In-common Methodology for Objective- and Outcome-based Programs Assessment

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Abstract

This paper reviews the development of continuous quality improvement plans for three closely aligned engineering technology programs at Central Connecticut State University (CCSU). Many of the goals for the three programs are similar thus allowing for the development of common learning objectives and learning outcomes which may be assessed simultaneously. The learning objectives and learning outcomes, while based upon the specific program mission, allow data collection, metrics for assessment and evaluation to be focused upon in-common core courses. Certain aspects of the mission, goals, outcomes and objectives will differ between programs. The assessment of the differences within each discipline is conducted within specialization courses with separate assessment methods. The final evaluation of data and the assessment of each program curriculum becomes a discipline dependent process with the analysis and evaluation of data, and the program recommendations conducted as an independent function by specialization faculty and members of the program industrial advisory board.

The University adopted an assessment plan for all its programs at nearly the same time that the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET) adopted the TC2K continuous improvement based criteria for program assessment and evaluation of data. The Engineering Technology Department took advantage of the opportunity by consolidating efforts in the initial planning stage wherein the University and the TAC of ABET programs assessments were fulfilled concurrently.

Careful planning by faculty on the CCSU assessment team resulted in an ultimately successful programs assessment, evaluation, and TAC of ABET accreditation. Design of continuous improvement plans with in-common learning objectives and learning outcomes based on standardized methodology for assessment across programs may prove to be effective.

1.0 Introduction

The Bachelor of Science in Engineering Technology programs at Central Connecticut State University (CCSU) share a common goal. This goal is "to provide graduates with a well-balanced education based on civic responsibility, cultural diversity and global awareness; critical thinking and problems solving techniques; writing and communication skills; quantitative skills; arts and humanity appreciation; scientific understanding; and computer literacy."

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There are many commonalities in the missions for the three programs in Engineering Technology: Mechanical, Manufacturing and Civil. Each program prepares graduates for professional careers as engineering technologists. The students acquire a knowledge base in mathematics, physical sciences, mechanics, fluids, manufacturing or construction processes, materials, testing, engineering design, computer-aided engineering graphics, computer programming, engineering standards, project planning and cost analysis. The students develop writing, communication, engineering problem solving and teamwork skills applicable to design, testing and fabrication of components, structures and systems. All three programs provide relevant applied experience within the academic environment through laboratory and classroom projects and experimentation. The programs also provide elective relevant industrial experience via cooperative education. The mission of the programs differ within the specialization by focus on thermodynamics, design and development, or CNC programming, production planning and quality control, or structures, project management and supervision.

The Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET) TC2K criteria calls for a continuous quality improvement plan. In response the faculty and Industrial Advisory Board (IAB) for the engineering technology programs at CCSU held a joint meeting to develop and approve program objectives, outcomes, assessment methods and evaluation procedures, i.e., to establish the required continuous improvement plans.

From the literature, Palomba and Banta provide generic guidelines for organizing the assessment process: establishment of goals, procedures, division of responsibilities, assignment of leadership and support of committees [1]. They also describe pros and cons of a centralized approach to assessment, data analysis, and distribution of results on examples of some institutions. They stipulate that the procedures should be efficient, but give no description of their definition of efficiency or examples of efficient assessment and evaluation procedures. Although the book describes many aspects of effective assessment programs implemented in American higher education, there are no suggestions on up front planning of data gathering and evaluation from the point of view of time efficiency regarding faculty involvement based upon commonalities between programs and subjects taught. In general, the described programs encourage sharing of tasks from top-down, instead of stipulating bottom-up development of data gathering and evaluation procedures that result in most productive use of faculty time.

Gupta lists numerous fundamental blocks, and pros and cons of various approaches to data gathering in terms of generic assessment of needs [2]. The focus of this book is on correct procedures and supporting infrastructure for gathering of representative data, processing information and drawing conclusions. Development of Teaching Goals Inventory (TGI) described by Angelo and Cross [3] is very good, although a tedious approach, in laying out the map of 'where we are' versus 'what needs to be done'. Thoroughly developed TGI helps establish commonalities between programs and specialties. Detailed TGI was developed for the

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Manufacturing ET program at CCSU in the late 1990's and was evaluated by IAB members. Subsequently, the Civil and Mechanical ET programs developed and evaluated their goals. Matrices were used for each program to document and illustrate the current degree of fulfillment of each learning objective.

Implementation of this method was judged too demanding on time, faculty and financial resources to be thoroughly executed at CCSU. Therefore an alternative approach resembling the philosophy of Group Technology (GT) used in design and manufacturing was developed. In this approach, focus on commonalities between different Engineering Technology programs is the goal. Only the necessary differences between programs are assessed independently. Also, this concept, as well as usefulness and validity of the tools, was reinforced during presentations and exercises attended by faculty participating in training sessions conducted by Rogers [4] and ABET TC2K and EC2K accreditation workshop leaders [5].

In his licentiate thesis from 1997, Broberg describes various tools for learners as knowledge workers [6]. Some of the noted tools that were kept in mind during the development process of assessment and evaluation at CCSU are: (1) establishing and maintaining focus of exploration, (2) communicating the learning process with others involved in a similar process, (3) bridging distances within collected information from the perspective of time and space, (4) managing information overload by stemming and filtering incoming information (by not gathering extraneous data), and (5) finding internal factors of relevance (e.g. continuous improvement). We believe assessment and evaluation should make use of similar techniques in that they are inherently knowledge processes. The previously mentioned goal, avoiding a variety of unnecessary assessment activities is supported by the tools 1 through 4 above. For us, simpler is better.

A number of publications, especially during the past six years, focus on: assessment tools and techniques, their usefulness and validity [1, 2, 3, 7, 8, 9, 10, 11]. Some limit the scope of their assessment plan to one engineering discipline only [10, 12], or to a single course [13]. Notably though, the ease of use and time efficiency are never mentioned as criteria for choosing an assessment methodology. The evaluated literature does not even mention simplicity as a goal for assessment and evaluation procedures. This seems counterintuitive when linking assessment procedures, data and evaluation results between programs, and academic and administrative departments in an institution of higher learning [1, 3, 4, 12, 14].

McGourty et al. suggest the development of pilot assessment processes [9]. Although valid, such an option was not possible at CCSU due to a very short time frame before the ABET accreditation visit. Focused data collection, however, has been in place at CCSU since 1995 [15], then in 1999 a structured format for data collection was developed for two core courses in the Manufacturing and Mechanical ET programs [16]. The years of collected data and these proven procedures provided the foundation to jumpstart the assessment and evaluation process for the ET programs.

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2.0 Objectives and Outcomes

Based on the commonalities of the three program missions the engineering technology objectives for each program were defined with four statements measured by an in-house developed standard alumni and employer survey. The Mechanical Engineering Technology Program Objectives are outlined as follows: (a-k reference ABET TC2K Criterion I) [17].

1) Graduates are prepared with an understanding of fundamental technical sciences that are integrated with the applied technical specialty, such as engineering materials and mechanics, fluid mechanics, thermodynamics, and electrical circuits, developing analytical techniques and problem solving skills necessary to adapt to technological changes, and for a career in mechanical engineering technology. (a, b, f)
2) Graduates acquire industry relevant experience within the academic environment through laboratory projects, experimentation, classroom lecture and demonstrations, and acquire in-depth technical knowledge in areas such as applied mechanics, computer-aided engineering graphics, design, and manufacturing processes. (a, c, d)
3) Graduates possess effective communication skills in oral, written, visual and graphic modes for interpersonal, team, and group environments. (e, g)
4) Graduates have appreciation for the responsibility of the contemporary engineering technologist by demonstrating professionalism and ethics including a commitment to utmost performance quality and timeliness, respect for diversity, awareness of international issues, and commitment to continuing professional development throughout their careers. (h, i, j, k)

The relationship between the engineering technology program objectives and the TAC of ABET Criterion I outcomes is illustrated in Table 1.

Table 1. Engineering Technology Programs Objectives at CCSU and TAC of ABET Criterion I

ET CCSU Objectives	TAC of ABET Criterion I Outcomes										
	a	b	c	d	e	f	G	h	i	j	k
1	●	●				●					
2	●		●	●							
3					●		●				
4								●	●	●	●

The learning outcomes relate to the skills, knowledge, and behaviors that the engineering technology students are expected to know and to do by the time of graduation. The outcomes for the Mechanical Engineering Technology program embrace the eleven (a through k) requirements of TAC of ABET Criterion I, and the achievement of these outcomes by each student will be assessed and evaluated before graduation. The program objectives associated with the listed

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learning outcomes below are indicated by numbers in parenthesis (1-4) and the letters (a-k) reference the TAC of ABET TC2K Criterion I.

Learning Outcomes - the engineering technology program demonstrates that graduates have:

1) Ability to apply basics knowledge of mathematics, science and engineering principles to solve technical problems. (1)(a, b, f)

2) Ability to identify, formulate and solve technical problems. (1, 2)(a, b, d, f)

3) Ability to use computational methods, skills, computers and modern technical tools in engineering practice. (1, 2, 3) (a, b, c, f, g)

4) Ability to design and conduct experiments, and to analyze and interpret data. (2) (c)

5) Ability to design a system, component or process to meet desired needs. (2) (a, d)

6) Ability to function effectively on teams and within a diverse environment. (3, 4) (e, j)

7) Ability to communicate effectively in oral, written, visual and graphic modes. (3) (g)

8) Recognition of the need for self-improvement through continuing education and the ability to engage in lifelong learning. (4) (h, k)

9) Understanding of professionalism and ethics and associated responsibilities. (4) (i, k)

10) Knowledge of contemporary issues and understanding of the impact of engineering/technical solutions within a global perspective. (1, 2, 4) (i, j)

The relationship between the objectives and learning outcomes for the Engineering Technology programs at CCSU and the TAC of ABET Criterion I outcomes are illustrated in Table 2.

2.1 Commonalities in Program Objectives and Outcomes

The curricula of engineering technology programs at Central Connecticut State University have a common core of engineering technology courses. The objectives and outcomes for the engineering technology curricula include the student's ability to apply basic knowledge of mathematics, science and engineering principles to solve technical problems. Both computational and problem solving skills are stressed within the core courses or the common technical sciences – introduction to engineering technology, mechanics (statics and dynamics), strength of materials and engineering economy – thus applying the prerequisite knowledge acquired by the students in calculus and physics. Due to these commonalities, the program objectives 3 and 4, and learning outcomes 1 through 10 are identical for all three ET programs.

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Table 2. CCSU Engineering Technology Program Objectives and Learning Outcomes, and TAC of ABET Criterion I

Learning Outcomes	ET CCSU Program Objectives				TAC of ABET Criterion I Outcomes a-k
	1	2	3	4	
1	●				a b f
2	●	●			a b d f
3	●	●	●		a b c f g
4		●			c
5		●			a d
6			●	●	e j
7			●		g
8				●	h k
9				●	i k
10	●	●		●	i j

2.2 Differences in Program Objectives and Outcomes

Objectives 1 and 2 differ for each program in that they are geared for careers in the respective disciplines. A prerequisite sequence within each engineering technology major includes specialty courses that emphasize the ability to use computational methods, skills, computers, and modern technical tools in engineering practice specific to the field. All graduates acquire industry relevant experience within the academic environment through laboratory projects, experimentation, classroom lecture and demonstrations. Regarding Objective 2, the acquired in-depth technical knowledge in discipline specific areas differ: applied mechanics, computer-aided engineering graphics, design, and manufacturing processes for the Mechanical ET program; applied mechanics, computer-aided engineering graphics, design, manufacturing processes and materials, tooling automation and production operations for the Manufacturing ET program; applied mechanics, structural analysis and design, computer-aided design, surveying, soils and hydrology for the Civil ET program. There are no differences in learning outcomes 1 through 10 for all three ET programs.

3.0 Assessments

The faculty and IAB members recognized the importance to implement an effective method to acquire assessment data, and to establish a standard for assessing the core curriculum for each program, as well as compiling the results and evaluating the findings. A Continuous Quality Improvement plan emerged in 1999 to evolve to its current format.

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3.1 Method

A multitude of methods were chosen to assess the Engineering Technology programs at CCSU. Table 3 provides the methods employed to assess the various objectives and outcomes for the Mechanical Engineering Technology Program.

Table 3. Assessment Method Used to Evaluate Program Objectives and Outcomes

Assessment Method	Objective				Outcome									
	1	2	3	4	1	2	3	4	5	6	7	8	9	10
Written Surveys	●	●	●	●										●
Focus Group	●	●	●	●										
Locally Developed Exams					●	●							●	
Portfolio							●	●	●		●			
Exit Interview									●			●		
Performance Appraisal										●				
Behavioral Observation								●			●			
Standardized Exam					●									
External Examiner														●
Rubric						●		●		●	●			

Both the Civil and Manufacturing Engineering Technology Programs used a similar or in-common approach in this regard. The only differences were in the chosen data sources.

3.2 Data Source

Written surveys were conducted of both graduates and employers. These surveys together with information from a focus group consisting of Industrial Advisory Board members, program professors, and soon to be graduates provide critical evaluation from the clients served by the various programs. The data from the Fundamentals of Engineering (EIT) standardized examination and our University assessment are also used within the continuous quality improvement plans. For much of the internal evaluation, specific courses were chosen as the source of data. Table 4 provides a list of courses used in the assessment process. Table 5 provides the specific courses used in the various programs together with the outcomes addressed through the substantiation method(s) listed. Table 5 shows that ET 150, ET 357, and ETC/ETM 498 are core courses and were selected to collect data for substantiating the learning outcomes of all programs. Specialization courses ETC 122, ETC 397, ETC 457 and ETC 458 for the Civil ET Program were selected to measure leaning outcomes 3, 4, and 6. In a similar manner, specialization courses ETM 260, ETM 462, and ETM 466 for the Manufacturing and Mechanical ET Programs were selected to measure the same three leaning outcomes 3, 4, and 6. ETM 461 is a specialization course for the Manufacturing ET Program measuring leaning outcome 4.

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Table 4. Specific Courses Used in Assessment Process

Course Number	Course Title
ET 150	Introduction to Engineering Technology
ET 357	Strength of Materials
ETC/ETM 498	Engineering Technology Senior Project
ETC 122	Introduction to CAD
ETC 397	Structural Analysis
ETC 457 or 458	Advanced Surveying or GPS Mapping for GIS
ETM 260	CAD and Integrated Manufacturing
ETM 462	Manufacturing Process Planning and Estimating
ETM 466	Design for Manufacture
ETM 461	Composites and Plastics Manufacturing Processes

Table 5. Specific Courses Used to Substantiate Learning Outcomes

Course Number	Program Plan Supported	Learning Outcome	Substantiation Method
ET 150	Civil / Mfg. / Mech.	9	Locally developed exam
ET 357	Civil / Mfg. / Mech.	1, 2	Locally developed exam
ETC/ETM 498	Civil / Mfg. / Mech.	2, 4, 5, 7, 8, 9	Rubric (2), Student work portfolio (4,5,7), Exit interview (5,8), Behavioral observation rubric (7), Locally developed exam (9)
ETC 122	Civil	3	Electronic student work
ETC 397	Civil	4	Student work portfolio / Behavioral observation rubric
ETC 457 or 458	Civil	6	Performance appraisal rubric
ETM 260	Mfg. / Mech.	3	Electronic student work
ETM 462	Mfg. / Mech.	4	Student work portfolio / Behavioral observation rubric
ETM 466	Mfg. / Mech.	6	Performance appraisal rubric
ETM 461	Mfg.	4	Student work portfolio / Behavioral observation rubric

3.3 Frequency of Data Collection

The methods for program evaluation were classified into external and internal tools. It was felt that data from methods having an internal character could be gathered on a yearly basis but that data from external sources should be collected less frequently so that graduates, employers and IAB members are not overburdened by assessment needs. The frequency of data collection is

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also stipulated by the duration of the accreditation. Overall the frequency of data collection for the current plan is as follows:

External:

- FE (EIT) examination – each year that performance data is provided
- Graduate Survey – Spring Graduates 2003 and every three to five years
- Employer Survey – Fall 2003 and every three to five years
- Focus Group – Industrial Advisory Board and invited employers – every three years
- University Assessment on International/Global Perspectives – periodically

Internal:

Portfolio:

ETC 122 – Student electronic data	Yearly
ETC 457 – Student work	Yearly
ETC 458 – Student work	Yearly
ETM 260 – Student electronic data	Yearly
ETM 461 – Student work	Yearly
ETM 462 – Student work	Yearly
ETM 466 – Student work	Yearly
ETM 498 – Rubric	Yearly

Locally Developed Examinations:

ET 150 – Quiz on professional ethics	Yearly
ET 357 – Student work and computational	Yearly

Performance Appraisal:

ETC 457 – Rubric	Yearly
ETC 458 – Rubric	Yearly
ETM 466 – Rubric	Yearly

Exit Interview:

ETC 498 – Faculty interactive questions	Yearly
ETM 498 – Faculty interactive questions	Yearly

Behavioral Observation:

ETC 397 – Rubric	Yearly
ETC 498 – Rubric	Yearly
ETM 461 – Rubric	Yearly
ETM 462 – Rubric	Yearly
ETM 498 – Rubric	Yearly

4.0 Program Evaluation

Program evaluation is a continuous process implemented through each program's Continuous Quality Improvement plan. The compiled data for assessing the objectives and outcomes were rated on a scale 1 to 4 (consistent with the University scale) and evaluated. A rating of 4 that the objective or outcome has been 90% met or exceeds expectations, a rating of 3 points toward 80% met or fully meets expectations, a rating of 2 is 70% or minimally attained, and rating of 1

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denotes failure or does not meet expectations. The rating was determined by faculty judging the expectations for students in fulfilling the learning outcome components identified in the rubrics or similar tools.

4.1 Evaluation of Assessment Data

The School of Technology at CCSU developed the "dynamic" assessment (accreditation) model for monitoring the program continuous improvement process as shown in Figure 1. Assessment data for each program, such as that which would be generated using the senior project rubric shown in Figure 2, was compiled by the engineering technology faculty. The program coordinator along with the program faculty compile, review and analyze the data then report the findings to the Department Chairperson. At bi-annual department meetings that are scheduled for review, analysis and evaluation of assessment data, the strengths or weaknesses for each program are outlined. Faculty discuss options for program revision to improve the program by modifying curricula, courses and/or content.

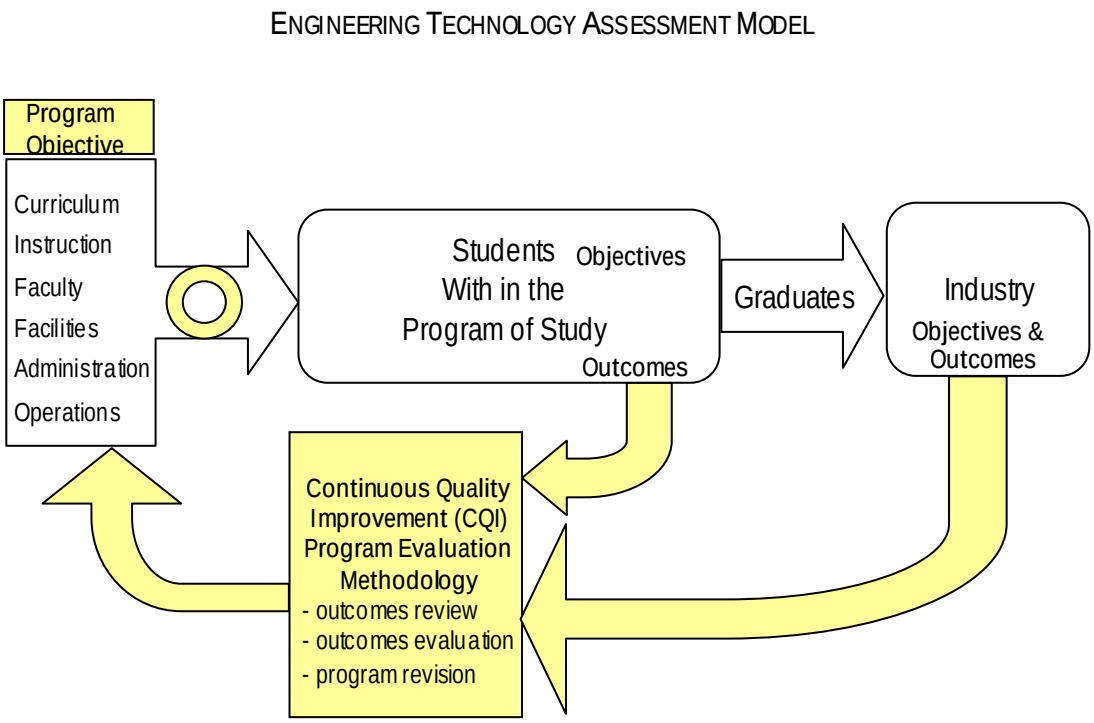

Fig. 1. Model for evaluation of objectives and learning outcomes developed and used at Central Connecticut State University based on Kremens[18].

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Course number and name: ETM 498 Senior Proj.-Mechanical **Date:** **Avg. student rating:**

ETM 498 Course Description: Prerequisite: Permission of instructor. Team work project to study, design, and/or research a project as engineering techologists. Final reports submitted to the department for archiving and oral presentations are required. Projects may originate from student, instructor, and/or industrial partner. [c]

Learning Outcomes Assessed: #2, #5, #6, and #7

The student will demonstrate - 2) Engineering Methodology - the ability to identify, formulate and solve technical poblems;
5) the ability to design a system component, or process to meet desired needs;
6) the ability to function effectively on teams within a diverse environment;
7) the ability to communicate effectively in oral, written, visual and graphic modes.

Outcome Measured	Rating of students								Evalutation (avg for the students). Comment required for a rating less than 2.0.
	1	2	3	4	5	6	7	8	
2 and 5 Engineering Methodology									
Identification of need									
Problem definition									
Search (information)									
Constraints									
Criteria									
Alternative solutions									
Analysis/Evaluation of solutions									
Decision									
Specifications									
7. Communications									
Voice (loud and clear)									
Enthusiasm									
Posture/Mannerism									
Language (professional vocabulary)									
Eye contact									
7. Presentation									
Multi-media (visual/audio/models)									
Organization format (logical order)									
Written format (spelling, syntax, etc.)									
Technical content (specialty)									
Calculations (math/science)									
Citation/References									
6. Project Teamwork/Organization									
Project planning									
Contribution (working in diverse environment)									
Summation of Rating									

Ratings: 1 - Outcome is not fulfilled. (Does Not Meet); 2 - Outcome is barely (70%+) attained. (Minimal);
3 - Outcome is (80%+) met but with some ambiguity. (Meets); 4 - Outcome is (90%+) clearly fullfilled. (Exeeds).

Mechanical ET Evaluation Ratings: Overall _____ #2 = _____ #5 = _____ # 6 = _____ #7 = _____

Mechanical Engineering Technology program __ Outcomes #2, #5, #6, #7 Action Taken:

Fig. 2. Rubric for assessing engineering technology senior project.

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The Program Coordinator, engineering technology faculty and members of each program Industrial Advisory Board also meet bi-annually. Assessment data and evaluations are reviewed with the Board to finalize recommendations regarding curriculum revisions, course topics and subject content, laboratory exercises, and other concerns as determined from the assessment data. Program, curriculum and course revisions are then approved by the Engineering Technology Department, submitted to School of Technology for review, and ultimately sent to the University Curriculum Committee, Faculty Senate and appropriate administrators for approval.

5.0 University Assessment

Central Connecticut State University requires an assessment and evaluation of each degree program to comply with State policy. Therefore, the Continuous Quality Improvement process serves both the Technology Accreditation Commission for the Accreditation Board for Engineering and Technology and the Connecticut State University (CSU) assessment criteria. Data to assess the University General Education part of curricula is collected and evaluated by the CCSU administrative offices. This assessment data is disseminated university-wide for departmental review. The departmental data collected and evaluated is presented in a formal report and input to a CSSU webpage to complete the University program assessment requirement.

6.0. Conclusions

Careful planning by faculty on the CCSU assessment team resulted in an ultimately successful programs assessment, evaluation, and TAC of ABET accreditation of the Civil, Manufacturing, and Mechanical Engineering Technology programs. The developed assessment and evaluation procedures resulted in efficient use of faculty time. Design of continuous improvement plans with in-common learning objectives and learning outcomes based on standardized methodology for assessment and evaluation across programs may prove to be effective at other institutions.

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