Assessment and Measurement Innovations for Continuous Improvement in Engineering Education

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Abstract

In the transition period for alignment of engineering program reporting with the new ABET EC-2000 criteria, although many departments were doing the things necessary for a quality educational process, new assessment and measurement techniques had to be defined and implemented in order to provide sufficient quantity and quality of data for verification of desired program outcomes. Many engineering departments had for years been "doing it the old way," i.e., essentially conducting informal qualitative assessments in talking to employers, alumni, students and others with interests in the educational program. However, this data was usually not properly documented, and the "right questions" were not always asked.

EC-2000 criteria require an indepth review of each program's mission and program educational objectives, which results in a set of program outcomes selected to measure the viability of the program. Once program outcomes are defined, an assessment and measurements process can be developed to measure the degree of achievement of these outcomes. Beginning with the constituents of a program (clients, supporters, and other individuals or organizations interacting with the department) and their relationship to its academic implementers, and operating within university policies and constraints, the process provides a means for verification of the desired outcomes, and properly integrated with the decision-making process of the organization, serves as a measure of the milestones of achievement defined to produce the desired outcomes. An optimal set of assessment tools for a given program can be selected; these instruments then facilitate the gathering of relevant data on a regular basis, which data is then fed back into the assessment process. This feedback mechanism allows continuous monitoring of progress toward predetermined programmatic milestones, whereupon program policies, implementation procedures, and the curriculum proper can be modified as needed to achieve the desired outcomes.

This paper presents a model for such a continuous improvement process, and describes lessons learned and changes made to the assessment and measurement system to ensure long-term

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continuous improvement in providing competent engineering graduates for the global engineering industry of this new century.

Introduction

In most cases, the move from the "old" to the "new" way of dealing with engineering accreditation requires not so much the re-invention of new processes as the re-thinking of old processes in the way they are used to satisfy the new criteria[1]. Each program is unique, however, and occasionally new processes are required to measure progress toward meeting desired program outcomes, and to assure continuous improvement over a long period of time[2].

Regardless, the process must begin with the mission statement of an organization, from which program educational objectives and desired program outcomes are developed. Tables 1 through 3 provide examples of a mission statement, a set of program objectives and the desired program outcomes for this program. The fourteen chosen outcomes are derived from EC-2000, Criteria 1-4, customized for this particular program and developed by the Mechanical Engineering faculty.

Critical to the overall process is the understanding of the program's relation to its constituents, those individuals and organizations that interact directly with the program. Figure 1 illustrates the constituents of the UL Lafayette Mechanical Engineering program. Once these basic tools are in place, the job of ongoing assessment and measurement, which is the key to achieving continuous improvement in any program, can commence.

Program Assessment and Measurement

Assessment and Measurements Process

A process for periodically measuring the degree of achievement of the desired program outcomes is next established, as shown in Figure 2. To be meaningful, the process must be: (a) consistent with program goals and constituent needs; (b) exercised on a regular basis; and (c) re-evaluated periodically and modified when necessary to accommodate changing program needs[3].

Assessment Tools

Although the principal tool of measurement for the process is the curriculum itself and the way in which it is administered, this process may be rather obscure if it is not synchronized directly to the desired program outcomes. This synchronization process, which is the subject of another paper and thus is not discussed here, helps to resolve the question of whether or not measurement instruments within each individual course (exams, quizzes, presentations, reports, etc.) are sufficient to provide adequately for the measurement of selected outcomes within each course, or if a comprehensive examination must be administered to students prior to graduation.

In addition to the curriculum itself, other assessment and measurement tools are still required to gain assurance that the program is producing the desired outcomes. Some of these are alumni questionnaires/surveys, senior exit interviews, FE (EIT) exam results, inputs from the program's Industrial Advisory Board, individual course/instructor evaluations by students, and Student Advisory Committee inputs. These instruments must be chosen judiciously, used regularly, and not be expected to provide data outside the scope of the parameter(s) each was intended to measure.

Centralization

In order to properly focus the assessment and measurement effort and to emphasize its importance, an Assessment and Measurements Office was created, with dedicated facilities for data gathering and analysis. This office serves as the focal point for the assessment and measurement activity of the department. Under the direction of one person, faculty responsible for individual areas of assessment use the facility and provide regular reports which are kept in this office. These reports are used to recommend prescribed actions for continuous improvement.

Oversight

Constant watchfulness is required in the conduct of the assessment and measurement process to assure that meaningful data, regularly collected and documented, is accumulated, and that appropriate modifications to the process are made as needed as a result of changes in technology and in the program environment. This oversight function is performed by the faculty itself, with inputs from constituents. Issues are discussed at weekly faculty meetings, with change action resulting as needed.

Results

Although the process is relatively new, it appears to be working satisfactorily, with faculty responsible for individual areas of assessment not feeling overburdened due to a reasonable distribution of labor between the tasks. The feedback mechanism for program evaluation has already resulted in several proposed curricular changes, some of which have been implemented and others of which are at present being debated (rather vigorously at times!) by faculty in weekly meetings and in dedicated sessions for the solution of specific problems. An example of a recent change is that more thermal science design content was added to one option of the curriculum by restructuring several courses in the energy area. While continuous monitoring requires watchfulness and a certain amount of extra effort, faculty are taking their responsibilities seriously, realizing that their individual contributions are all important for reaching the end goals of the program.

Conclusion

Without a doubt, the practical implementation and long-term maintenance of a successful assessment and measurements program can only be accomplished through the dedication and hard work of the faculty and staff involved, motivated by their understanding of the good resulting from proper utilization of a workable continuous improvement process. This is so because it does require a considerable amount of effort over and above what is normally considered the scope of traditional academic duties. Without faculty working together, and without the assistance of a strong Industrial Advisory Board to link the program to the outside engineering world, no engineering program can remain relevant for very long. Surging technology innovations and frequent changes in the industrial climate necessitate constant watchfulness and the ability to adapt any engineering program to the needs of students who will soon be engineers in the workplace.

References

1. ABET Criteria EC-2000, "Criteria for Accrediting Programs in Engineering in the United States," December 26, 2000, *Engineering Accreditation Commission*, Accreditation Board for Engineering and Technology, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202.

2. "Under the Magnifying Glass," Alvin P. Sanoff, *Prism*, October 2001, pp. 37-38.

3. "User-Friendly Handbook for Project Evaluation: Science, Mathematics, Engineering and Technology Education," F. Stevens, F. Lawrenz and L. Sharp, EHR/NSF (Education and Human Resources/National Science Foundation) Evaluation Handbook, June 1997.

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Table 1. Mission Statement for the Mechanical Engineering Program of the University of Louisiana at Lafayette

"Our mission is to provide quality education and meaningful career opportunities for mechanical engineering graduates of the University of Louisiana at Lafayette. We develop highly qualified graduates with potential to assume positions of increasing responsibility in industry, or to pursue higher learning in the form of graduate studies;

We facilitate relevant research and development activities for faculty for economic and professional development, faculty proficiency, and feedback to the instructional program;

We provide services to the College of Engineering, the University, and the Community in which this University resides.

Our mission will be accomplished by recruiting and educating students in an accredited curriculum of academic course work supplemented by professional development experiences. Demand for graduates will be driven externally by the local economy and global marketplace, and internally by (1) the quality of the instructional program; (2) the relevant work experience of Mechanical Engineering students; and (3) the degree of student professional development achieved (leadership, teamwork, communication skills, etc.). Frequent contact with employers through initiatives such as continuing education, co-op programs, summer intern opportunities, consultations research/development projects, publications and presentations, student design and development projects, and service projects, is considered essential."

Table 2. Program Educational Objectives

To provide a curriculum which contains a sound background in basic sciences, mathematics, engineering science and engineering design, in order to prepare graduates for the practice of professional engineering or for graduate study, and for lifelong learning. Also, to provide students with a well-rounded education through courses with humanistic-social background and English composition skills, which augment the technical courses. Pertinent to this are the following:

1. to develop in students mathematical and computational skills, and methods of engineering analysis;
2. to train students in the use of up-to-date data analysis and experimental techniques as applied to practical engineering applications;
3. to instill in students a design methodology, including the ability to analyze and synthesize
4. problems, think creatively, communicate ideas effectively, and perform well in a team environment.
5. to provide students with a strong professional and ethical sense in the practice of the engineering profession as has been a part of the long history of this profession.
6. To prepare students for the transition from the academic environment to the industrial environment and the workplace.

Table 3. Desired Program Outcomes

1. An ability to apply knowledge of mathematics, through multivariate calculus and differential equations;
2. a familiarity with statistics and linear algebra;
3. an ability to apply scientific knowledge, including chemistry and physics, with depth in physics;
4. an ability to apply knowledge of fundamental engineering principles;
5. an ability to design and conduct experiments, and to collect and analyze data using modern analytical, computational, and experimental practices;
6. an ability to design a system, component, or process to meet desired needs;
7. an ability to function in multidisciplinary teams;
8. an ability to identify, formulate and solve mechanical engineering problems from both the thermal and mechanical systems areas;
9. an understanding of professional and ethical responsibility;
10. an ability to communicate effectively, both orally and in written communications;
11. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
12. a recognition of the need for, and an ability to engage in, life-long learning;
13. a knowledge of contemporary issues;
14. an ability to use and apply modern engineering skills, techniques, and computational tools.

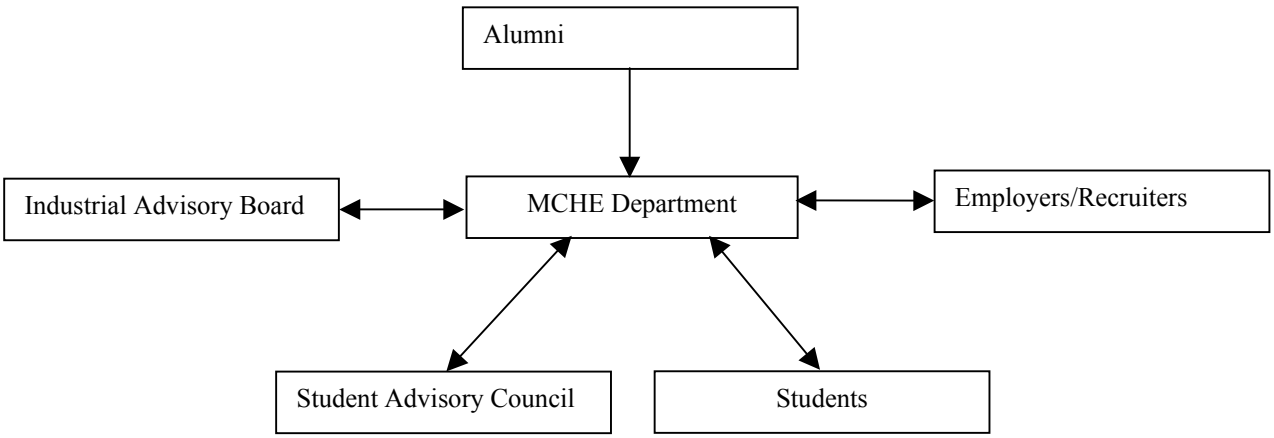

Figure 1. Interactions With Constituents

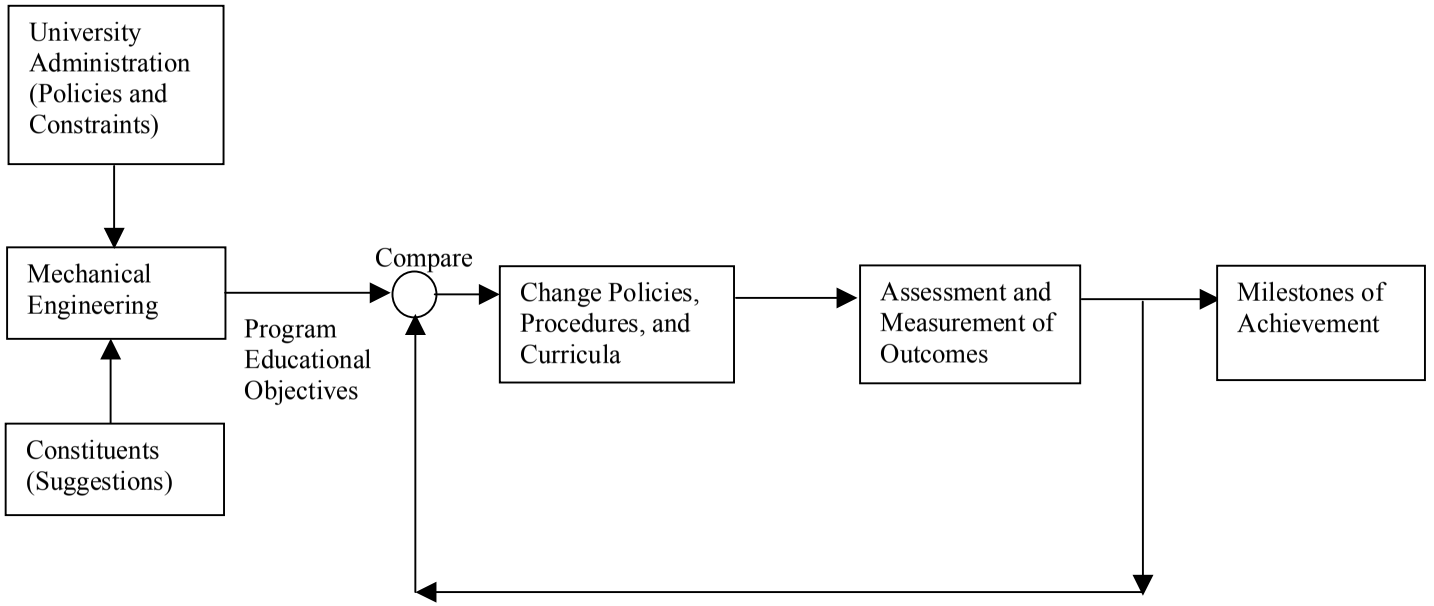

Figure 2. Assessment and Measurement Process for Continuous Improvement

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