2006-1176: A CONTINUOUS IMPROVEMENT PROCESS FOR A LARGE MULTI-PROGRAM ENGINEERING TECHNOLOGY DEPARTMENT

Daniel Johnson, Rochester Institute of Technology

Daniel P. Johnson is the Program Chair for the Manufacturing Engineering Technology Program at RIT. Prior to joining the MMET Faculty he was Director of RIT's Manufacturing Management and Leadership Program and a Manufacturing Engineer for Allied Signal. He has a Master of Engineering Degree in Manufacturing and a BS in Industrial and Manufacturing Engineering from RIT as well as an AAS in Engineering Science from Hudson Valley Community College.

Robert Merrill, Rochester Institute of Technology

Professor Merrill is the Program Chair for the Mechanical Engineering Technology Program at RIT. He has taught at RIT for 34 years and served as the Department Chair for the Mechanical Engineering Technology Department for 4 years. He worked in industry for 4 years prior to joining RIT and has been consultant to area industry for over 25 years. Professor Merrill earned a BSME from Clarkson and a MSME from Northeastern.

James Scudder, Rochester Institute of Technology

Professor Scudder was the Program Chair for Electrical/Mechanical Engineering Technology at RIT for more than 10 years and was a member of the faculty for almost 20. He had 28 years of industry experience at the Eastman Kodak Company and received bachelor and masters degrees from Cornell University. He was a Licensed Professional Engineer in the State of New York and was the faculty advisor for the RIT Model Railroad Club. Sadly, Jim passed away before this paper was completed. His co-authors will miss him dearly.

John Stratton, Rochester Institute of Technology

John A. Stratton, PE, is Professor of Electrical/Mechanical Engineering Technology at the Rochester Institute of Technology and has served as the chair of two departments and as Associate Dean over the last several years. John is Past Chair of the St. Lawrence Section of ASEE. He was the first President of Tau Alpha Pi if ASEE, Inc. John has published several papers for the ASEE and the IEEE.

George Sutherland, Rochester Institute of Technology

Since August 1, 2003 Dr. Sutherland has been Professor in and the Chair of the MMET/PS Department in the College of Applied Science and Technology at RIT in Rochester, NY. Prior to joining RIT Dr. Sutherland was the founding President, in 1997, of Washington Manufacturing Services (WMS), a private not-for-profit WA company. From 1985 to 1997 Dr. Sutherland was the Vice President of CAMP Inc., a Cleveland Ohio based not-for-profit company that he co-founded in 1984 and joined in 1985. From 1979-85 he was manager of the Automation Mechanics Lab of the General Electric Company Lighting Business Group. Dr. Sutherland was an Assistant and then Associate Professor in the Mechanical Engineering department at The Ohio State University in Columbus, Ohio from 1973-79. Dr. Sutherland holds a Ph.D. in mechanical design from Stanford University.

© American Society for Engineering Education, 2006

A Continuous Improvement Process for a Large Multi-Program Engineering Technology Department

Introduction:

The seven engineering technology (ET) programs at the Rochester Institute of Technology (RIT) were due for a TAC of ABET re-accreditation visit in the fall of 2004. This was the first year in which all of the visits would occur using the TC2K criteria. Three of these programs are housed in the Manufacturing & Mechanical Engineering Technology and Packaging Science Department (MMET/PS). The department chose to have the three programs use the same continuous improvement process, adjusted for the mission of each program.

RIT is a private non-profit university in upstate New York, with approximately 15,000 (headcount) students. The engineering technology programs are housed in the College of Applied Science and Technology (CAST), with a focus on both technology and service. CAST has approximately 3,200 headcount students, with 1,550 of these in ET or related programs. MMET/PS has about 900 headcount students, with 625 of these students enrolled in undergraduate ET programs.

The three TAC of ABET accredited ET programs in MMET/PS are Mechanical Engineering Technology, Manufacturing Engineering Technology, and Electrical/Mechanical Engineering Technology. The three programs share the same liberal arts, mathematics, physics, introductory chemistry, free and technical electives, and mechanical and manufacturing core of courses. Each of the programs also has a series of courses particular to the needs of its intended students and employers.

The three programs chose to have their program educational objectives written in very similar terms. They also chose to use the TAC A-K program outcomes, expanding outcome "A" to include each of the components required by the applicable program criteria. Each of the programs also chose a few additional program outcomes particular to their anticipated students and employers.

CAST and each of the ET departments trained its faculty and administrators in TC2K through a series of activities. An expert in TC2K presented a general one-day seminar to all ET faculty and administrators. The associate dean, department chairs, program chairs and selected faculty attended many of the ABET and ASEE training events. Three of the ET faculty have been trained as TAC of ABET program evaluators and have participated in the evaluation of programs at other universities.

Development of Program Outcomes

After the ABET Review in 1998, the engineering technology programs in the MMET/PS Department began to develop the capability to accomplish outcomes assessment and evaluation. The strategy adopted included the following:

- Develop Program Educational Objectives (PEO's) consistent with RIT, College of Applied Science (CAST) and Manufacturing and Mechanical Engineering Technology and Packaging Science Department (MMET/PS) goals.
- Develop Program Outcomes (PO's) consistent with the PEO's, ABET Criteria 2 (a through k) and ABET Criteria 8.
- Develop Intended Learning Outcomes (ILO's) that support each program's PO's and PEO's. ILO's are the defined outcomes of a specific class; each ILO is related to at least one PO.
- Establish appropriate measurements for assessing PO's and PEO's.
- Develop the processes required to conduct assessments, analyze results and determine corrective actions.

The result of this activity is the MMET/PS Continuous Improvement Plan which is being followed. The Plan and associated documentation is provided in Figure 5.

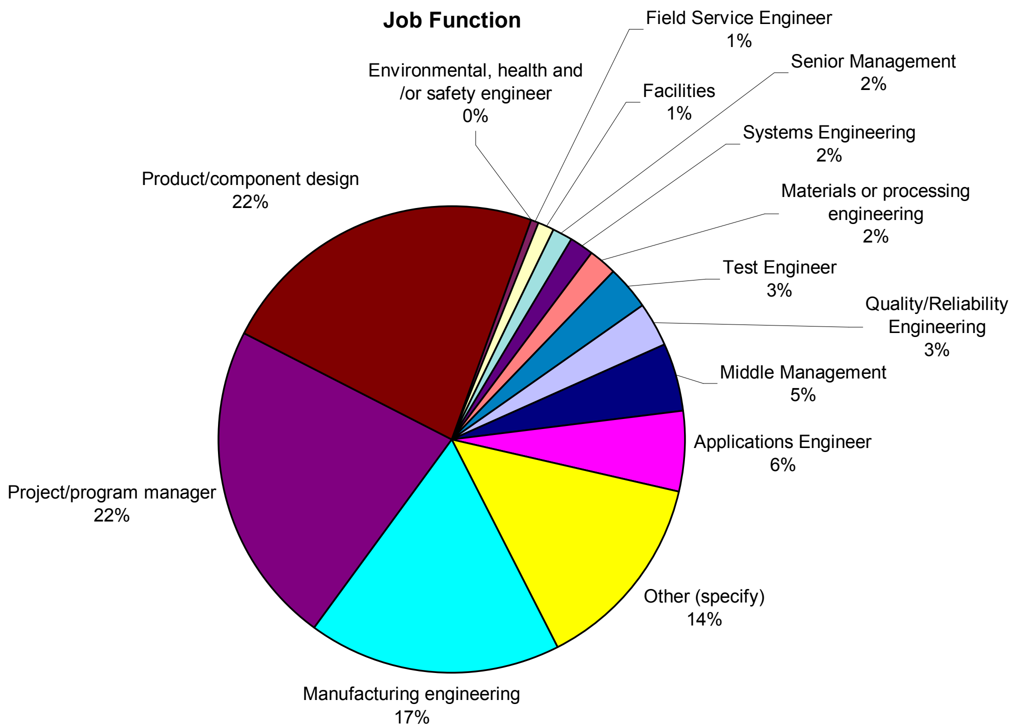
This section provides some of the background for the plan and a description of some of the activities and results of the assessment and evaluation of data collected and used to develop PEO's and PO's.

The first step taken in developing the program PEO's and PO's was to conduct a survey of graduates and employers for the purpose of gathering input from them regarding program content. The survey was developed by the MET Industrial Advisory Board with input from the faculty. The survey posed questions regarding program content, demographics and the value of various educational strategies. It was sent to over 1300 graduates from 1972 through 2001 as well as some employers. Over 200 responses were received, most of them from graduates.

Similar surveys were conducted for both the Manufacturing and Electrical/Mechanical Engineering Technology programs. The results for these surveys were consistent with those for the MET Program and led to similar conclusions regarding PEO's and PO's. Only the MET results are presented here in the interest of conserving space.

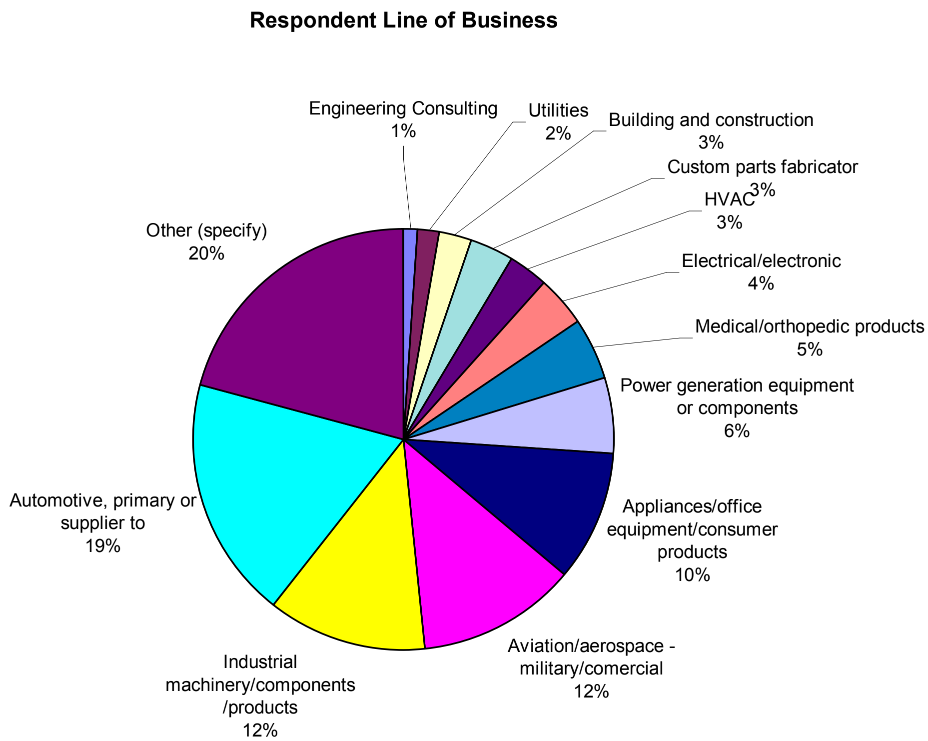
The responses to the demographic questions help in understanding and interpreting the content questions on the survey. A broad range of job functions from Environmental Health and Safety all the way up to Senior Management were reported. However, the majority (>60%) were engaged in the development, design and manufacturing of products. These results are shown in Figure 1.

Figure 1 Respondent Job Function



In addition, most respondents (>80%) reported that they were employed in companies that manufacture products. These results are shown in Figure 2 and tend to support the conclusion stated above.

Figure 2 Respondent Line of Business



Survey questions were divided into two categories and called Survey 1 and Survey 2. Survey 1 questions were proposed by IAB Members and relate to the general needs of industry. Survey 2 questions dealt with the more traditional content similar to ABET Criteria 8. Respondents were asked to agree or disagree with the statements shown in Table 1 relative to specific topics.

Table 1- MET Survey Questions

Survey Question	State level of agreement with the following statements
1	Understanding of the following concepts and ability to apply the following skills are valuable to graduates.
2	The following are outcomes of the educational process. Are these outcomes in line with today's industrial requirements?

The responses were scaled from 1 to 5 with 1 corresponding to "Strongly Disagree" and 5 to "Strongly Agree" and 2, 3 and 4 in between. The average response to each question was computed. They ranged from 4.48 which indicates strong agreement for Communications and Technical Electives to 3.6 for Metrology and Instrumentation which indicates moderate agreement. The most surprising result was the high agreement regarding the need for project management skills. The average of all responses was 4.06 indicating good overall agreement with the statements presented.

The survey results are summarized in Table 2.

Table 2 - MET Survey Results

Survey Question	Statement	Average Response
1	Communication - skills include report writing, presenting.	4.48
2	Technical Electives - Provide opportunity to develop more depth in the following broad areas: product design, power generation, HVAC, plastics and manufacturing.	4.48
2	Manufacturing Processes - Specify the appropriate process to manufacture both metallic and plastic piece parts.	4.41
1	Project Management - ability to serve as both a team member and a team leader; understands concepts of team building, budgeting & cash flow and time resource management.	4.33
1	Data Analysis – conduct, analyze and interpret experiments and apply experimental results to improve design and process.	4.25
2	Mechanics - Apply concepts of equilibrium, Newton's Laws, Conservation of Energy and Momentum, and friction to find unknown forces, moments, velocities and accelerations in design problems.	4.23
2	Engineering Graphics - Create 3D parametric models of parts and assemblies; from 3D model create 2D drawings that meet drafting standards.	4.23
2	Materials - Select metallic (ferrous and non-ferrous) and plastic (thermoplastic, thermoset, elastomer and adhesive) materials and design heat treatments for applications.	4.20
1	Documentation - understands importance of proper documentation to meet legal, regulatory, and sound engineering practice compliance.	4.20
2	Machine Design - Select rolling-element bearings, threaded fasteners, brakes, clutches, belts, pulleys, and sprockets for mechanical design applications.	4.19
1	Ethics - understands the importance and consequences of ethical behavior.	4.18
2	Engineering Graphics - Read, apply, and measure GD & T and size tolerances to meet design goals and reflect manufacturing process capabilities.	4.17
2	Mechanics - Design axially loaded members, beams, bars in torsion and machine parts in combined loading for both static failure and deflection criteria.	4.16
1	Office Technology - thorough understanding of common support (such as integrated word processing, spreadsheets and presentation graphics) and communication software (faxes, scanners, internet, video conferencing, conference calling).	4.09
1	Interpersonal Skills - ability to work in a multi-cultural environment (including awareness of cultural differences, languages, laws, and politics).	4.04
2	Thermofluids - Apply the laws of thermodynamics to the analysis, experimental evaluation, and design of equipment such as engines, pumps, boilers, heat exchangers, compressors, power generation and refrigeration cycles.	3.97
2	Machine Design - Design spur gears, gear trains, springs, power transmission shafts, and sleeve bearings based on appropriate fatigue and deformation criteria.	3.95
1	Commercialization Process - understand that a regimented procedure is required to take a product from feasibility through scale-up and launch.	3.95
2	Manufacturing Processes - Specify process flow within a factory including detailed process steps, scheduling, materials handling, and production flow.	3.95

Table 2 - MET Survey Results		
Survey Question	Statement	Average Response
2	Electrical - Interface mechanical instrumentation (pressure, temperature, etc.) to electrical control systems. Monitor and control mechanical systems with software such as LabView.	3.93
1	Technology Development - understanding of integrated systems development in the global environment.	3.93
1	Quality and Statistics - understanding of process control and importance of 6-sigma; proficiency with design of experiments.	3.91
2	Thermofluids - Design fluid delivery systems including pump and compressor selection and piping systems.	3.89
2	Electrical - Apply concepts of power, current, and voltage for AC and DC circuits, perform power calculations, have the background to use electronic simulation software such as PSpice. Use simple troubleshooting to find bad connections, and determine the effect on the system of such bad connections.	3.85
2	Electrical - Use electronic instruments and devices (oscilloscopes, voltmeters, signal generators, etc.) to measure voltage, current and power of electrical equipment.	3.78
1	Modeling and Simulation - skill with software modeling techniques for virtual prototypes and simulation of product and process.	3.74
2	Materials - Select and run metal and plastic tests to ASTM Standards.	3.65
1	Metrology and Instrumentation - understand importance of, and be able to apply proper metrology systems and instrumentation to meet regulatory and customer requirements.	3.60
	Grand Average Response	4.06

Analysis of MET Survey Results:

In general, the results of the survey provided confirmation that the MET Program was well positioned to educate students appropriately to pursue careers in the fields indicated in the demographic questions asked in the survey. In particular, the relative importance of communication, manufacturing processes, data analysis, mechanics, engineering graphics, materials, etc. reaffirmed that the emphases of the MET Program were correct. Furthermore, none of the results conflict with either ABET Criteria 2 or Criteria 8, but instead pointed to areas with improvement potential.

The most notable potential improvement is in the project management area. Even though faculty did address some project management topics in some courses, there were no specific curricular elements regarding this topic prior to the study. In order to correct this deficiency, a PO for project management was added and ILO's for project management have been added to some of the required courses in the program.

A second area of potential improvement evident is in the documentation to comply with regulatory requirements and sound engineering practice. Again, this has not been an emphasis of the program and has been addressed by adding a PO relating to documentation and ILO's to support it in some of the required courses.

Program Outcomes:

Early on in the development of PO's, it was decided to align PO's as closely as possible with ABET Criteria 2 and Criteria 8 for each program and differentiate the programs from the ABET Criterion by adding PO's that are of particular interest to the constituents of each program. This eases the task of assuring compliance with ABET Criterion and makes assessment simpler while still allowing for the uniqueness of the program. To this end, PO's A through K correspond closely with ABET Criteria a through k with some being identical. For PO A, the essence of ABET Criteria 2a was merged with Program Criteria 8 by adding PO's A1 through A10 which are discipline specific in nature.

Program Outcomes L through O were added in response to the findings from the survey as well as input from faculty and the MET IAB.

L "Competence in the use of the computer as a problem solving and communications tool" was added mostly due to faculty input with concurrence from the MET IAB because it is a program emphasis and is assumed to be a strength of graduates in the current industrial environment.

M "The ability to apply project management techniques to the completion of laboratory and project assignments" was added based on the survey results.

N "Knowledge of and the ability to apply codes and regulations, and produce proper documentation to comply with them" was added for two reasons. First, the faculty and IAB felt that knowledge of codes and regulations was important in industry today. The second part was added based on the survey results.

O "Meaningful work experience in the mechanical engineering technology field" was added to account for the program co-op requirement.

What False Starts Did We Have?

Even with a full day of training, the faculty still found the idea that outcomes assessment was an appropriate basis for accrediting programs difficult to comprehend. Since we began early in the TC2K Criteria process, no program criteria were available. It was very difficult to determine where we were going when there was little basis for judgment. TAC has since provided program criteria for most of the programs, including those of interest to this study.

The second problem was that we spent a lot of time developing course outlines rather than first developing the PEO's, PO's, ILO's and the actual continuous improvement process. We were seeing too many trees and not the forest.

Some faculty did not fully adapt to writing course outlines for the new process. They still viewed the old outlines as adequate and did not understand the new phraseology. This is difficult enough for those who are used to writing educational materials and for whom English is a first language. For others, it is an even greater challenge. Program chairs had to rewrite the outlines for faculty who struggled with this task.

Without fully developing the continuous improvement plan (CIP) first, we had to go back after the fact to re-write all course outlines to include ILO's appropriate to the final program outcomes. We then had to determine the means for assessing outcomes, and rewrite again to assure that the assessment methods were properly documented in course outlines. Finally, a matrix was prepared by each program documenting the linkages from ILO's to PO's.

Initially, we thought the service colleges of liberal arts and science would help to provide assessments for areas such as social responsibility, diversity and communications. Science was able to write acceptable outlines, but had not started a process of evaluation. Liberal Arts provided us with outlines in a variety of formats with no plan for evaluation. As such, it was decided to support all of our PO's with ILO's from courses within the department or college. While we expected to have some input from the other colleges, whatever input they provided was used to support our conclusions rather than as the basis for them. As the service colleges implement better defined continuous improvement processes, we may be able to use their input more directly.

At this point, technical and professional electives are not being used as a central focus of our program level assessment. It might be that in some programs, this would be useful if students had to choose from a limited variety of electives, but we have a very wide array of electives. However, all technical electives are assessed at the course level as described later in this paper.

Working Together:

A general finding of our implementation was that the similarity of the PEO's and PO's across the three programs was a critical factor to our success. This allowed a common assessment approach in all department programs and makes many of the improvement efforts a shared concern of the entire department as opposed to a stand alone effort of a single program chair. Faculty and coursework are also impacted. Courses and faculty are shared across programs, so most courses and faculty are responsible for fulfilling the objective of several programs. Because the outcome and objectives are similar we prevented a proliferation of course ILO's that only support one program's outcomes. Tables 3 and 4 below show the commonality and differences across the PEO's and PO's of the three programs.

MMET/PS Department Program Educational Objectives (PEO's)		
Electrical/Mechanical Engineering Technology	Manufacturing Engineering Technology	Mechanical Engineering Technology
Graduates from the Program will demonstrate...		
1. A professional work ethic, a commitment to lifelong learning, quality and continuous improvement through the clear ability to assume increasing levels of technical and/or management responsibility.		
2. Participation and leadership while working on teams involved in the analysis, design, development, implementation, or oversight of electrical, mechanical and/or manufacturing systems and processes.	2. Leadership and participation in teams that act as change agents and innovators in product design and manufacturing related organizations.	2. Participation and leadership while working on teams involved in the analysis, design, development, implementation, or oversight of mechanical and/or manufacturing systems and processes.
3. An ability to design effective and efficient new products, systems and processes.	3. The ability to drive the design of manufacturable products, design effective and efficient new production processes and improve the performance of existing operations.	3. An ability to design new and improved products, systems and processes that are appropriate for their use.
4. Effective communication at all levels of the organization.		

Table 3

<table>
<tr><th colspan="3">MMET/PS Department Program Outcomes (PO's)</th></tr>
<tr><th>Electrical/Mechanical Engineering Technology</th><th>Manufacturing Engineering Technology</th><th>Mechanical Engineering Technology</th></tr>
<tr><td colspan="3">Graduates from the Program will demonstrate...</td></tr>
<tr><td>A. The ability to apply technical expertise from the following areas to the analysis, design, development, implementation, or oversight of mechanical and electrical systems and processes:
A1 Manufacturing processes
A2 Engineering materials
A3 Statics
A4 Strength of materials
A5 Dynamics
A6 Fluid power/fluid mechanics
A7 Thermodynamics
A8 Computer aided engineering tools
A9 Computer programming
A10 Electric circuits
A11 Electronics
A12 Electric power
A13 Microcomputers
A14 Industrial control systems
A15 Industrial instrumentation
A16 Project and production management.
A17 Engineering economics</td><td>A. The ability to apply the knowledge, techniques, skills and modern tools of manufacturing technology listed below to the solution of manufacturing problems:
A1 Materials
A2 Manufacturing Processes
A3 Quality
A4 Tooling
A5 Automation
A6 Production Operations
A7 Maintenance
A8 Industrial Organization and Management
A9 Statistics
A10 Financial Measures
A11 Systems Integration</td><td>A. The ability to apply technical expertise from the following areas to the analysis, design, development, implementation, or oversight of mechanical systems and processes:
A1 Manufacturing processes
A2 Engineering materials
A3 Statics
A4 Strength of materials
A5 Dynamics
A6 Fluid mechanics
A7 Thermodynamics
A8 Computer aided engineering tools
A9 Mechanical design
A10 Electric, Hydraulic and Pneumatic Circuits</td></tr>
<tr><td colspan="3">B. The ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology.</td></tr>
<tr><td colspan="3">C. The ability to formulate, conduct, analyze, and interpret experiments and apply experimental results to improve designs and processes.</td></tr>
<tr><td>D. The ability to apply creativity to the design of systems, components or processes in the E/M ET field.</td><td>D. The ability to apply creativity in the design of manufacturing systems, components and processes.</td><td>D. The ability to apply creativity to the design of mechanical systems, components and processes.</td></tr>
<tr><td colspan="3">E. The ability to function effectively on teams.
F. The ability to identify, analyze and solve technical problems.
G. Effective communication.
H. Recognition of the need for, and the ability to engage in lifelong learning.
I. Knowledge of ethical and social responsibility expected of professionals working in the ___ engineering technology field.
J. Respect for diversity and a knowledge of contemporary professional, societal and global issues.
K. Commitment to quality, timeliness, and continuous improvement.
L. Competence in the use of the computer as a problem solving and communications tool.</td></tr>
<tr><td>M. Specialized expertise in a single technical field.
N. Meaningful work experience in the electrical/mechanical engineering technology field.</td><td>M. The ability to apply project management techniques to the completion of lab assignments and projects.
N. Successful completion of a comprehensive design project ...
O. Meaningful work experience in the MfgET field.
P. The ability to articulate the economic and organizational importance of mfg to companies, individuals and the community.</td><td>M. The ability to apply project management techniques to the completion of laboratory and project assignments.
N. Knowledge of and the ability to apply codes and regulations, and produce proper documentation to comply with them.
O. Meaningful work experience in the MET field.</td></tr>
</table>

Table 4

The RIT MMET Three-Loop Continuous Improvement Plan

Overview:

A key element in developing a robust system for maintaining and improving an ABET accredited program is the continuous improvement plan (CIP). The goal of the MMET/PS Department was to create a plan that faculty and administration would actually use on a regular basis for the routine operations of the program. It was NOT intended to be a complicated all-encompassing procedure that requires significant resources to update as ABET accreditation time approaches. In the case where there are several programs with overlapping curriculums operating in one department or college it is very valuable if the faculty from these programs can agree on a common CIP. This means that common documents can be developed for measuring instruments and that best practices can be quickly shared among programs.

The RIT MMET programs' CIP uses a three-level approach. This same approach is used by each of the three MMET programs (Mechanical ET, Manufacturing ET, and Electrical/Mechanical ET), and also by the department's non-ET Packaging Science program. Each level has phases for measurement, assessment, evaluation and action. The lower level improves individual courses within the curriculum. The middle level improves the curriculum from the viewpoint of achieving stated program outcomes (PO's). The higher level improves the curriculum from the viewpoint of achieving stated Program Educational Objectives (PEO's). Figure 5 summarizes the three-level approach.

Course Evaluation:

At the lower level the key measures evaluate whether the course is successfully covering material supporting the course intended learning outcomes (ILO's) and whether the students are learning this material. Students respond to a survey at the end of the course, which asks them to what degree they think the individual course ILO's were covered and to what degree they think they mastered them. Figure 6 is a template for the survey questionnaire. In addition to this ILO-based measuring system, students are surveyed as to their opinion of the course and the instructor. Figure 7 shows a sample questionnaire. Individual comments are a useful component of this survey. Finally each student is graded as a part of taking the course.

Once the course ILO questionnaires are processed, each instructor is provided with a copy of the results. The instructor can use the grades and comments to make changes to the course approach in terms of amount of time spent on certain subjects and the method of delivery. The results are also viewed by the department chair, program chair, and course coordinator (if he/she is not the course instructor). These people discuss any issues with the course instructor. Normally this does not result in a change to the formal course outline, which at RIT requires submitting formal paperwork, a course action form (CAF), for the change to the College's curriculum committee for review and action. Any items that are discussed by the program curriculum committee, whether they result in a CAF or not, are documented by a department Course Continuous Improvement Action Form (Figure 8).

The general student course and instructor evaluations are treated similarly to the student course ILO evaluations. In addition to possible course improvements, they are used by the department chair to evaluate faculty and suggest how they might improve their teaching skills. This is done informally each quarter and formally each year through the written faculty annual review system.

In the area of grades, RIT provides the department and program with a grade distribution report from the preceding quarter. The report provides the grade distribution for each course section in the department, and also includes the average course grade distribution for other departments in the college, the college as a whole and RIT as a whole. MMET program grade distributions tend to follow the college and institution average. Unusual course results (i.e. results not within acceptable limits of the average) are discussed by the department chair, program chair and the faculty involved. Possible results are a change in the course outline, grading approaches, or course instructor.

Program Outcomes Evaluation:

The middle evaluation level (see Figure 5) focuses on the measurement and evaluation of program outcomes (PO's). Actions from these measurements are either to suggest course outline changes, which feed into the lower loop evaluation, or changes to the curriculum. Curriculum changes can involve dropping required courses, adding required courses, changing when courses should be taken, changing the category of electives, or even changing the credits required for graduation.

Since fulfilling PO's depend on ILO's being fulfilled, a primary measure of PO's being met is whether the contributing ILO's are being met. Thus each quarter, when the ILO's are being evaluated, the program chair also reviews those measurements to make sure they are not systematically weak in a particular PO area, especially if that is a PO with few contributing ILO's. An additional very important evaluation tool for PO's is the quarterly coop report from employers of coop students. This report asks the employer several questions that are closely tied to program PO's.

Following the end of the spring quarter each year, the program chair formally reviews the coop reports, critical course evaluations, and student course success information. This review results in a report that is distributed in the early Fall to the program faculty, department chair, and the program industrial advisory board (IAB). As a result of this report and feedback from the IAB, the program and department chair develop an action plan that recommends changes to courses and the curriculum. The program chair submits this action plan to the IAB and updates them on progress in its implementation.

A standard format is used for each program in preparing yearly reports allowing the sharing of assessment information. Summaries are developed for each PO that show the learning opportunities, assessment criteria, assessment methods and results, analysis of data and action plans. The summary for the materials PO which is common to all three programs is shown in Figure 3 as an example.

<table>
<tr><th></th><th colspan="6">Program Outcome</th></tr>
<tr><td>PO Number</td><td colspan="6">Graduates from the Mechanical Engineering Technology Program will demonstrate:</td></tr>
<tr><td>A2</td><td colspan="6">The ability to apply technical expertise from the following areas to the analysis, design, development, implementation, or oversight of mechanical systems and processes: Engineering Materials</td></tr>
<tr><td>Strategy</td><td colspan="6">Primary Learning Opportunity:
• 0610-211 Introduction to Materials Technology
• 0610-416 Materials Technology
Application Opportunity:
• 0610-304 Materials Testing
• 0610-303 Strength of Materials
• 0610-315 Principles of Mechanical Design
• 0610-403 Failure Mechanics
• 0610-409 MET Lab II
• 0610-506 Machine Design I</td></tr>
<tr><td rowspan="2">Performance Criteria Measures</td><td colspan="6">1. Select a metal for a specific design application (0610-211)</td></tr>
<tr><td colspan="6">2. Select plastics, adhesives, ceramics, and composites for design applications (0610-416)</td></tr>
<tr><td colspan="7">Assessment Methods</td></tr>
<tr><td>Data Sources</td><td colspan="2">Performance Criteria</td><td colspan="4">Results</td></tr>
<tr><td rowspan="5">Student ILO Assessment for 0610-211 and 0610-416</td><td rowspan="5">Average Score > 80</td><td>PC</td><td>Metric</td><td>Fall 2004</td><td>Winter 2004</td><td>Spring 2005</td></tr>
<tr><td rowspan="2">1</td><td>Coverage</td><td>87</td><td>NA</td><td>91</td></tr>
<tr><td>Confidence</td><td>84</td><td>NA</td><td>86</td></tr>
<tr><td rowspan="2">2</td><td>Coverage</td><td>87</td><td>NA</td><td>86</td></tr>
<tr><td>Confidence</td><td>85</td><td>NA</td><td>79</td></tr>
<tr><td rowspan="2">Grades in 0610-211 Introduction to Materials Technology</td><td colspan="2" rowspan="2">Success Rate > 80% where success is a C grade or better in the course. W's and I's are not included in the calculation.</td><td>Historical Norm</td><td>Fall 2004</td><td>Winter 2004</td><td>Spring 2005</td></tr>
<tr><td>91%</td><td>94%</td><td>NA</td><td>90%</td></tr>
<tr><td rowspan="2">Grades in 0610-416 Materials Technology</td><td colspan="2" rowspan="2">Success Rate > 80% where success is a C grade or better in the course. W's and I's are not included in the calculation.</td><td>Historical Norm</td><td>Fall 2004</td><td>Winter 2004</td><td>Spring 2005</td></tr>
<tr><td>95%</td><td>98%</td><td>NA</td><td>97%</td></tr>
<tr><td>Analysis of Results</td><td colspan="6">Although the confidence level for PC 2 is just below the target, results for this PO are satisfactory. However, a more direct measure of the ILO's would be helpful.</td></tr>
<tr><td>Action Plan</td><td colspan="6">More direct measures of the ILO's for this PO will be developed. Data will be collected and a baseline established.</td></tr>
</table>

Figure 3

Action plans are summarized for each program and used to guide program improvements. Many of such improvements affect all programs in the department. A sample of the action plan summary is shown in Figure 4.

Figure 4

Continuous Improvement Action Plans

Program Outcome	Action Plans	Priority	Person or Group Responsible	Target Date	Post Action Assessment
A1 Manufacturing Processes	No curriculum action at this time.	Low	MfgET Curriculum Committee	TBD	0617-420 instructor changed for 2004/5.
A2 Materials	More direct measures of the ILO's for this PO will be developed. Data will be collected and a baseline established.	Low	MET Curriculum Committee	TBD	
A3 Statics	1. Add 1 contact hour per week to 0610-302 Introduction to Statics. 2. Implement a Statics Pre-Test to be given at the beginning of 0610-303 Strength of Materials to assess student preparation in statics.	High	Bob Merrill, Jim Scudder	9/2003	The additional contact time has eased the stress in the class allowing more time for problem solving. Recent pre-test results are somewhat improved. See the next action plan for PO A3.
A3 Statics	Additional Statics Pre-Test results will be collected over the next year to confirm the improvement that has been achieved.	Low	Bob Merrill	9/2005	
A4 Strength of Materials	1. Add 1 contact hour per week to 0610-303 Strength of Materials 2. Implement a Strength of Materials Test to be given at the beginning of 0610-407 MET Lab I and 0610-403 Failure Mechanics to assess student preparation.	High	Bob Merrill, Jim Scudder	9/2004	The additional contact time has eased the stress on both students and instructors allowing more time for problem solving, but has not resulted in improvement so far. Test results have not been good and do not show much improvement so far. See the second group of action plans below for PO A4 attempt to address these issues.

Program Educational Objectives Evaluation:

The highest evaluation level (see Figure 5) focuses on the measurement and evaluation of Program Educational Objectives (PEO's). PEO measurement takes the form of alumni and employer surveys (conducted every three years), IAB discussions, and alumni discussions (at special events).

Each year, in conjunction with the PO formal evaluation report, the program chair generates a PEO assessment report. The evaluation and action plan steps for this report are similar to, and done in conjunction with, the PO assessment report.

Every three years, as a part of the department strategic planning process, each program reviews its PEO's and PO's. In particular PEO's are reviewed (in the form of surveys and focus groups) with employers who have been hiring the majority of the program's graduates. The IAB and faculty then discuss and approve the updated PEO's and PO's in the context of the feedback from alumni and employers.

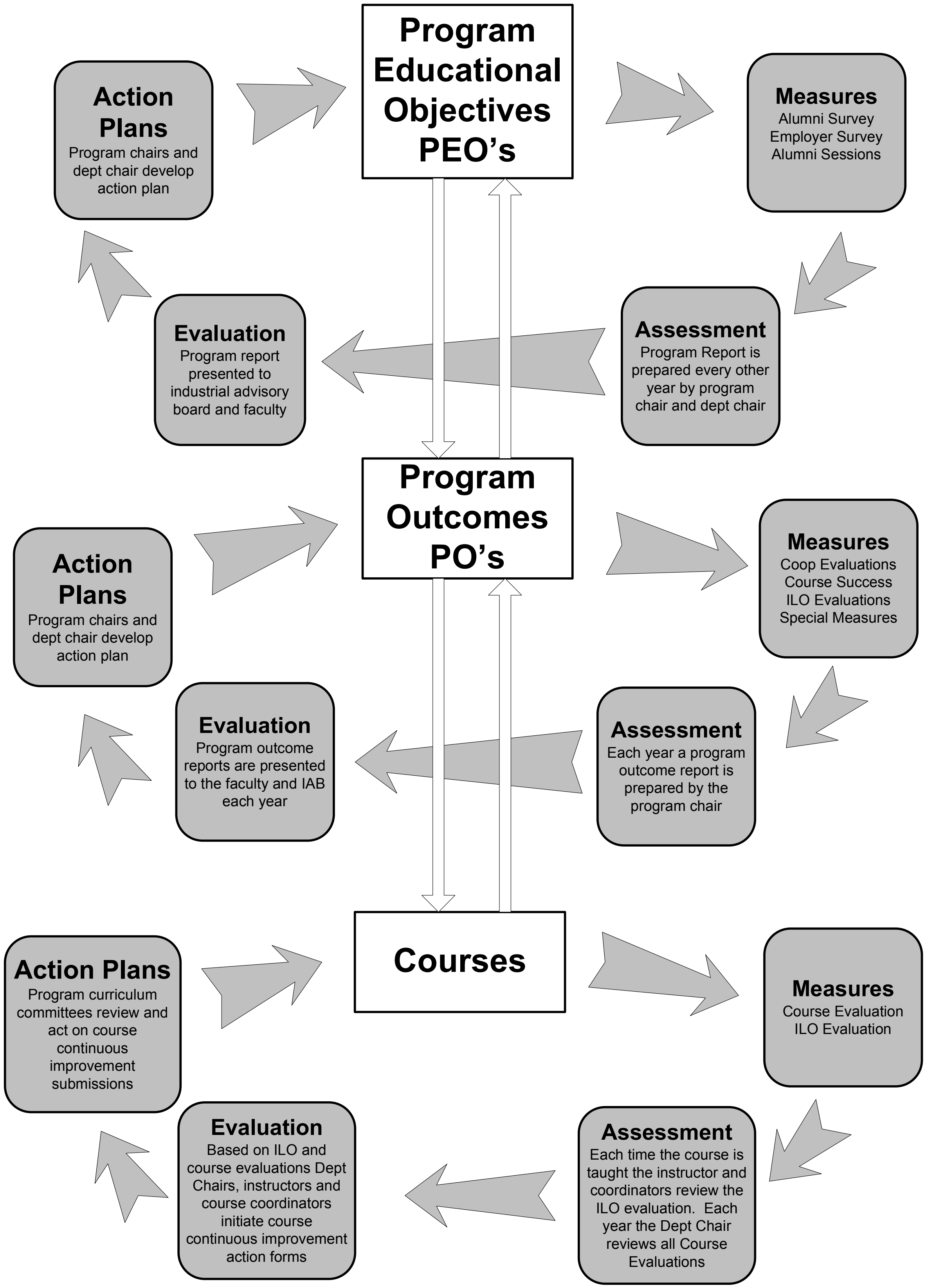


Figure 5 Overview of Program Continuous Improvement Plan [9]

Figure 6   Course Objectives Assessment Questionnaire Template

The following are course objectives (also known at RIT as Intended Learning Outcomes) for fill in course number. These are competencies that you, as a student, should have received from the course. Please indicate from 1-5 (1 being poor and 5 being excellent) how well the objective was covered in the course, and how confident you are that you understand the objective. Use the extra space to add comments.

State ILO 1 from the course outline

Coverage 1 2 3 4 5 Confidence 1 2 3 4 5

State ILO 2 from the course outline

Coverage 1 2 3 4 5 Confidence 1 2 3 4 5

State ILO 3 from the course outline

Coverage 1 2 3 4 5 Confidence 1 2 3 4 5

Figure 7 Student Course Assessment Form

R·I·T Rochester Institute of Technology
Engineering Technologies

INSTRUCTOR

COURSE

STUDENT EVALUATION OF INSTRUCTION

PLEASE READ ENGINEERING TECHNOLOGIES COMMITTEE ON EVALUATION OF INSTRUCTION HAS PREPARED THESE MATERIALS FOR YOU TO USE IN ASSISTING THE FACULTY AND ADMINISTRATION OF THE DEPARTMENTS IN PROPERLY EVALUATING THE INSTRUCTORS, COURSES AND TEXTS, WITH THE GOAL OF IMPROVING THE QUALITY OF THE PROGRAMS. CAREFUL AND THOUGHTFUL RESPONSES ARE URGED SO THAT THE FACULTY AND ADMINISTRATION MAY WORK TOGETHER ON AREAS OF MUTUAL CONCERN.

PLEASE FOLLOW THESE INSTRUCTIONS:

1. MARK CAREFULLY THE COURSE NUMBER AND THE INSTRUCTOR NUMBER GIVEN TO YOU BY YOUR INSTRUCTOR.
2. DO NOT WRITE OR MARK ANYTHING ON THIS FORM, OTHER THAN THE COURSE NUMBER, THE INSTRUCTOR NUMBER AND YOUR ANSWERS TO THE QUESTIONS.
3. GIVE ONLY ONE ANSWER TO EACH QUESTION.

Quarter: ____________________

THE COURSE

1) How well have the <u>course objectives</u> been fulfilled?
a) Very well b) Well c) Not very well — 1. A B C

2) What is your present feeling about <u>how much you learned</u> in this course?
a) I learned a lot b) I learned a moderate amount c) I learned very little — 2. A B C

3) What is your opinion of the <u>principal textbook</u> of this course?
(Omit this question if there is no text.)
a) Good text for the course b) An adequate text for the course c) The text was deficient — 3. A B C

4) In general, how helpful were <u>out of class assignments</u> such as homework, laboratory work, papers, etc.?
a) Very helpful b) Moderately helpful c)Not vey helpful — 4. A B C

THE INSTRUCTOR

5) How was the instructor's presentation of the course material?
a) Very effective b) Reasonably effective c) Satisfactory d) Not very effective e) Ineffective — 5. A B C D E

6) How do you feel about the instructor's handling of matters such as planning work, making assignments, announcing quizzes, etc.? a) Well organized b) Satisfactorily organized c) Poorly organized — 6. A B C

7) Rate the instructor's receptiveness to questions in class, lab, and office hours.
a) Encouraged questions b) Did not encourage or discourage questions c)Discouraged questions — 7. A B C

8) Rate the instructor's response to student questions.
a) Highly effective b) Reasonably effective c) Satisfactory d) Not very effective e) Ineffective — 8. A B C D E

9) Was the instructor available for posted office hours? a) Usually available b) Sometimes available c) Rarely available d) I don't know, I never sought assistance — 9. A B C D

10) How well did the instructor motivate you to learn?
a) Very well b) Well c) Not very well — 10. A B C

11) How effective was the instructor at returning graded work to you?
a) Promptly b) Satisfactory c) Took too long d) Not applicable — 11. A B C D

EXAMS

12) In general, how did you feel about the <u>clarity of quiz/exam questions</u>?
a) Generally very clear b) Satisfactory c) Often vague and ambiguous — 12. A B C

13) In general, how did you feel about the relevance of quiz/exam questions? a) Highly relevant b) Relevant c) Irrelevant — 13. A B C

14) Concerning strictness in grading quizzes/exams the standards were: a) Too strict b) Fair c) Too lenient — 14. A B C

15) With regard to consistency in grading quizzes/exams the standards were:
a) Usually consistent b) Somewhat consistent c) Inconsistent — 15. A B C

OVERALL

16) Overall, how would you rate this course?
a) Excellent b) Very good c) Satisfactory d) Needs improvement e) Poor — 16. A B C D E

17) Overall, how would you rate this instructor?
a) Excellent b) Very good c) Satisfactory d) Needs improvement e) Poor — 17. A B C D E

Mark Reflex® by NCS EM-225051-1:654 ED06 Printed in U.S.A.

© Copyright 1999 by National Computer Systems, Inc. All rights reserved.

Figure 8

Manufacturing and Mechanical Engineering Technology/Packaging Science
Course Continuous Improvement Action Form

Initiator: ________________________________ Date: _________________

Course(s) Involved:

Specific Reason(s) Action Might Be Required:

Suggestions for Action (optional):

Program Responsible for Course(s)
[ ] MET [ ] Mfg. [ ] E/M [ ] Pkg. [ ] External ____________

After completing above, route this form to the Program Curriculum Committee responsible for the course(s) or in the case of external courses, to the MMET/PS Department Chair.

Resolution: Curriculum Committee INVESTIGATION completed: Date: _________ [ ] See CC minutes for details[ ] No Investigation Required Curriculum Committee ACTION taken: Date: __________________ [ ] See CC minutes for details [ ] No Action Taken (explain)

Findings and Conclusions:

The primary finding of this effort is that if our team had not worked together to create similar objectives, outcomes and measures we would have suffered and perhaps failed separately. The key to working together in a meaningful fashion was that our PEO's and PO's were so similar. As shown in Table 3 half of the PEO's are identical across the three programs and the differences in the others are minor. For PO's ten of a maximum of sixteen are the same (as shown in Figure 4). This similarity allowed us to cooperate and share measurement procedures, assessment findings and action plans. We are surprised by how many of the improvement activities we identified could be addressed at the department level and thereby benefit all of our programs.

A second major finding of our efforts was the realization that we need to assess four parts of each program outcome or objective. The four parts Validation, Coverage, Confidence, and Capability are described in Table 5 below.

Outcome and Objective Assessment in Four Parts			
Part	**Questions**	**Data Sources**	**Evaluation Methods**
Validation	• Is the outcome reasonable to expect from a graduate? • Is the outcome measurable in some way? • Is it meaningful to employers? • Is it an important part of being a contributing member of society?	• Curricular Standards and Regulations • Professional Organizations • Current and Potential Employers • Futurists • Advisory Boards • Alumni	• Reviews against standards • Advisory board sessions • Focus Groups
Coverage	• Are there sufficient and effective learning material and experiences is the topic area?	• STUDENTS! • Other curricula	• Course Evaluations • Curriculum Review • ILO Evaluations
Confidence	• Does the student feel able to meet the objective under reasonable circumstances?	• STUDENTS! • Recent Alumni	• Surveys • Focus Groups • Course Evaluations • ILO Evaluations
Capability	• What can really be accomplished when measured objectively?	• External Evaluations • Faculty Evaluations • Alumni	• Surveys • Focus Groups • Coop Employer Evaluations • Employer Evaluations of Graduates

Table 5

In this model, the validity of an outcome must be verified. Second, the coverage of the outcome must be assessed. Third, the confidence of the student is assessed, obviously, if a student does not have confidence in his or her own performance of an outcome, we have an opportunity for improvement. Fourth and finally the student's capability is considered. The four parts must be assessed differently. Validity is best measured using external sources like advisory boards and professional organization standards. Coverage and confidence can be assessed by students. In fact, it took us some time to recognize the importance of accepting student evaluations as meaningful and valid measurement of coverage and confidence, but not a good measure of validity or ultimately their capability. Students are the experts when it comes to the details of our curricula, as the users in the system they can be a gold mine of improvement opportunities particularly in the area of what is covered and how well it is delivered. Our best measure of capability is still the coop employer evaluations of students. In fact this finding is our next major conclusion of the work.

RIT's cooperative education program is a key to the effectiveness of our continuous improvement system. The employer evaluations our students receive give us an externally validated evaluation directly from the most important constituent of our program. Without this external evaluation of capability we might have to implement standardized testing and other techniques that while valid may have unintended side effects and unsupportable costs.

In conclusion, we feel that a sustainable continuous improvement system should be the real goal of these efforts. In order to make our system meaningful yet manageable it was necessary to combine and leverage as many efforts as possible. This included tying the system to existing measures and sharing measurement and evaluation techniques across as many programs as possible. It is true that our system does not yet perfectly measure all outcomes and objectives, but the most urgent areas for improvement have been identified and attacked, and we have documented areas where additional development is required. Several program improvements have been made and the assessment system has measured their affect. Our team has experienced efforts in other department and at other locations where a technically more perfect system has been created. However these systems are often so complex and arduous to operate they are very difficult to sustain. Additionally, if these systems are not implemented at least department-wide (if not college-wide) they represent a second system of evaluation and double the work because the systems accepted and required by the rest of the organization must still be maintained.

References

1. "Mapping Multiple Sources for Comprehensive Program Assessment", Gwen Lee-Thomas, Presentation at ASEE-IL/IN Sectional Conference, March 29-31, 2001
2. "Development, Assessment and Implementation of Program Educational Objectives and Program Outcomes of BSEE Program", Satinderpaul Singh Devgan, Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition, June 2005
3. "A 30 Year Survey of Rochester Institute of Technology Engineering Technology Graduates", Carol Richardson, John Stratton and Maureen Valentine, Proceedings of the 2004 American Society for Engineering Education Annual Conference and Exposition, June 2004
4. "Improvements in Electric Power Systems Curricula: Developing Continuous Improvement Plan", Ilya Grinberg, James Maxwell, Frank Pietryga and John Stratton, Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition, June 2005
5. "Case Study: Using Quality Function Deployment to Meet ABET 2000 Requirements for Outcome Assessment", Philip R. Rosenkrantz, Proceedings of the 2000 American Society for Engineering Education Annual Conference and Exposition, June 2000
6. "Large Scale Implementation of Outcome-Based Course Assessment", Ronald Land, Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition, June 2005
7. "Asynchronous Assessment: Using Electronic Portfolios to Assess Student Outcomes", Gloria M. Rogers and Julia M. Williams, Proceedings of the 1999 American Society for Engineering Education Annual Conference and Exposition, June 1999
8. "Establishing and Assessing Educational Objectives for Engineering Programs", Nashwan Yountis, Proceedings of the 2003 American Society for Engineering Education Annual Conference and Exposition, June 2003
9. "Updating the Objectives of a Manufacturing Engineering Technology Program", Daniel P. Johnson, Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition, June 2005
10. "Using a Web-Based Survey to Obtain Students' Assessment of Their Learning in a Course", Susan M. Daffinrud and Helene Demont, Proceedings of the 2003 CIEC Conference, January 2003
11. "An Integrated Approach to Evaluation of Program Educational Objectives and Assessment of Program Outcomes", Michael Leonard and Eleanor Nault, Proceedings of the 2004 American Society for Engineering Education Annual Conference and Exposition, June 2004