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Searching Academic Excellence in IE Curriculum through Assessment

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Abstract

Every ABET accredited IE program engages in course assessment (both direct and indirect) to demonstrate attainment of Program Outcomes and course objectives. Stakeholders that provide inputs are faculty, students, alumni, employers, industrial advisory boards, among others. Course improvements should lead to innovation and curricular reforms. Stakeholders' inputs have a large role in determining the degree of compliance and excellence achieved. Other models for achieving Performance Excellence include the Malcolm Baldrige Quality Award; State based Quality Awards, Balanced Scorecards, etc. These models seek to implement a minimal set of key indicators that provide a measure of progress towards achieving mission and vision of programs. Assessment provides the core measurement system to continuous improvement in courses and curricular enhancements and innovation. Changes in the economic forces that drive growth, sustainability, and resilience also drive innovation in curricula. Our main point is to integrate local efforts in course assessments into greater mission and vision achievement that come from breakthrough improvements.

Keywords
Assessment, ABET outcomes, Knowledge-Skills, Abilities (KSAs), Baldrige Award, Performance Excellence

1. Introduction

Assessment has been the basis to enhance education practices to achieve profound learning in industrial engineering (IE) programs. IE students have specific motivations and aspirations when they enroll in their respective schools or institutions. Students' requirements are ascertained by means of focus groups, surveys, structured interviews, among others. Alumni also provide valuable information on what areas they needed to learn before graduating, which loop-holes or gaps they had upon graduation. Just ask alumni what is missing in their curriculum. This source is essential for improving the curriculum.

These inputs provide valuable data for restructuring Program Objectives in a two to three year cycle. Program Educational Objectives are broad statements of what graduates are expected to attain within a few years from graduation. These objectives must be based on the needs of constituents of the program. Employers and alumni should be part of Industry Advisory Boards that also serve as focus groups to provide excellent information to reformulate program objectives, mission, and vision of the IE programs. This leads to a two loops assessment system where one cycle is completed on a yearly basis, and the second has a three year cycle to provide more stable-long term horizon. (Figure 1). Program objectives must be consistent with the Institutional mission and vision. There must be a documented, systematic process to review these objectives with the participation of constituents over time.

ABET provides a framework establishing minimum assessment standards and achievement of program outcomes for every engineering program, in a generic way. Each program must articulate how they are going to achieve these outcomes (a through k). The best way to assess program outcomes is in three courses (Larry David 2015) and using three courses at different points in the curriculum to show progress in achievement in time.

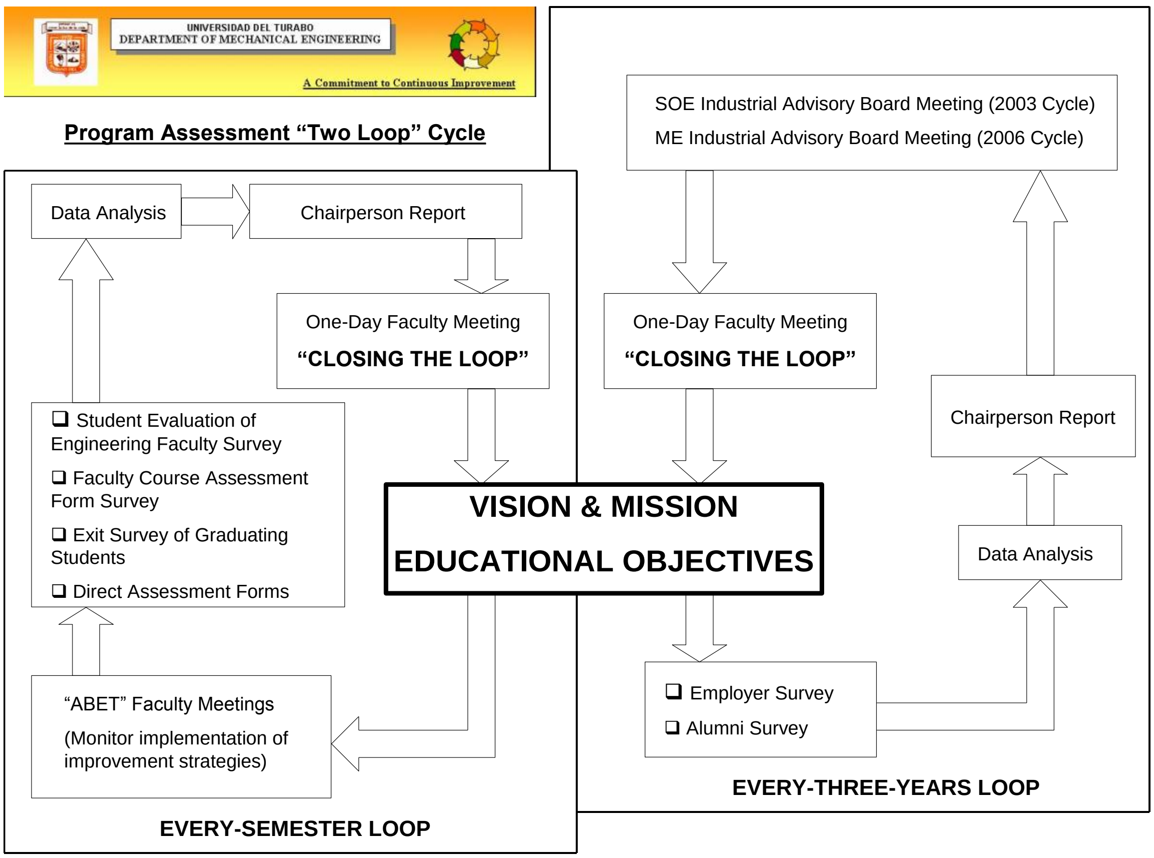

Figure 1. Two-tiered Continuous Improvement Loops

Although ABET does not require assessment of Program Objectives, Criterion 8, it would be advantageous to assess how well the criteria is being met or surpassed. This provides a broader view of program achievement in terms of ability to design integrated systems encompassing knowledge, information, technology, persons, equipment, capital, physical facilities to produce services or products of high quality, at a reasonable cost and consistently on time; dealing with the stochastic nature of production systems; and predicting the behavior of such systems. A threshold level must be defined to assess attainment of program outcomes and objectives. This represents additional effort which we consider worth the effort.

2. Literature Review

Baldrige Criteria for Performance Excellence assesses the practices in the dimensions of Leadership; Student, Stakeholders and Market Knowledge; Strategic Planning; Measurement, Analysis and Knowledge Management; Workforce Focus; Process Management; and Results. These seven dimensions have a rubric for assessing the level of maturity of development, deployment and continuous improvements based on facts and data. Some schools and universities have won this award, School of Business of University of Wisconsin Stout and Richland College, Dallas County Community College 2005.

EDUCASE Center for Applied Research Bulletin – Continuous Improvement Strategies in Higher Education point out which strategies were used by 301 public and private institutions to implement their improvement strategies. 88 percent of CEOs responded they were using continuous improvement strategies.

1. Process improvement (function improvement-local efforts in 40 percent of institutions);
2. Institutional effectiveness assessment (56 percent);
3. Continuous improvement – (27 percent of institutions) to level efforts to improve quality of services;
4. Student learning assessment (58 percent of institutions) – using student learning focus to improve fundamental processes and as driver of improvements;
5. Introduction of accreditation standards to drive improvement efforts (47 percent of institutions);
6. Baldrige Methodology to achieve excellence in performance (15 %); State Quality Award Preparation –usually similar to Baldrige criteria;
7. Balanced Scorecard (11 %) –data driven set of measures that serves as "dashboard" to guide institutional vital signs, including financial, student services, process performance, and capacity for learning and innovation;
8. Quality-based cost accounting –to identify areas for improvements in processes to excel customers' expectations.

They state "Adopting continuous improvement strategies enabled institutions to achieve improvements in: students and stakeholders' services, process improvements to facilitate employees performing their jobs, and improve institutional outcomes. "

3. Assessment of Student Learning

Good Practices for assessing student learning encompass:

- Educational values.
- Reflecting an understanding of learning as multidimensional, integrated, and revealed performance level over time.
- The programs it seeks to improve should have clear, explicitly stated purposes.
- Attention to outcomes but also and equally to the experiences that lead to those outcomes.
- It is ongoing, not episodic effort.
- Representatives from across the educational community being involved.
- Beginning with issues of use and illuminates questions that people really care about.
- It is part of a larger set of conditions that promote change.
- Educators meet responsibilities to students and to the public.

Assessment is the systematic collection and analysis of information to improve student learning. What students should be learning is defined in ABET's program outcomes *a through k* for each engineering discipline. Assessment provides clues on what students are actually learning and their growth rate across the curriculum. Continuous improvement of our methodologies guides professors on what we should be doing to enhance student learning and growth.

Program assessment focuses on assessing student learning and experience to determine whether they have acquired the knowledge, skills and abilities (KSAs) associated with industrial engineering. Program assessment is based on the Department mission and vision, must be systematic, faculty designed and implemented to be sustainable. Program educational outcomes (PEOs) are KSAs that students must acquire before graduation, and these must be demonstrated though assessment to achieve program accreditation. These PEOs are specific skills, knowledge, abilities, values and attitudes that reflect broader Program Objectives. The later are skills to be demonstrated by graduates within a two to five year time frame after graduation. Thus it is somewhat useless to include program outcomes in your alumni surveys or employer surveys. Here we match the program outcomes with TUEE KSAs identified with several constituencies as described below.

ABET criteria define program outcomes or abilities students must demonstrate before graduation:

a. An ability to apply knowledge of mathematics, science and engineering.
   KSA 2. Physical sciences and engineering science fundamentals
b. An ability to design and conduct experiments, as well as to analyze and interpret data.
   KSA 20. Data interpretation and visualization.
c. An ability to design a system, components or processes to meet desired needs.
   KSA 19. Applied knowledge of engineering core sciences and implementation skills to apply them in the real world.
   KSA 34. Understanding of design
d. An ability to function on a multidisciplinary team.
   KSA 14. Teamwork skills and ability to function in multidisciplinary teams.
e. An ability to identify, formulate, and solve engineering problems.
   KSA 3. Ability to identify, formulate, and solve engineering problems
f. An understanding of professional and ethical responsibility.
   KSA 9. High ethical standards, integrity, and global, social, intellectual, and technological responsibility.
   KSA 17. Public safety.
g. An ability to communicate effectively.
   KSA 1. Good communication skills.
h. A broad education necessary to understand the impact of engineering solutions in a global and societal context.
   KSA 7.Cultural awareness in the broad sense (nationality, ethnicity, linguistic, gender, sexual orientation)
i. A recognition of the need for, and an ability to engage in life-long learning.
   .KSA 5. Curiosity and persistent desire for continuous learning.
j. A knowledge of contemporary issues.
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
   KSA 16. Ability to use new technology and modern engineering tools necessary for engineering practice.
   KSA 18. Informational technology (IT).
   KSA 21. Security knowledge (cyber, data, etc.)
   KSA 26. Application based research and evaluation skills.

KSA 4. Systems integration. KSA 24. Systems thinking (skill).
KSA 6. Self-drive and motivation.
KSA 8 Economics and business acumen. KSA29. Mentoring skills.
KSA 10. Critical thinking. KSA 12. Ability to prioritize efficiently.
KSA 13. Project management (supervising, planning, scheduling, budgeting, etc.).
KSA 15. Entrepreneurship and intrapreneurship. KSA 11. Willingness to take calculated risks.
KSA22. Leadership. KSA 27 Ability to create a vision. KSA 36. Ownership and accountability.
KSA 23. Creativity. KSA 32. Innovation.
KSA 25. Emotional intelligence. KSA 35. Conflict resolution.
KSA 28. Good personal and professional judgement.
.KSA 30. Flexibility and ability to adapt to rapid change.

KSA 31. Ability to deal with ambiguity and complexity.
KSA 33. Technical intuition / metacognition.

3.1 Transforming Undergraduate Engineering Education (TUEE)

TUEE has sought to clarify understanding of the knowledge, skills, and abilities (KSAs) needed in engineering in the near future. Representatives from industry, American Society for Engineering Education (ASEE) staffers, academics and representatives from U.S. intelligence community identified core competencies that are essential plus additional skills and professional qualities that help students succeed in a rapidly changing, dynamic field of engineering. These KSAs are matched to ABET a through k plus the non-overlapping KSAs which are aggregated I same row above. The set of KSAs can well become the new generation of program outcomes for the Industrial engineer of the future. Mathematical skills to understand the dimensions of problems beyond what models represent. Graduates should incorporate programming, systems thinking, and the ability to incorporate relevant tools. Communication skills, persistence, learning capabilities, drive and motivation, business perspective, high ethical standards, critical thinking, and risk taking ability are necessary for future engineers. Stakeholders had a role in developing the set of expanded (36) KSAs for engineering graduates. These provide target description to define what future IE graduates should demonstrate.

Besides the set of KSAs identified by industry, government, academia and engineering education associations the professor must deal with the relevancy of his/her courses to achieve the KSA sets identified. Each course can focus on a subset of such skills, abilities, knowledge by instilling a set of values in students. This mapping will ensure currency in curriculum innovation for the next twenty to fifty years.

Faculty define which methods will be used to measure proficiency of students' learning Vs program educational objectives with both direct and indirect assessment instruments. Decide at what point in time and in which courses will you assess each PEO (a –k). Faculty teaching each course should be responsible to gather the assessment data, summarize it and present actions to improve student learning. When corrective action is required the professor should document the improvement actions taken and determine whether improvement in student learning did occur. Not all objectives need to show improvements over time, for a realistic system. The timeline for course assessment should be well established and adhered to. The time phased data should be integrated across professors and courses along the curriculum to assess student learning progress over time.

Each course should identify which program objective it supports, but each objective should be assessed in no more than three courses that represent say, sophomore, Junior, and senior status of students. Overall assessments should have positive trends over the curriculum. Special emphasis must be given to Capstone Design Projects with squishier objectives, such as ethical values, ability to engage in life-long learning, and impact on society of engineering solutions.

Here we emphasize which course, projects; internships contribute to meeting the program outcomes. Are there processes that don't contribute to program outcomes? Which courses should be included?

One example of an innovation in IE curriculum is the Learning Factory at UPR Mayaguez. This was planned in the 1980's when the new IE building was to be constructed by separating 5,000 square feet to locate this dream. It took at least a decade to obtain funding, industry partnerships, plus a consortium with Penn State to finally equip the plant for producing surface mounted circuits. Now it produces LED lighting for public illumination. Several subcontracts were needed to make the dream an economically feasible reality.

4. Conclusion

Assessment is the best tool available for continuous improvement of IE curriculum. An input from constituents or stakeholders is essential to achieve an improvement in professional development of our graduates. Accreditation is used to certify that program meets the minimum requirements of Excellence.

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Biography

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