Outcomes Assessment in an MET Program

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Engineering technology programs are now faced with the challenge of implementing outcomes assessment based on the TAC/ABET criterion in the TC2K accreditation document. While continuous improvement has been a common theme in prior accreditation requirements, the TC2K criterion takes the assessment of student learning outcomes to the logical next level. This paper will address the basics of creating a student learning outcomes assessment plan for a TAC/ABET accredited four-year Mechanical Engineering Technology degree program. Where and how learning outcomes can be assessed will be discussed.

School Background

The Purdue School of Engineering and Technology is located on the Indiana University Purdue University at Indianapolis (IUPUI) campus. IUPUI has an enrollment of 28,339 students (fall 2001) in 18 schools and is the third largest university in Indiana. The North Central Association (NCA) accredits IUPUI. The School of Engineering and Technology offers 42 programs from certificates to Ph.D. and has an enrollment of 2,332 full and part time students (fall 2001). The Department of Mechanical Engineering Technology offers undergraduate associate and baccalaureate degree programs in Mechanical Engineering Technology (MET), Computer Integrated Manufacturing Technology (CIMT) and Computer Graphics Technology (CGT). The MET and CIMT degree programs were reaccredited by TAC/ABET in 2001 for six years. Therefore, the department anticipates its next TAC/ABET visit in 2006.

Continuous Improvement at IUPUI

The various degree programs offered by the Purdue School of Engineering and Technology at IUPUI have utilized assessment of student learning as the base for continuous improvement plans for several years. The school has employed a standing Assessment Committee consisting of a faculty member and department chair from each department. The Assessment Committee was established in 1996 to disseminate student learning assessment techniques, develop and share appropriate methods for engineering and engineering technology programs and coordinate the implementation of department and/or program specific plans. The Assessment Committee is chaired by a full professor of engineering receives who release time to coordinate the school's assessment efforts as well as representing the school at the campus level.

At the campus level, IUPUI has long maintained a strong belief in continuous improvement. The goal is fully supported by the campus administration through the *Office of Planning and Institutional Improvement (PAII)* headed by Vice Chancellor Trudy Banta. The office was established in 1992 and has the mission "To develop, integrate and continuously improve

institutional planning, implementation strategies, evaluation and improvement activities at IUPUI".[1]. Not only does PAII coordinate all campus planning and assessment activities, the office is very active in research and publishing in the area of student learning assessment through its professional staff. PAII also includes the *Office of Information Management and Institutional Research (IMIR)*. IMIR's mission is to "…provide and coordinate information support for planning, administering and evaluating academic and administrative programs in ways that will continuously improve Indiana University Purdue University Indianapolis (IUPUI)".[2]. Among IMIR's many data gathering and analysis responsibilities is the charge to conduct student, staff and faculty surveys. Of particular interest in the area of continuous improvement are surveys annually of entering students, continuing students, non-returning students and recent alumni. This data is invaluable in determining and assessing a wide variety of department and degree program factors including student-learning assessment.

Another activity coordinated by the Office of Planning and Institutional Improvement is the degree program reviews. Each undergraduate degree program on the IUPUI campus is required to undergo a periodic program review which is very similar to a TAC/ABET accreditation visit in format. Both campus reviewers and external reviewers are used to evaluate the degree programs. The review team prepares a written report of their findings, which is responded to by the department responsible for the degree program under review. Typically this program review occurs on a five year cycle, however, the School of Engineering and Technology has received permission to employ a six year cycle and now conducts its program reviews during the spring semester prior to the ABET accreditation visits.

These activities have resulted in a significant level of outcomes assessment activity throughout the campus including the School of Engineering and Technology.

Principles of Undergraduate Learning

The fundamental component of the IUPUI student learning assessment process is the *Principles of Undergraduate Learning*. This seven principles or PUL's are used as the basis of learning assessment in all undergraduate programs campus-wide. The seven principles and their specific measurable outcomes are as follows:

1. **Core Communications and Quantitative Skills**: The ability of students to write, read, speak, and listen, and perform quantitative analysis, and use information resources and technology.
    a. Express ideas and facts in a variety of written formats.
    b. Comprehend, interpret and analyze texts.
    c. Communicate orally in one-on-one and group settings.
    d. Solve problems that are quantitative in nature.
    e. Make efficient use of information resources and technology.
2. **Critical Thinking**: The ability to analyze complex issues and make informed decisions from multiple perspectives.
    a. Analyze complex issues and make informed decisions.

b. Synthesize information in order to come to reasoned conclusions.

c. Communicate orally in one-on-one and group settings.

d. Solve challenging problems.

e. Use knowledge and understanding to generate and explore new questions.

3. **Integration and Application of Knowledge**: The ability to use information and concepts from studies in multiple disciplines in their intellectual, professional, and community lives.

    a. Apply knowledge to enhance personal lives, meet professional standards and competencies and further the goals of society.

4. **Intellectual Depth, Breadth and Adaptiveness**: The ability of students to examine and organize disciplinary ways of knowing and to apply them to specific issues and problems.

    a. Demonstrate substantial knowledge and understanding of at least one field of study.

    b. Compare and contrast approaches to knowledge in different disciplines.

    c. Modify one's approach to an issue or problem based on the contexts and requirements of particular situations.

5. **Understanding Society and Culture**: The ability to recognize their own cultural traditions and to understand and appreciate the diversity of the human experience, both within the United States and internationally.

    a. Compare and contrast the range of diversity and universality in human history, societies and ways of life.

    b. Analyze and understand the interconnectedness of global and local concerns.

    c. Operate with civility in a complex social world.

6. **Values and Ethics**: The ability of students to make judgments with respect to individual conduct, citizenship and aesthetics.

    a. Make informed and principled choices regarding conflicting situations in their personal and public lives and to foresee the consequences of these choices.

    b. Recognize the importance of aesthetics in their personal lives and to society.

Outcomes Assessment and MET

The initial step in developing a new continuous improvement plan for the MET degree program was to develop a student learning outcomes assessment plan based on the IUPUI Principles of Undergraduate Learning. This development of the student learning outcomes assessment plan followed a logical sequence:

1. Identify the required courses than included the material identified in each specific measurable outcome. This step resulted in a rather large list of possible locations for outcomes assessment.

2. Determine the courses where each specific measurable outcome will be assessed. While continuous improvement should be a fundamental tool in all courses, it is not practical to formally assess student learning in all courses due to the volume of data, which could be collected, and the time required. Courses were selected using two criteria:

    a. Assessment of student learning in each major component of the mechanical engineering field (i.e. engineering mechanics, fluids, thermodynamics, machine design, graphics, etc.).

    b. Assessment of student learning during the 1st, 2nd, 3rd and 4th years of the degree programs to insure students are receiving adequate preparation is lower level courses and will be capable of work in upper level courses.

3. Determine the artifact or evidence, which will be collected and evaluated for student learning. The artifact can include any type of student work including tests, quizzes, homework, laboratory reports, term projects, oral reports, term papers or design projects.

4. Determine the evaluation methodology and tools including rubrics to be employed with the artifact or evidence.

5. Establish the expected level of performance.

6. Analyze the results to develop findings.

7. Provide feedback to the curricular planning process.

Appendix I illustrates the evolving student learning outcomes assessment plan developed for the MET degree programs at IUPUI. This plan is still under development with the implementation partially completed. Appendix II illustrates the assessment tool used for the MET 105, Introduction to Engineering Technology course. Since this course includes a review and/or introduction of many important problem solving and analysis tools needed by MET students, it was felt that assessing student learning in the course would be key for the freshmen level. Similar assessment tools have been developed or are under development of other courses in the student learning outcomes assessment plan.

As can be seen by the outcomes assessment plan, the Department of Mechanical Engineering Technology has chosen to use a comprehensive examination for graduating seniors to assess student learning in several areas. The exam is patterned after the Fundamentals of Engineering (FE) examination for professional registration. The FE exam is unfortunately not available for engineering technology graduates in the state of Indiana. This comprehensive examination was beta tested for December 2001 graduates and will be fully implemented for May 2002 graduates.

Technology Criteria 2000

Over the last few years many faculty in engineering technology have been working with TAC/ABET and professional organizations to develop the Technology Criteria 2000 (TC2K). A key component of TC2K are the seven criteria which engineering technology programs are now required to meet. Criterion 1, Students and Graduates, is of importance when developing student learning assessment plans. Criterion 1 states[3]:

"An engineering technology program must demonstrate that graduates have:

a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines

b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology,

c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,

d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,

e. an ability to function effectively on teams,

f. an ability to identify, analyze and solve technical problems,

g. an ability to communicate effectively,

h. a recognition of the need for, and an ability to engage in lifelong learning,

i. an ability to understand professional, ethical and social responsibilities,

j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and

k. a commitment to quality, timeliness, and continuous improvement."

The Department of Mechanical Engineering Technology is fortunate that the *Principles of Undergraduate Learning* parallel Criterion 1 a through k of the Engineering Technology Criteria 2000 (TC2K) accreditation requirements. To extend the previously developed student learning outcomes assessment plan based on the PUL's and the matrix shown in Appendix I to the TC2K student learning outcomes assessment requirements, another matrix was developed by the School of Engineering and Technology Assessment Committee. This matrix, shown in Appendix III, simply relates the PUL's and Criterion 1 a through k requirements. This is now serving as the basis of the further development of the student learning outcomes assessment portion of the department's continuous improvement plan.

Conclusions

Under the leadership of assessment experts at the campus level and committed faculty at the school level, the Department of Mechanical Engineering Technology has achieved a modest level of experience in developing student learning outcomes assessment programs for engineering technology programs. Department faculty are gaining more experience in outcomes assessment and assessing student learning which will hopefully lead to an environment where these activities will become routine.

Bibliography

1. Office of the Vice Chancellor for Planning and Institutional Improvement. http://www.planning.iupui.edu/
2. IUPUI Office of Information and Institutional Research. http://www.imir.iupui.edu/imir/
3. Criteria for Accrediting Engineering Technology Programs 2002-2003. Technology Accreditation Commission, Accreditation Board for Engineering and Technology, Inc. December 1, 2001, p 33.

Biographical Information

Professor Kenneth Rennels, P.E., Chair, Department of Mechanical Engineering Technology, Associate Professor CIMT. Degrees include a BS and MS Industrial Engineering, Purdue University and a MS Business Administration, Indiana University. He has eleven years industrial experience in the aerospace industry and has been on the IUPUI faculty for 16 years. He is a senior member of SAE, SME, ASME and ASEE.

Appendix I

DEPARTMENT OF MECHANICAL ENGINEERING TECHNOLOGY
PLAN FOR ASSESSING GENERAL EDUCATION THROUGH THE PRINCIPLES OF UNDERGRADUATE LEARNING
MECHANICAL ENGINEERING TECHNOLOGY DEGREE PROGRAM

PRINCIPLES OF UNDERGRADUATE LEARNING		SPECIFIC MEASURABLE OUTCOME What will students be able to do that you will assess?	LOCATION Where is this material taught?	LOCATION Where is this material assessed?	ARTIFACTS OR EVIDENCE What will be collected and evaluated?	EVALUATION METHOD	LEVEL OF PERFORMANCE EXPECTED
#1	**Core Communications and Quantitative Skills**: The ability of students to write, read, speak, and listen, and perform quantitative analysis, and use information resources and technology.	1a. Express ideas and facts in a variety of written formats.	IET 104 MET 105 MET 111 MET 141 MET 220 MET 230 MET 242 MET 320 MET 350 MET 384 MET 414 TCM 220 TCM 340	TCM 220 TCM 340	Student Writing Projects	Standardized Evaluation Forms and Assessment Team	Score of 3 on 5 point scale.
		1b. Comprehend, interpret, and analyze texts.	CGT 110 IET 104 MET 102 MET 111 MET 141 MET 142 MET 220 MET 230 MET 242 MET 320 MET 344 MET 350 MET 384	MET 220 MET 350	Final Exam	Student Learning Evaluation Analysis	80% Success Rate
		1c. Communicate orally in one-on-one and group settings.	IET 104 MET 141 MET 142 MET 220 MET 230 MET 242 MET 320 MET 350 MET 384 MET 414 TCM 370	TCM 370	Student Oral Presentations	Standardized Evaluation Forms and Assessment Team	Score of 3 on 5 point scale.
		1d. Solve problems that are quantitative in nature.	CGT 110 IET 104 IET 150 MET 102 MET 105 MET 111 MET 141 MET 142 MET 220 MET 230 MET 240 MET 242 MET 320 MET 344 MET 350 MET 384 MET 414	MET 105	Final Exam	Student Learning Evaluation Analysis	80% Success Rate
		1e. Make efficient use of information resources and technology.	CGT 110 IET 104 MET 102 MET 105 MET 220 MET 230 MET 320 MET 350 MET 384 MET 414	MET 220 MET 350	Final Exam	Student Learning Evaluation Analysis	80% Success Rate

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#2	**Critical Thinking**: The ability to analyze complex issues and make informed decisions from multiple perspectives.	2a. Analyze complex issues and make informed decisions.	IET 104 MET 220 MET 230 MET 384 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area
		2b. Synthesize information in order to come to reasoned conclusions.	IET 104 IET 150 MET 102 MET 111 MET 220 MET 230 MET 384 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area
		2c. Evaluate the logic, validity and relevance of data.	IET 150 MET 105 MET 220 MET 230 MET 320 MET 350 MET 384 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area
		2d. Solve challenging problems.	IET 150 MET 102 MET 111 MET 220 MET 230 MET 320 MET 350 MET 384 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area
		2e. Use knowledge and understanding to generate and explore new questions.	IET 104 MET 220 MET 230 MET 320 MET 350 MET 384 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area
#3	**Integration and Application of Knowledge**: The ability to use information and concepts from studies in multiple disciplines in their intellectual, professional, and community lives.	3a. Apply knowledge to enhance personal lives, meet professional standards and competencies and further the goals of society.	CGT 110 IET 104 MET 102 MET 111 MET 344 MET 384 MET 414	MET 414	Senior Design Capstone Project	Standardized Evaluation Forms and Assessment Team	Score of 3 on 5 point scale.
#4	**Intellectual Depth, Breadth and Adaptiveness**: The ability of students to examine and organize disciplinary ways of knowing and to apply them to specific issues and problems.	4a. Demonstrate substantial knowledge and understanding of at least one field of study.	CGT 110 IET 150 MET 111 MET 220 MET 320 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area
		4b. Compare and contrast approaches to knowledge in different disciplines.	MET 414	MET 414	Senior Design Capstone Project	Standardized Evaluation Forms and Assessment Team	Score of 3 on 5 point scale.
		4c. Modify one's approach to an issue or problem based on the contexts and requirements of particular situations.	MET 102 MET 414	MET 414	Comprehensive Examination	Results Analysis by Subject Area	70% Success Rate in Each Subject Area

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#5	**Understanding Society and Culture**: The ability to recognize their own cultural traditions and to understand and appreciate the diversity of the human experience, both within the United States and internationally.	5a. Compare and contrast the range of diversity and universality in human history, societies and ways of life.	Humanities and Social Science Electives	School of Liberal Arts			
		5b. Analyze and understand the interconnectedness of global and local concerns.	Humanities and Social Science Electives IET 104	School of Liberal Arts			
		5c. Operate with civility in a complex social world.	Humanities and Social Science Electives	School of Liberal Arts			
#6	**Values and Ethics**: The ability of students to make judgments with respect to individual conduct, citizenship and aesthetics.	6a. Make informed and principled choices regarding conflicting situations in their personal and public lives and to foresee the consequences of these choices.	Humanities and Social Science Electives	School of Liberal Arts			
		6b. Recognize the importance of aesthetics in their personal lives and to society.	MET 414	MET 414	Senior Design Capstone Project	Standardized Evaluation Forms and Assessment Team	Score of 3 on 5 point scale.

Course Titles:

MET 102	Production Drafting
MET 105	Introduction to Engineering Technology
MET 111	Applied Statics
MET 141	Materials and Processes I
MET 142	Materials I
MET 220	Heat and Power
MET 230	Fluid Power
MET 242	Manufacturing Processes II
MET 320	Thermodynamics
MET 344	Materials II
MET 350	Fluid Dynamics
MET 384	Instrumentation
MET 414	Senior Design
CGT 110	Graphics Communication
IET 104	Industrial Organization
IET 150	Quantitative Analysis for Technology
TCM 220	Technical Writing
TCM 240	Business Correspondence
TCM 370	Technical Oral Communications

Appendix II

Course Assessment Tool

Course:	MET 105			Exam: Final Exam			
Semester:	Spring 2001			Total number of points: 100			
Instructor:	Bob Herman						
Number of Questions:	15	2	2	1	3	2	25
Question type:	calculator problem	trigonometry	engr equation	interpolation	problem	spreadsheet	
Available points:	30	10	10	5	15	16	86
Student #1	27	0	0	5	4	8	44
Student #2	27	10	7	0	10	12	66
Student #3	24	5	5	5	4	16	59
Student #4	24	10	4	5	5	8	56
Student #5	28	8	4	0	15	5	60
Student #6	25	5	10	5	15	15	75
Student #7	20	8	0	5	10	0	43
Student #8	22	5	0	5	10	8	50
Student #9	23	10	4	5	0	16	58
Student #10	19	0	0	5	15	16	55
Student #11	28	10	5	5	10	0	58
Level of Question:	1	2	1	2	3	1	
Challenging Problem:					X		
Depth of Knowledge:		X		X	X		
Comprehension:	X	X	X	X	X	X	
Scoring Criteria:	average						
Desired Average (goal):	24.0	8.0	8.0	4.0	12.0	12.8	68.8
Actual Average:	24.3	6.5	3.5	4.1	8.9	9.5	56.7
Number of Students:	11	11	11	11	11	11	11
Goal Status:	Goal met	Goal not met	Goal not met	Goal Met	Goal not met	Goal not met	Goal not met
Desired Score (goal):	24.0	8.0	8.0	4.0	12.0	12.8	68.8
Desired % Class >= Desired Score:	80%	80%	80%	80%	80%	80%	80%
#Student >= Desired Score:	7	6	1	9	3	4	1
%Class >= Desired Score:	64%	55%	9%	82%	27%	36%	9%
Goal Status:	Goal not met	Goal not met	Goal not met	Goal met	Goal not met	Goal not met	Goal not met

Levels of problem solving as a measure of critical thinking:
Level 1: Applying a step-by-step solution process to a problem similar to lab projects. Student is required to make no decisions.
Level 2: Determining the appropriate solution process to solve the problem. Decision making based on knowledge.
Level 3: Determining the best solution process to solve the problem.
Level 4: Converting real-world information to data for problem solution or interpreting problem solutions.
Level 5: Generating new problem solution methods from basic principles.

Appendix III

ABET/PUL OUTCOMES MATRIX
TECHNOLOGY

ABET OUTCOMES TAC CRITERIA #1 items (a) to (k)	INDIANA UNIVERSITY PURDUE UNIVERSITY INDIANAPOLIS PRINCIPLES OF UNDERGRADUATE LEARNING																			
	ONE					TWO					THREE			FOUR			FIVE			SIX	
	Core Communication and Quantitative Skills					Critical Thinking					Integration and Application of Knowledge			Intellectual Depth, Breadth, and Adaptiveness			Understand Society and Culture			Values and Ethics	
	a	b	c	d	e	a	b	c	d	e	a	b	c	a	b	c	a	b	c	a	b
(a) Demonstrate an appropriate mastery of the knowledge, techniques, skills and modern tools of their discipline				■	■							■		■							
(b) Apply current knowledge and adapt to emerging applications in mathematics, science, engineering and technology						■	■		■	■			■	■		■					
(c) Conduct, analyze and interpret experiments and apply experimental results to improve processes		■				■		■		■				■							
(d) Apply creativity in the design of systems, components or processes appropriate to program objectives							■		■				■	■		■					■
(e) Function effectively on teams			■																■		
(f) Identify, analyze and solve technical problems		■		■		■	■	■	■					■		■					
(g) Communicate effectively	■		■								■								■		
(h) Recognize the need for and possess the ability to pursue lifelong learning											■										
(i) Understand professional, ethical and societal responsibilities						■						■						■		■	
(j) Recognize contemporary professional, societal and global issues and be aware of and respect diversity										■		■	■		■		■	■	■	■	
(k) Have a commitment to quality, timeliness and continuous improvement					■					■	■					■				■	