Assessing Educational Performance
A Strategic Approach

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Abstract

The 21st century promises to be an extraordinarily challenging era. The demands of a new technology revolution, globalization, pressing social concerns and a renaissance in business ethics all call for a new kind of engineer. The 21st century engineer must possess not only technical skills but also interdisciplinary skills and a firm foundation for making ethical decisions. Engineering schools have a responsibility to develop our students' leadership skills in order that they may improve the quality of life through science and engineering.

How will we know if we have properly prepared our students? Students and employers tend to rate graduate programs by their perceived quality, but are our current assessment methods adequate for the future? Is there one good way to evaluate and compare graduate programs? Are universities expanding their use of quantitative metrics for evaluating their programs?

A number of methods are used to evaluate engineering programs. Among them are the Baldrige Education Criteria for Performance Excellence, the ABET Criteria for Accrediting Engineering Programs, and U.S. News and World Report magazine ranking of America's Best Colleges.

This paper presents the assessment method used by the School of Engineering at the University of St. Thomas in St. Paul, Minnesota. We use the Malcolm Baldrige Education Criteria for Performance Excellence to assess our overall performance. Then we measure our performance against our mission and the program objectives and outcomes. We will discuss our experience with this assessment method and provide some comparisons with other assessment methods.

I. The University of St. Thomas School of Engineering

The University of St. Thomas (UST) for U.S. News and World Report ranking is a doctoral intensive Catholic university serving 5,429 under-graduate students and 5,937 graduate students on campuses in St. Paul, Minneapolis, and Owatonna, Minnesota and in Rome. UST is Minnesota's largest private educational institution. The University integrates liberal arts education and career preparation, emphasizing values necessary for complete human development and responsible citizenship in contemporary society. UST provides quality

education through an integration of theory and practice, enhancing students' professional competence and ethical judgment, and fostering personal growth and appreciation for lifelong learning.

The UST School of Engineering employs this philosophy to educate engineers and technology leaders. We offer Bachelor of Science degrees in Mechanical Engineering (BSME) and Electrical Engineering (BSEE); and Master's degrees in Manufacturing Systems Engineering (MMSE), Manufacturing Systems (MSMS) and Technology Management (MSTM). We aim to produce a new kind of engineer and a new kind of leader. By this we mean that our mission is to provide a practical, values-based learning experience that produces well-rounded, innovative engineers and technology leaders who have the technical skills, passion, and courage to make a difference. In carrying out our mission, we seek to excel in the satisfaction of all stakeholders and our assessment methods integrate their requirements and expectations.

II. The Baldrige Education Criteria for Performance Excellence

The Malcolm Baldrige National Quality Award was established by a resolution of Congress in 1987 in response to a compelling need to improve the quality of products and services made in America. The purposes of the Award Program were to advance the knowledge of quality principles, share information broadly across U. S. industry, and to recognize role models and best practices. The Program proved to be highly successful. Many experts give the Baldrige Program credit for revolutionizing management practice and revitalizing U. S. industry. The Baldrige Program's success in revolutionizing American industry led to its extension into education and healthcare where it is exerting a similar positive influence.

It is this track record of success as an assessment vehicle that led us to adopt the Baldrige Criteria as our model. Each year, the UST School of Engineering evaluates itself using the Baldrige Education Criteria for Performance Excellence [1]. The Criteria serve as a world class standard against which we measure our performance in delivering high quality educational programs to our students, our organizational effectiveness, and our organizational learning. The "Results" category of the Baldrige Criteria directs us to evaluate our performance in six areas: 1) student learning, 2) student and stakeholder satisfaction, 3) budgetary, financial, and market, 4) faculty and staff results, 5) organizational effectiveness and 6) governance and social responsibility.

III. UST School of Engineering Assessment Process

To assess our performance against each of these seven results areas of the Baldrige Criteria. we developed an Integrated Information Management System (IIMS) that collects, reports and analyzes the information required. This Integrated Information Management System (IIMS) provides a balanced scorecard [2] of performance metrics (Figure 1) which addresses all of our stakeholders. The system is designed to measure progress in achieving our strategic objectives. Dr. Edward Deming's Plan-Do-Check-Action model guildes our philosophy of continuous improvement through cycles of measurement, analysis, improvement, and control[3]. (See Figure 5 and related discussion in this paper.) Our unique **Stakeholder Performance Improvement Process**, described below, is our method for accomplishing this.

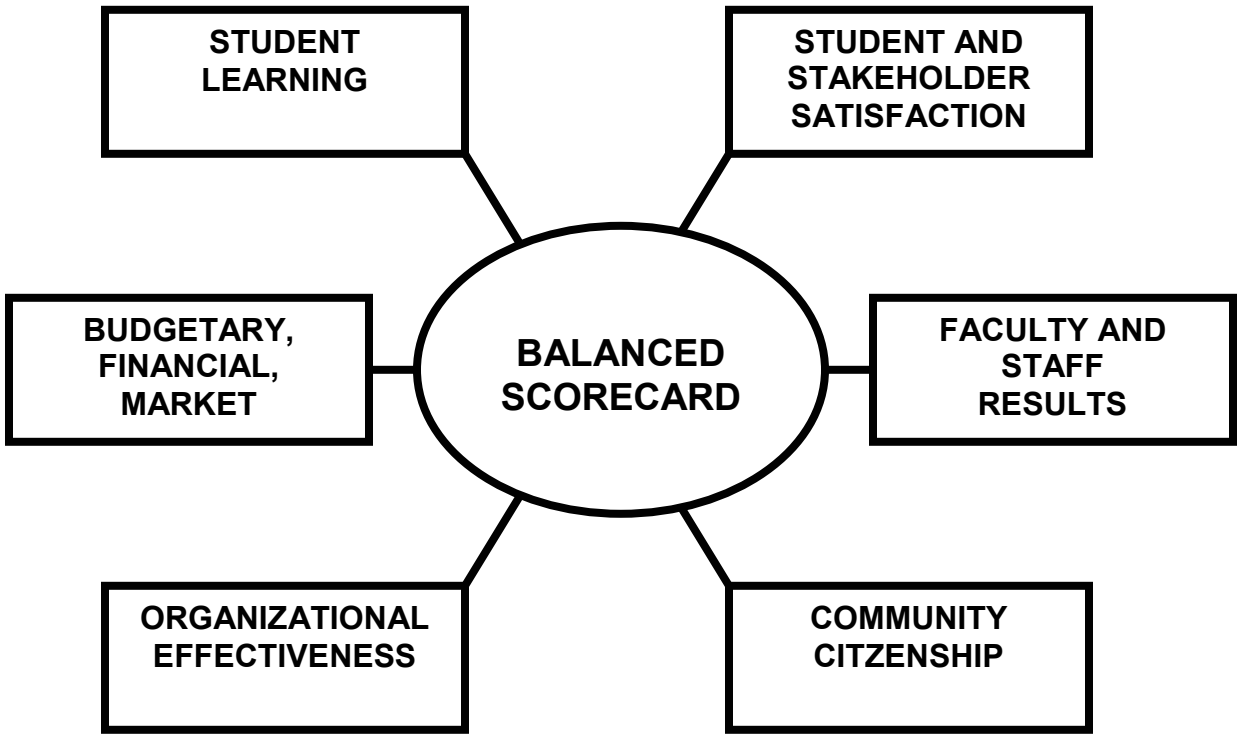

FIGURE 1 – BALANCED SCORECARD OF PERFORMANCE MEASURES

IV. Stakeholder Performance Improvement Process

Our Stakeholder Performance Improvement Process is shown in Figure 2. It is based on the fundamental premise that it is first necessary to correctly identify our stakeholders and to determine their requirements and expectations before we measure results. This is a prerequisite to the measurement of our performance. Our Stakeholder Performance Improvement Process drives us to evaluate our performance from an external point of view; that is, from the viewpoint of the stakeholder. Following is a description of how the process works.

A. Identify all stakeholders

In addition to students, the UST School of Engineering defines five key stakeholder groups. They are: employers, family, faculty, staff and the community. It would be possible to identify countless other "stakeholders" since virtually everyone has a "stake" in the affairs of a university. Our criteria are that a stakeholder has a direct input into the objectives and strategies of our School and be directly impacted by the services and results we deliver. Our criteria lead to fewer rather than more stakeholders but they also lead to more focused and comprehensive relationships with them. We elicit inputs from each student segment and stakeholder group to determine their unique requirements and expectations.

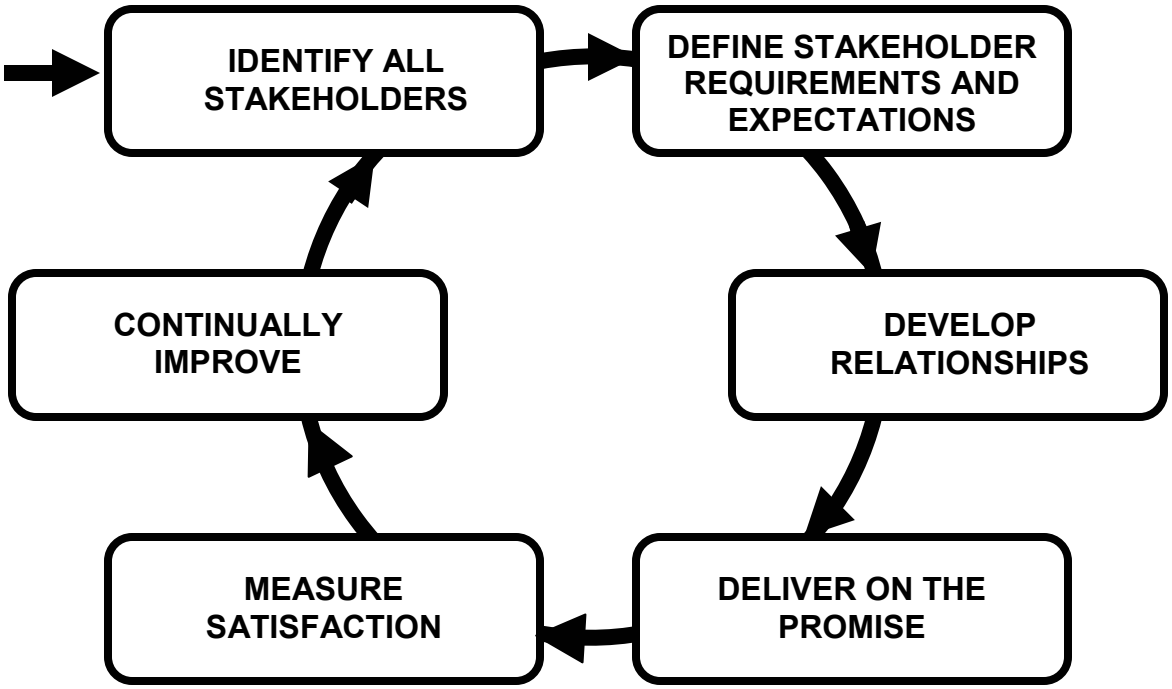

FIGURE 2 – STAKEHOLDER PERFORMANCE IMPROVEMENT PROCESS

B. Define stakeholder requirements and expectations

We determine stakeholder requirements the old fashioned way--by listening to them. But stakeholders cannot always articulate their requirements and expectations. They also have unarticulated needs that can only be determined by interactive dialogue. We make extensive use of personal interaction with all of our stakeholders in order to determine both articulated and unarticulated needs. Figure 3 shows our stakeholder requirements and expectations.

C. Develop relationships

After stakeholder requirements and expectations are determined, the UST School of Engineering develops formal relationships that enable us to meet those requirements and expectations. We maintain communication with our students and key stakeholders through personal contact. The systematic communications mechanisms used are described below:

Students

Our relationship with undergraduate students begins well before they ever arrive on campus and continues throughout their student years and after they graduate. The continuum of relationship development is as follows:

	Undergraduate	Graduate
Students	-Values-based engineering education -Liberal arts focus -Small class size -Personal attention	-Current, relevant curriculum -Practical applications-based learning experience -Leadership learning for career enhancement -Classes scheduled at convenient times
Employers	-Engineers with practical knowledge -Well-rounded engineers -State-of-the-art curricula -Applied research -Source of female and minority engineers	-Graduates with practical knowledge -Graduates trained to be leaders -Engineers with concentrated training in their technologies -State-of-the-art curricula -Applied research
Faculty	-Excited, engaged students -Opportunity for self-development -Minimal administrative bureaucracy -Opportunity to network with colleagues -Facilities optimal for learning/teaching and research -Efficient administrative support for classes	-Excited, engaged students -Opportunity for self-development -Minimal administrative bureaucracy -Opportunity to network with colleagues -Facilities optimal for learning/teaching and research -Efficient administrative support for classes
Staff	-Feeling valued by their co-workers -Collegial work environment -Healthful work area -Fair compensation -Competitive benefits -Effective interdepartmental relationships	-Feeling valued by their co-workers -Collegial work environment -Healthful work area -Fair compensation -Competitive benefits -Effective interdepartmental relationships
Family	-Understanding of the engineering program -Values-based education -Personal attention and guidance -Atmosphere conducive to learning -Liberal arts foundation -Optimal learning facilities -Support for job search process -Employment after graduation	-Classes at convenient times -Career advancement opportunities -Consideration of families in student advising
Community	-Supply of engineers to promote vibrant economy -Opportunities for under-represented groups -Projects to enhance the quality of life	-Supply of engineers to promote vibrant economy -Opportunities for under-represented groups -Projects to enhance the quality of life

FIGURE 3 – STAKEHOLDER REQUIREMENTS AND EXPECTATIONS

- We host a series of outreach programs for pre-high school students to introduce them to the study of technology and engineering. Among these programs is the Science, Technology and Engineering Preview Summer (STEPS) camp for seventh grade girls and Saint Paul Connections, which offers high school students short, after-school and Saturday classes designed to give glimpses of career opportunities in a wide variety of workplace settings.

- Our faculty members visit targeted high schools to introduce juniors and seniors to the study of engineering. We also conduct an "Engineering with Passion" Day for prospective students to visit our campus and get a first hand view of our programs and facilities.

- An Introduction to Engineering class is conducted for incoming freshmen. This gives our students an in-depth look at the field of engineering and permits them to evaluate their interest in and aptitude for it.

- Each student is assigned a personal advisor to guide and counsel them through their student years.

- An alumni group (University Manufacturing Alumni Connection [UMAC]) gives us feedback from graduates on opportunities to improve its curriculum and course offerings

For graduate programs, relationships are developed through information sessions conducted for prospective students and through our personal advising program.

Employers

- The Industry Advisory Board (IAB) supplies the voice of industry. It advises the UST School of Engineering on its strategic direction, helping us to remain customer-focused, responsive, and applications-oriented.

- We hold an annual Engineer of the Future event to introduce employers to our graduating engineers seeking jobs and undergraduates seeking internships. In an innovative setting, students each prepare an individual booth that permits them to exhibit the skills, and talents they offer to prospective employers.

- Our students, under the sponsorship of local companies, carry out Senior Design Projects. Besides dealing with technical issues during the design process, the students learn to work in teams and deal with the "soft" issues such as ethics, safety, economics and environmental factors.

Family

- The UST School of Engineering hosts an annual Parents Visit Day. Parents of undergraduate students spend a day on campus touring the facilities, experiencing college from the students' perspective, and offering their suggestions for improvement.

Faculty and Staff

- Regular meetings are held with full-time faculty and staff to communicate important information, coordinate departmental activities, and review project status and provide professional development.

- The Department Director meets once a semester with each faculty member to critique his/her course and discuss opportunities for continual improvement.

Community

- We sponsor one service-oriented design project each year. This year, a group of seniors are tackling a "wasted food source" for their project. Our students are building a breadfruit dehydrating machine that will preserve a naturally occurring and plentiful food source in tropical countries. The dried breadfruit can be used in products such as breakfast bars, which supply 60 percent of the nutritional requirements for local school children.

- In addition, the STEPS Program and Saint Paul Connections (discussed under the Student section above) are part of our community relationship development process.

D. Deliver on the promise

As stated in our mission, "We provide a practical, values-based learning experience that produces well-rounded, innovative engineers and technology leaders who have the technical skills, passion, and courage to make a difference". That is the promise we make to our students and other stakeholders. Our Stakeholder Performance Improvement Process measures how well we deliver on that promise.

The Curriculum Integration System (Figure 4) is our mechanism for delivering our promise. It translates the key elements of our mission, vision, and values statements and applicable Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC of ABET) [4] requirements into program objectives and outcomes for each of the our degree programs.

EAC of ABET defines Program Educational Objectives as "statements that describe the expected accomplishments of graduates during the first few years after graduation". Also, according to EAC of ABET, Program Learning Outcomes are "statements that describe what students are expected to know and are able to do by the time of graduation, the achievement of which indicates that the student is equipped to achieve the Program Educational Objectives. Programs must have an assessment process that provides evidence that outcomes are being measured."

When preparing a course, our instructors translate the program outcomes into course objectives and student learning outcomes. Instructors prepare a course syllabus that specifies how the course will be delivered and what students will be expected to learn. Correlating course level student learning outcomes with the program level outcomes closes the loop. This assures us that all program outcomes, and therefore program objectives, are being met.

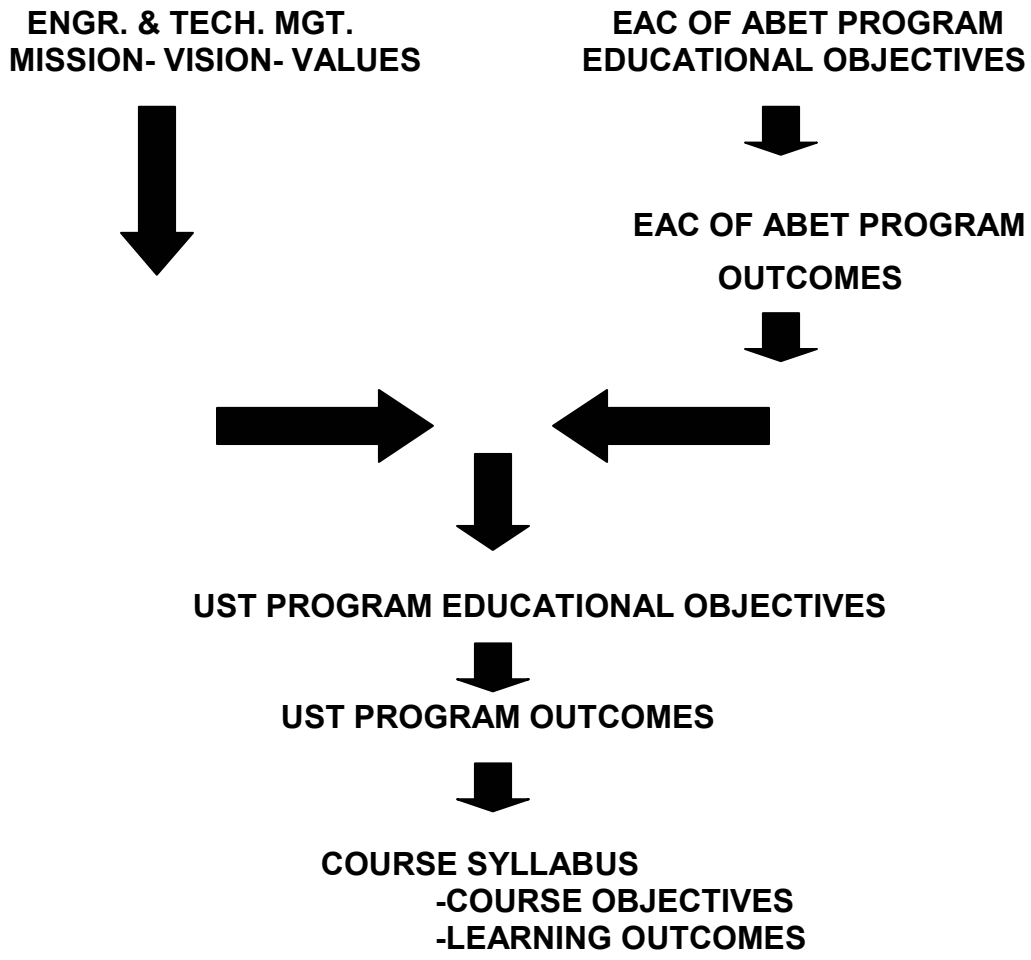

FIGURE 4 – CURRICULUM INTEGRATION SYSTEM

E. Measure satisfaction

The UST School of Engineering has established an Assessment Process that analyzes performance results to support senior leadership and University review. In this process, responsibility for each Balanced Scorecard measure is assigned to a faculty or staff member who becomes the "driver" for that measure. Over the yearly cycle, the driver makes sure that the data is collected and analyzed. The driver compiles results for improvement opportunities, recommends actions, and prepares a report to the faculty. Faculty discussions precipitate actions that the driver sees through to completion. Recommended actions are correlated with the strategies developed during the Strategic Planning process and prioritized. This enables individual faculty and staff members to see how their actions fit into the "big picture." Thus, we take a systematic approach to the measurement of student and stakeholder satisfaction.

Student Learning

First and foremost, we measure the effectiveness of our learner-centered processes. The questions we are seeking to answer are:

> Have we accomplished our mission to produce well-rounded, innovative engineers and technology leaders who have the technical skills, passion and courage to make a difference?
> How much have our students learned and grown?

Our measurement process is aligned with EAC of ABET requirements. It measures what students are expected to know and are able to do by the time of graduation (i.e. program outcomes) and the expected accomplishments of graduates during the first few years after graduation (i.e. program objectives).

Accordingly, we measure student learning by a five-stage process.

- Stage 1 is EAC of ABET accreditation of our programs.
- Stage 2 is End-of-Course Evaluations. At the end of each course, students are asked to rate the course and the instructor on a variety of items indicating the degree to which learning outcomes have been achieved.
- Stage 3 is the Student Self-assessment of Outcomes by Class. Each year, from freshman through senior year, EE students and ME are asked to evaluate their own ability to accomplish program outcomes (including EAC of ABET outcomes). This is a measure of student progress during their college career.
- Stage 4 is the Fundamentals of Engineering (FE) Exam. The FE exam measures graduate engineers' knowledge of a comprehensive set of engineering principles. It measures a graduate's preparedness to achieve program objectives in the future as defined by EAC of ABET.
- Stage 5 is an Alumni Follow-up Survey. This survey asks graduates to rate themselves on their ability to accomplish program objectives after they have been employed for some time. It is designed to specifically identify the post-collegiate success of the graduates.

Stakeholder Satisfaction

Students

- We conduct a satisfaction survey of alumni after they have graduated. This survey assesses the utilization of and satisfaction with course offerings, facilities, and services during their student years. The survey also measures alumni loyalty by asking if they would recommend our programs to other prospective students.

Family

- Parents of juniors and seniors visit the UST School of Engineering in April of each year. During their visit, they participate in focus groups to get parents' input on, and satisfaction with, the program as well as their suggestions for improvements.

Employers

- We have implemented a web-based Employer Feedback Questionnaire. The electronic design allows us to send it to alumni with the request that they forward the questions to

their supervisor for direct response. The Employer Feedback Questionnaire seeks vital quantitative and qualitative feedback from employers about our bachelor's degree alumni.

Faculty and Staff

- Each year we conduct a survey of faculty and staff well-being, satisfaction, and motivation factors as they are listed in Figure 3.

Community

- Each community service project is evaluated for its impact and on the degree to which it meets its intended objectives.

F. Continually improve

We have developed a continuous improvement process based on the W. Edwards Deming model of Plan-Do-Check-Act (Figure 5). Four levels are involved in this process: Voice of the Customer, Program, Curriculum, and Course. Various activities occur at each level, and

Level	A. Plan	B. Do	C. Check	D. Act
I Voice of the Customer	Identify constituents and solicit their input	Develop program objectives	Assess effectiveness of process in light of the University mission	Modify process and list of constituents based on assessment
II Program	Develop assessment tools and standards for evaluating accomplishment of program objectives	Develop student outcomes that support accomplishment of program objectives	Assess accomplish-ment of program objectives and effectiveness of student outcomes in supporting objectives	Modify list of desired outcomes to better support program objectives
III Curriculum	Develop assessment tools and standards for evaluating accomplishment of student outcomes	Develop list of required and elective courses, individual course learning objectives, and prerequisites	Assess effectiveness of curriculum in producing desired student outcomes	Modify curriculum, course learning objectives, and prerequisites to better achieve learning outcomes
IV Course	Develop course material including assessment tools, standards, and resources, including syllabus	Offer course	Assess accomplish-ment of learning objectives: course/ instructor evaluations	Modify course materials and activities to better accomplish objectives and provide feedback

FIGURE 5 – CONTINUAL IMPROVEMENT PROCESS

it is an iterative process. This process assures that our programs continue to meet industry's needs and that they are delivered in a rigorous way in accordance with our mission and EAC of ABET requirements

Our Stakeholder Performance Improvement Process has led us to many opportunities to better meet the expectations of our stakeholders. Since the process looks at us through the eyes of our stakeholders, we gain an externally focused analysis of our performance. A few of the actions we have taken are:

- Our discussions with regional companies have led to the initiation of bachelor's degree programs in Mechanical and Electrical Engineering, a Master's Degree in Technology Management and a concentration in Medical Devices.
- We started our Engineer of the Future program in response to parents request that we help students find jobs.
- The STEPS Program was initiated in response to the need for more women engineers.
- We developed a course on Fuel Cells when we discovered that there was a demand for such a course and that no college in the area was offering one.

Our process expands our horizons and leads us to innovative accomplishments driven by the requirements and expectations of our stakeholders. We believe the process is helping us achieve our vision to be known as an effective, stakeholder-focused learning organization serving as a model for other learning institutions.

Having explained how our Stakeholder Performance improvement Process helps us to track our progress toward the Baldrige Criteria each year, and how feedback from the Baldrige review helps us to improve each year, let us now look at how the Baldrige Criteria fits with two other popular educational assessments—EAC of ABET and U.S. News and World Report rankings.

V. Evaluation of the Baldrige Criteria

The Baldrige Education Criteria for Performance Excellence have been described as a large open book test on academic management -- "Everything you've always wanted to know about running an educational institution, but didn't have time to ask." Our experience shows that it is well worth the time to take the open book test annually. We have now performed the Baldrige self-assessment three times and each time it becomes more valuable. The primary benefits we have received are:

- The Baldrige criteria provide an objective and holistic, quantitative measure of our overall performance as an educational institution. It serves as a realistic self-assessment tool. It guards against either over confidence or false humility and it removes the subjectivity from our strategic planning and our priority actions for improvement.
- The Baldrige criteria are a focused business excellence model. They promote a systematic approach to engineering education. The result is that daily actions are aligned with the mission of the university and the activities of all faculty and staff members are coordinated.

- The Baldrige criteria promote operational efficiency and effective use of resources. The criteria encourage organizations to define their work in terms of processes and analyze the various steps in the processes in some detail. This results in streamlining by eliminating unnecessary operations, reducing errors and improving communications.

VI. Comments on Other Assessment Methods

There are several other methods available for assessing educational programs. The most common is the EAC of ABET Engineering Criteria 2000. As stated above, the UST School of Engineering seeks EAC of ABET accreditation of each of our engineering programs as soon as they are eligible. All of our programs have been successfully accredited. There is strong correlation between the EAC of ABET criteria and the Baldrige criteria as shown in Figure 6. [5]

EAC of ABET	Baldrige
Criterion 1 - Students - Quality - Performance	Item 7.1 - Students Learning Results Item 7.2 - Student and Stakeholder Focused Results
Criterion 2 - Program Educational Objectives - Process - Curriculum - Evaluation	Item 2.1 - Strategy Development Item 2.2 - Strategy Deployment
Criterion 3 - Program Outcomes and Assessment - Skills and Knowledge of Graduates - Feedback to Improve Program	Item 3.1 - Student, Stakeholder and Market Knowledge Item 7.1 - Students Learning Results Item 7.2 - Student and Stakeholder Focused Results
Criterion 4 - Professional Component - Content of Courses - Quality	Item 6.1 - Learning-centered Processes
Criterion 5 - Faculty - Size - Qualifications	Item 5.1 - Work Systems Item 5.2 - Faculty and Staff Learning and Motivation Item 5.3 - Faculty and Staff Well-being and Satisfaction
Criterion 6 - Facilities - Conducive to Learning - Faculty-student Interaction - Modern Engineering Tools	Item 6.2 - Support Processes Item 7.4 - Faculty and Staff Results Item 7.5 - Organizational Effectiveness Results
Criterion 7 - Institutional Support and Financial Resources - Program Quality and Continuity - Faculty Development - Equipment - Support Personal	Item 1.1 - Organizational Leadership Item 4.1 - Measurement and Analysis of Organizational Performance Item 6.1 - Learning-centered Processes Item 7.3 - Budgetary, Financial, and Market Results
Criterion 8 – Program Criteria	Item 6.1 - Learning-centered Processes

FIGURE 6 – EAC of ABET- BALDRIGE CORRELATION

U.S. News and World Report magazine ranks engineering schools using a quantitative ranking system using four criteria as follows:

- Reputation (40%)

- Student Selectivity (10%)
- Faculty Resources (25%)
- Research Activity (25%).

For a comprehensive discussion of the U.S. News and World Report assessment methodology, see the paper cited in the bibliography [6].

IV. Conclusion

All three assessment methods discussed in this paper have merit. All of them seek to provide guidance on how to become a great university and all of them are helpful in developing strategies and prioritizing improvement actions.

The U.S. News and World Report is perhaps the most subjective since it relies on opinion and perception rather that quantitative data. The EAC of ABET assessment provides a solid, tangible evaluation of engineering programs although it generally deals with minimum requirements rather "best in class" performance. The Baldrige Criteria provide a quantitative, holistic assessment of all aspects of a school of engineering. Perhaps the comparison among the methods can best be made in terms of an Olympic sports analogy. The EAC of ABET is comparable to qualifying for the Olympic Games. The U.S. News and World Report method is comparable to winning the gold medal in figure skating since it involves some subjective judgment and some politics. Winning the Baldrige Award for Education would be comparable to winning an Olympic Gold Medal in a sport such as diving that is not totally quantifiable but, nevertheless, is scored to the nearest 100 th of a point.

Based on our experience, we believe that the Baldrige Criteria yield the most comprehensive and rigorous assessment of an educational institution and we highly recommend it.

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