

Developing an Educational Process for an Engineering Technology Program

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Abstract

The new criteria for engineering technology accreditation by ABET known as TC2K have been evolving for several years. The TC2K criteria create an outcomes-based assessment process rather than the traditional input-based ABET assessment process. There are fundamental changes in the accreditation criteria that make them significantly different. These changes warrant a new design of the processes used to prepare for accreditation. These new processes must clearly define and embed quality and self-assessment into engineering technology programs.

This paper describes the educational process developed for the mechanical (MET) and manufacturing engineering technology (CIMT) degree programs at Purdue University in West Lafayette, Indiana. Emphasis is given to the processes and plans developed in response to the TC2K Criteria 1 through 3.

Background

During the past decade or so, assessment and improvement efforts have become a part of accreditation processes in many disciplines and across the university through bodies such as the North Central Association. Starting in 2004, all of the ABET Technology Accreditation Commission (TAC) programs are now required to use the new TC2K criteria. The ABET Engineering Accreditation Commission began the transition for engineering programs in the late 1990's with the implementation of EC2000, and is now beginning the second round of visits under outcomes-based assessment. The transition from review of inputs to evaluation of processes and outcomes has been the subject of a number of American Society for Engineering Education publications, engineering technology list-serve debates, and comments solicited by the Technology Accreditation Commission (TAC) as the TC2K general program evaluation criteria were developed. The present version of the TAC criteria adopted in November 2003 contains eight fundamental criteria points. The bibliography includes citations for several publications that the MET faculty used to learn about the changes to the criteria and develop plans for accrediting its programs.

Previous ABET accreditation had been focused on course level concerns, plus surveys of graduates and their employers. Criteria 1, 2, and 3 program educational objectives, program outcomes and assessment and evaluation plans, present the new outcomes-based accreditation elements. These criteria describe the review process intended to ensure that graduates achieve specific program level educational objectives and outcomes within an established timeframe so that linkage from assessment data to known inputs is possible. Despite the shift to assessment of outcomes, many of the traditional elements of an ABET accreditation review are still included in

Criteria 4 through 8. Each program must continue to ensure the appropriate framework for its delivery is intact.

Defining the current status and planning the path to accreditation

A review of the current educational processes and activities began the preparation for the upcoming accreditation visit. A faculty team studied the current educational processes and the requirements for the new outcomes-based evaluation process. The team identified several significant accreditation issues for the associate and baccalaureate degree programs in mechanical and manufacturing engineering technology at Purdue, West Lafayette. The establishment of effective assessments at the degree program level, a formal, but simple assessment process, and the alignment and documentation of the existing departmental educational processes to support the new criteria.

The concepts behind outcomes-based assessment and continuous improvement were not new to the department. An inherent tendency toward a Deming-style Plan, Do, Check, Act (PDCA) approach is part of the departmental culture.¹ This approach drives the Mechanical Engineering Technology Department's educational process. See figure 1 below.

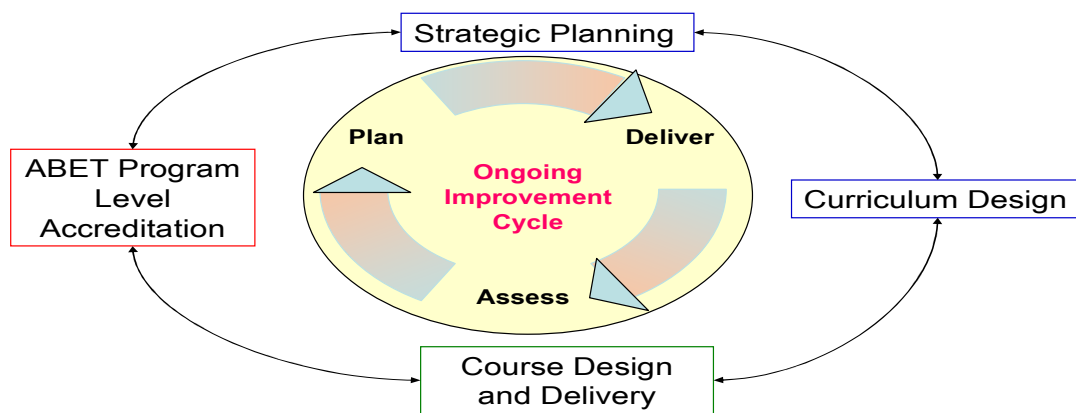


Figure 1: Ongoing Improvement Cycle, driver of the educational process

The Faculty members, Curriculum Committees (for MET and CIMT) and the Assessment Committee are the drivers of the department's educational process. The process helps the department deliver educational programs that are of high quality and in tune with departmental plans, curricula, courses, degree objectives and desired student learning outcomes.

The existing foundation for the department's education processes included a departmental strategic plan that defines the department's core values, beliefs, mission, and vision. Core learning objectives were developed and approved for all major courses. A well-defined faculty-driven curriculum design and review processes has been in place for many years. Faculty members are conducting assessment and attempting to improve their courses and the degree program through continuous improvement documentation. This documentation is an important

input to each faculty member's annual performance review. Active industrial advisory committees support each degree program and provide important inputs and guidance.

The faculty team identified several educational process elements needed for a successful TC2K-type program evaluation. The web site titled, "Assessment Planning Resources"³, developed by Gloria Rogers is very helpful. Additional assessment instruction and planning information is available on CD ROM for purchase at nominal cost from this site. The sample paper prepared by Rogers provides examples of how this process might come together to meet the ABET criteria. Although this paper is not reviewed or approved by ABET it presents a very complete and logical picture of a sample educational process and its operation that helps faculty visualize the process.⁴

A clear differentiation must exist between expectations at graduation and two to five years later (e.g., distinct program outcomes and longer-term educational objectives) is needed. This differentiation is described in several resources^{4, 5, 6} Specific outcome indicators must link to the defined program outcomes. Assessment activities defined by the faculty establish metrics and the process of evaluation. It is clear from the Criteria and Self Study documentation that a well-defined process for implementing program-level changes (beyond purely curricular/course level changes) is required.^{5, 6}

A major focus of work by the faculty concentrated on the outcomes expected of the graduates of the program. Weeks and Pagano state, "The outcomes as stated in TC2K Criterion 2 are minimum standards, not intended to be an exhaustive list. This list provides a template that programs can use to define their outcomes. Programs must look at their own institutions, their own students, their own communities and constituents—and develop a process that supports achievement of their specific outcomes and demonstrates that the program is, in fact, achieving them (closing the loop)."⁷ The faculty have some flexibility to define outcomes to best fit them to the degree program.

The MET educational process including ongoing integration of outcome-driven processes into the department culture (see figure 2, below). The process, fueled by the work of the faculty, designs and delivers courses and faculty interaction with students. The Curriculum Committees for each program work with the faculty, students and the Industrial Advisory Committees to monitor courses and prerequisites and keep the curriculum up to date. The new addition to the process is the Assessment Committee charged with the design and implementation of a department-wide oversight process to ensure ongoing program improvements and that the "loop" is closed.

The educational process is very dynamic and fluid, but the process is cyclical across time. The process moves through the academic calendar beginning in the fall semester, on into the spring semester, and through the summer when the cycle starts over. The two semester academic calendar governs the process and its schedule. Several cycles of activity during the fall and spring semesters feed the continuous evaluation and improvement processes at key times. Timing is critical! Mid-semester reviews with faculty members assure the progress of the ongoing process of measurement and assessment. The Assessment committee reviews fall data summaries and inputs from the faculty during the spring. The academic year is reviewed in May following the completion of the spring term. The new educational process provides new rigor to the assessment process. The hard work is beginning to produce tangible benefits.

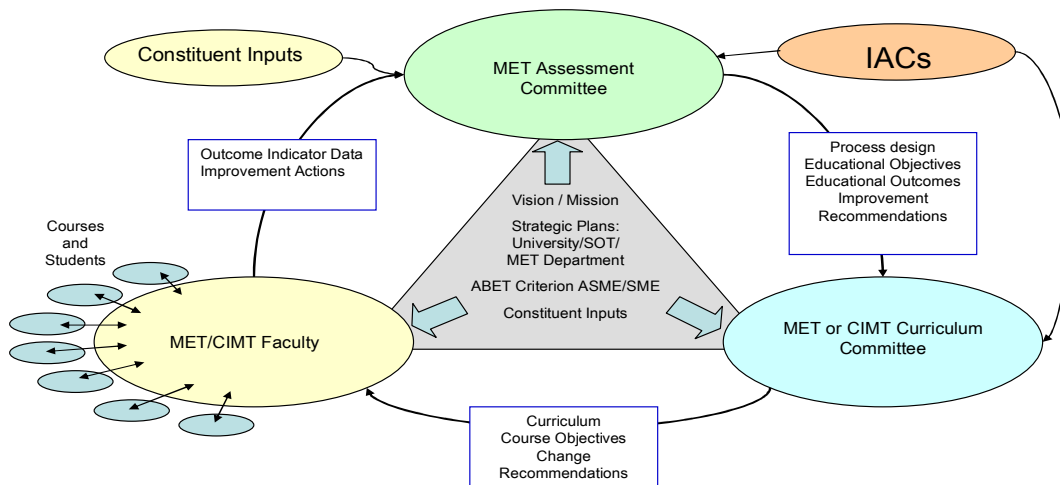


Figure 2: The Educational Process for the MET Department

Preparation steps for the new accreditation

The initial pass at setting up educational objectives, program outcomes, planned assessment points, and the metrics used began during the summer of 2003 for the Purdue MET program in New Albany, Indiana. The current forms of the program outcomes and educational objectives stated for the West Lafayette campus build on the work of the New Albany faculty in preparation for their accreditation visit in October 2004.

Program level outcomes and objectives were written for both the MET and CIMT degree programs. The program level outcomes and objectives for the mechanical engineering technology and the manufacturing engineering technology programs are very similar. Differences address the key technical skills that students develop during the completion of each degree program.

Following several months of discussion and review, the faculty agreed upon a list of outcomes and objectives for the programs offered at West Lafayette. The outcomes and objectives for the MET degree program approved by the faculty in August 2004 are shown below.

MET Program Level Outcomes: Students at the time of graduation:

1. Apply knowledge, problem solving techniques, and hands-on skills in the area of product development, materials specification, manufacturing processes, fluid power, energy systems and continuous improvement.
2. Recognize the need to continue professional development by engaging in lifelong learning.
3. Communicate with others in an effective manner
4. Work effectively in teams
5. Fulfill the requirements of their profession being aware of accepted standards of integrity and ethical conduct

Educational Objectives for MET: Graduates two to five years after graduation:

1. Effectively deliver services and support to both internal and external clients by applying technical knowledge, problem solving techniques and hands-on skills in traditional and emerging areas of the mechanical discipline
2. Are active participants in ongoing professional development, professional growth and increasing professional responsibility
3. Communicate ideas effectively to technical and non-technical people
4. Work effectively in industrial teams
5. Work within the accepted standards of professional integrity and conduct

The process of blending current activities with the new educational process documentation for ABET began with the review of key course learning objectives that could provide measurable indicators of outcome performance. The selected course level metrics are identified as “outcome indicators.”² These “outcome indicators” supply the course level metric data that when summarized will provide performance evidence for the stated outcomes.

The ABET criteria state in items “a-k” that an engineering technology program must demonstrate that graduates must have the technical and functional skills and knowledge to meet industry requirements. The ABET Coordinators for each program worked with the faculty to prepare detailed spreadsheet “maps” that show how the specific outcome criteria from ABET “a-k.” are covered by the stated educational program outcomes and the links back to specific courses and activities. The ABET Self Study Questionnaire section on program outcomes provides important background material.⁵ Assigned faculty members are responsible for the collection of these specific metrics and reporting the results to the Assessment Committee. In most cases, the faculty will be reporting on measures and metrics that they are already using for course-level assessment. The development and reporting on some new metrics is also expected.

The ABET Criteria states, “Assessment measures typically consist of, but are not limited to, student portfolios, student performance in project work and activity-based learning; results of integrated curricular experiences; relevant nationally-normed examinations; results of surveys to assess graduate and employer satisfaction with employment, career development, career mobility, and job title; and preparation for continuing education.”⁶

The faculty identified two or more assessment points for each program outcome. Assessment points identify the course or other activity where performance-indicating data are collected. Multiple assessment measures in a process that produces documented results provides the best evidence on the performance to the stated outcomes and objectives. Faculty members teaching the courses with identified assessment points determine how to best assess their respective course learning outcomes and to identify the performance standards.

The faculty proposed the use of a variety of assessment methods that supports a “triangulation” approach to the assessment. In some cases, test or quiz grades support learning of key concepts. Scoring rubric templates help faculty assess written work, oral presentations and team activities. The completion of specific assignments and activities provides metric data that provides evidence supporting specific outcomes and student skills. Samples of project work, completion of specific activity-based learning activities, nationally normed exam performance and survey responses may provide key metrics for evaluation. The faculty members are

responsible for the selection of the metric, the collection of the data, the analysis and interpretation of the data reporting on how the results drive continuous improvement.

The MET and CIMT degree programs were both designed to meet the traditional ABET criteria. The coverage of criteria “h-k” that address the functional skills needed by graduates to be effective in the work place requires special attention. These skills had not always been a priority for the faculty, but rise in importance in the new criteria. The ABET Coordinators worked with assessment specialists in the Purdue Center for Instructional Excellence to develop survey questions that target the “h-k” criteria. This portion of the criteria has challenged a faculty that has extensive technical experience, but has little experience in the assessment of diversity, teamwork and student attitudes.

Surveys of students, graduates and employers of graduates complete the assessment package. Student in selected fourth and eighth semester classes complete the surveys. Graduates identified as two to five years past graduation are included in a survey group. Employers of graduates receive a survey on a two to three year cycle.

A final planning step entails deciding what the ABET display materials will include and how they should be organized. The approach adopted by Purdue West Lafayette’s mechanical and manufacturing engineering technology degree programs is to have two categories of display. The focus of the display will be on the assessment of the program outcomes. The ABET Coordinators for each program will prepare files containing supporting documentation for each program outcome. Each program outcome file documents the assessment point metrics, assessment results, and the planned changes and improvements, if any. Where the assessment method warrants it, samples of student work will be included. A supplementary course-based display prepared by the faculty leading the core courses will include the textbook, course learning objectives, and course-level assessment documentation.

Ongoing assessment and evaluation

ABET requires that each program has a documented process by which the objectives are determined and periodically evaluated. Additionally, each program must demonstrate that the result of the assessment of objectives and outcomes improves and further develops the program in accordance with a documented process.

The Assessment Committee conducts this evaluation and drives the implementation the continuous improvement process for the MET Department. One committee performs the oversight function for both the MET and CIMT degree programs. The Committee is chaired by the MET department head and its membership consists of current ABET program evaluators in the department, an assigned accreditation coordinator for each program and location, and a representative from each of the West Lafayette-based industrial advisory committees. The purview of the committee includes the design of the educational process, the wording of the educational objectives and program outcomes for each program and location, oversight for assessment points and metrics, and consideration of all collected assessment data and the corresponding analysis.

The Assessment Committee meets regularly to evaluate the data collected to measure achievement of the program educational outcomes and objectives. “It is not enough, of course, to develop these tools and to assess student performance. To close the loop, it is important to make improvements based on assessment and evaluation results.”⁷ When warranted, the Assessment

Committee may recommend changing an assessment method, changing the frequency of data collection, or changing the wording of an existing outcome or objective.

Lessons learned and ongoing questions

The design, documentation, and implementation of closed-loop outcomes-based assessment processes are complex and difficult. The overall educational process cannot be completed without the dedicated efforts of the faculty and the support of the administration. Along the way, the faculty team found many questions that will require additional work and consideration. The MET faculty has learned much from the processes put in place and the initial experiences of applying them.

One of the biggest issues that must be resolved for the long-term success of this effort is how to sustain a beneficial level of effort on assessment, evaluation, and implementation of the program level changes. Assessment is resource intensive from the standpoint of the faculty collecting and analyzing the data at a regular frequency to the process oversight and documentation.

Ongoing implementation questions include the following. How often do assessments and evaluations need to be completed for each program outcome or educational objective? How much documentation of the process and archiving of data and analysis is needed to fully document the processes? How long are the cycles where program improvements can be seen? Many questions need to be addressed about the sustainability of the processes over long periods of time and the amount of resources that can be devoted to ongoing continuous improvement.

Summary

The process for accreditation under the new outcomes-based criteria is developing in the Mechanical Engineering Technology Department at Purdue University in West Lafayette. The process is dynamic. It blends the technical expertise of the faculty with the concepts of assessment and continuous improvement. The change from input-driven to outcome-driven accreditation requires fundamental changes in the educational process.

The plan for the MET Department at Purdue University began with a review of the new outcome criteria “a-k.” and the current educational processes and activities. The resulting process builds the new program level measures and assessments on a strong foundation of course excellence. The work already done by the faculty to evaluate the performance of their classes and make improvements is the foundation of the new program-level educational plan. The new process uses existing work by the faculty to provide the key outcome indicators whenever possible.

The MET Department’s Assessment Committee provides the oversight of the educational process and closes the loop shown in figure 2. The closed loop educational process provides improved control of the teaching and learning taking place in the Department and provides a documented framework for continuing improvement.

Acknowledgements

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Bibliography:

1. Evans, J. R. and Lindsay, W. M. (2005). *The Management and Control of Quality*, 6th Ed. Cincinnati, OH: Southwestern Publishing Co.
2. Felder, R, Brent, R. (2004). *The ABC's of Engineering Education: ABET, Bloom's Taxonomy, Cooperative Learning and So On*. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition. Salt Lake City.
3. Rogers, G. *Assessment Planning Resources*. Rose-Hulman Institute of Technology.
<http://www.assessmentplan.com/>
4. Rogers, G. (2003). *A Sample Report for ABET Criteria Related to Objectives and Outcomes*. Rose-Hulman Institute of Technology.
5. Technology Accreditation Commission. *Self-Study Questionnaire*, ABET, Inc.
<http://www.abet.org/documents/tac/T003%20Self-Study%20Questionnaire%2011-1-03.doc>
6. Technology Accreditation Commission. *Criteria for Accrediting Engineering Technology Programs*. ABET, Inc. <http://www.abet.org/images/Criteria/T001%2004-05%20TAC%20Criteria%201-19-04.pdf>
7. Weiss, M., Weeks, M., Pagano, M. (2004). *ABET's TEI project: Focus on program improvement*. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition. Salt Lake City.

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