998. This grass-roots initiative is being carried out by many organizations and in conjunction with the Organization of American States (OAS). It focuses on developing plans for enhancing engineering education and practice throughout Latin American and the Caribbean [14,15]. The OAS ministers of science and technology issued a major declaration in support of this capacity-building effort during their meeting in Lima, Peru, in 2004.

Efforts are now underway to offer regional workshops on engineering education innovation and reform, quality assurance and assessment, and technology innovation, in addition to finding resources to support these initiatives. The Engineering for the Americas team is focused on creating a comprehensive partnership committed to advancing the mandate set forth in the Lima Declaration. It also is pursuing opportunities from government, academic, industry, professional societies, accreditation agencies, and a variety of funding institutions to invest in building engineering capacity and sustainable competitiveness throughout the Americas.

Figure 2 - Engineering for the Americas, Lima, Perú Nov 2004

CONCLUDING REMARKS

Engineering education, as any dynamic process, as any engineering problem, needs to be clearly understood in all of its components in order that it can adequately address the needs of the community it serves. As with any engineering problem, the output, the input, its process variables as well as the ecosystem it exists within need to be clearly identified and assessed, so that appropriate changes are made and quality is enhanced as a continuous process. Thus, as a continuous process, it needs to be imbedded, ingrained in those that implement it. It is truly a culture, a way of life, not an isolated event that institutions or programs undergo just to simply comply with accreditation criteria. The true value of assessment and accreditation lies in the fact that it provides its most important constituents – students, faculty and employers – with the best possible engineering professional it can provide; a professional that possesses the skills, values and competencies that make him/her a valuable contributor in his/her country or as a member of a multinational engineering workforce. This culture takes time and resources to be developed, it does not come easy.

All six of the undergraduate engineering programs at UPRM were evaluated under the new ABET EC 200 criteria in 2002. ABET's accreditation visit team commented: "The institution's systematic and innovative effort to introduce the culture of outcomes-based assessment to the College of Engineering community is especially noteworthy." As a result of these experiences, UPRM is expanding the quality assurance and outcomes assessment efforts institution-wide. These efforts and documentation solidify the institution's magnet to attract more than 100 national and multinational companies that recruit graduates, especially engineering.

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