# AC 2011-1806: USING DIRECT ASSESSMENT TO RESOLVE TAC/ABET CRITERION 3 PROGRAM OUTCOMES

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# Using Direct Assessment to Resolve TAC/ABET Criterion 3 Program Outcomes


## Abstract

The focus of the assessment process was on developing and administering reliable and valid direct methods to assess student outcomes. The direct methods of assessment, based on the list of direct measures recognized at the 2008 TAC Commission Summit, developed by the Computer Engineering Technology (CET) faculty included tests, constructed with a test blueprint, and performance appraisals with scoring rubrics. These direct assessment measures provided evidence of student learning which subsequently guides faculty in identifying its program weaknesses. Furthermore, CET faculty found the interpretation of the data much easier with these measures of assessment. The assessment process developed for the program not only included the traditional summative approach, but also included formative assessment within the overall Continuous Quality Improvement (CQI) model. The inclusion of formative assessment within the overall CQI model provides an opportunity for early intervention for program-level attrition. Specifically, this paper provides information regarding assessment planning, the assessment process, the development of assessment instruments, and the challenges encountered by the department and should provide information that will benefit other engineering and engineering technology programs seeking accreditation or re-accreditation.


## 1. Introduction

Colleges and universities across the nation value the importance of accreditation, which provides two fundamental purposes for an institution: assuring the quality of the institution or its programs and to assist in the improvement of the institution or programs through the self-study process. The comprehensive process for producing a self-study report provides an opportunity for an institution or program to review its goals and expectations, as well as identify student strengths and weaknesses. By providing a process to identify shortcoming with respect to student attainment of student learning outcomes, institutions or programs are better able to make necessary improvements, as well as understand their institutional or program strengths.

The Computer Engineering Technology (CET) program, in the CET department at NewYork City College of Technology/City University of New York, is accredited by the Technology Accreditation Commission/Accreditation Board for Engineering and Technology (TAC/ABET). The TAC/ABET is the world leading accreditation organization in engineering and engineering technology programs. When a program is accredited by TAC/ABET, it communicates to an institution's constituencies that the program has met the quality standards established by the ABET professions. This paper details the overall assessment process developed by College's Assessment and Institutional Research office at NYCCT, together with the ABET accredited programs within the College, in response to a program weakness identified by ABET with respect to ABET Criterion 3 Program Outcomes.

## 2. Assessment Planning

It is our College's effort in establishing a culture of assessment for learning. During the course of the academic year (2009-2010), numerous department meetings were held with the Academic Dean, as well as the College's Assessment and Institutional Research office, to plan and develop the direct assessment activities for the program outcomes as part of the CET program's Continuous Quality Improvement (CQI) process. As a result of these meetings, faculty members proceeded to plan and document the program assessment cycle for ABET Criterion 3 (3a – 3k) and Criterion 9 (9a – 9c). As stated by Middle States Commission on Higher Education (MSCHE)[9], assessment is not an "event but a process that is an integral part of the life of the institution." In other words, assessment for learning is an on-going process where institution uses the assessment results to improve instructional effectiveness which consequently improves student learning.

The department faculty identified an assessment cycle that did not require the assessment of every program outcome, every year, in order to remain sustainable over time. The assessment cycle developed by the CET department faculty is presented in **Table 1**.

**Table 1: CET Assessment Cycle for ABET Criteria 3a through 3k and 9a through 9c.**

| ABET Program Outcome (Criteria 3a – 3k) and ABET Program Criteria (Criteria 9a – 9c) | 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 | 2014-2015 | 2015-2016 |
|---|---|---|---|---|---|---|
| 3(a) Mastery of the knowledge, techniques, skills and modern tools of their disciplines | ♦ | | | ♦ | | |
| 3(b) Ability to apply current knowledge and adapt to emerging applications of math, science, engineering and | ♦ | | | ♦ | | |
| 3(c) Ability to conduct, analyze and interpret experiments and apply experimental results to improve processes | ♦ | | | ♦ | | |
| 3(d) An ability to apply creativity in the design of systems, components or processes appropriate to program | ♦ | ♦ | | ♦ | ♦ | |
| 3(e) An ability to function effectively on teams | ♦ | ♦ | | ♦ | ♦ | |
| 3(f) An ability to identify, analyze and solve technical problems | ♦ | ♦ | | ♦ | ♦ | |
| 3(g) An ability to communicate effectively | ♦ | ♦ | | ♦ | ♦ | |
| 3(h) Recognition of the need for, and an ability to engage in lifelong learning | | ♦ | ♦ | | ♦ | ♦ |
| 3(i) Ability to understand professional, ethical and social responsibilities | | ♦ | ♦ | | ♦ | ♦ |
| 3(j) Respect for diversity and a knowledge of contemporary professional, societal and global issues | | ♦ | ♦ | | ♦ | ♦ |
| 3(k) Commitment to quality, timeliness, and continuous improvement | | ♦ | ♦ | | ♦ | ♦ |
| 9(a) The ability to analyze, design, and implement hardware and software computer systems | | ♦ | ♦ | | ♦ | ♦ |
| 9(b) The ability to apply project management techniques to computer systems | | ♦ | ♦ | | ♦ | ♦ |
| 9(c) The ability to utilize statistics/probability, transform methods, discrete mathematics, or applied differential equations in support of computer systems and networks | | ♦ | ♦ | | ♦ | ♦ |

The CET department accreditation coordinator was delegated with the responsibility to oversee the assessment cycle and ensure the activities are completed according to the department timelines. Once the assessment cycle was defined, the faculty proceeded to develop and document a work plan to carry out the assessment activities. Next, the CET department would implement and collect data from the assessment activities accordingly to the timeline. The assessment results would provide the faculty members feedback of student learning and teaching. Moreover, the assessment results provide insightful information that can guide faculty in modifying and planning for instruction.

### 2.1 Identifying Performance Criteria for ABET Program Outcomes

According to Rogers[1], Performance Criteria must be identified for each ABET Criterion in order to validly conduct program-level assessment activities. Performance criteria are specific, measurable statements identifying the performance required to meet the outcome. For performance appraisals (e.g., design projects, lab experiments), well-stated Performance Criteria provide faculty with clear direction for implementation, as well as explicit expectations of student performance. Therefore, Performance Criteria were defined for each Program Outcome (an example of the CET department program level Performance Criteria is provided in **Table 2** as part of the department's assessment plan).

**Table 2: Assessment Cycle for ABET Criterion 3a:** ***"An appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines[2]."***

| Performance Criterion | Strategies | Assessment Method(s) | Where data are collected | Time of Data Collection | Evaluation of Results* | Assessment Coordinators |
|---|---|---|---|---|---|---|
| 1. Perform needs analysis by defining the problem | CET3510<br>CET3525<br>CET4811 | Comprehensive Design Project | CET4811 | Fall 2010<br>Fall 2013 | Spring 2011<br>Spring 2014 | Faculty Member1<br>Faculty Member2 |
| 2. Identify resources (parts, equipment, etc.) to build the systems | CET3510<br>CET3525<br>CET4811 | Comprehensive Design Project<br>LDE | CET4811<br>CET3510 | Fall 2010<br>Fall 2013 | Spring 2011<br>Spring 2014 | Faculty Member1<br>Faculty Member2 |
| 3. Develop a procedure for constructing the systems | CET3510<br>CET3525<br>CET4811 | Comprehensive Design Project<br>LDE | CET4811<br>CET3510 | Fall 2010<br>Fall 2013 | Spring 2011<br>Spring 2014 | Faculty Member1<br>Faculty Member2 |
| 4. Analyze test results of computer-controlled systems | CET3510<br>CET3525<br>CET4811 | Comprehensive Design Project<br>LDE | CET4811<br>CET3510 | Fall 2010<br>Fall 2013 | Spring 2011<br>Spring 2014 | Faculty Member1<br>Faculty Member2 |

*CET Curriculum Committee meets to discuss results and determines action necessary for CQI

The next step for faculty was to determine the type of direct assessment methods that would be utilized to assess each of the Program Outcomes. The classification of direct methods is shown in **Table 3**:

**Table 3: Direct Measures of Assessment**

| **Direct Measures of Assessment** | |
|---|---|
| Behavioral Observations | Performance Appraisal |
| External Examiner | Portfolio |
| Locally Developed Exam | Simulation |
| Oral Exam | Standardized Exam |

These measures of assessment are based on the list of direct measures recognized at the 2008 TAC Commission Summit[3]. CET department recognized the importance of having a sustainable assessment process in place. According to MSCHE[9], one of the fundamental elements of assessment of student learning is to have an assessment process that demonstrates "sufficient simplicity, practicality, detail, and ownership to be sustainable." With that in mind, the faculty members in CET department were aware of the challenges of having an overwhelmingly large amount of data that can be generated by having too much assessment tools for different semesters. At the same time, the faculty members recognized having multiple types of direct assessment measures is essential in generating a concrete evidence of student learning. Therefore they came to a consensus that they will focus on two direct measures in assessing student learning at the program level.

According to Rogers[1], it is not necessary to use all the direct assessment methods in Table 3 to assess Program Outcomes. She suggested taking a few direct methods from Table 3 to assess Program Outcomes.

**3. Development of Assessment Instruments**

It was important that the assessment process was well understood by faculty and perceived as a group effort. The College administration supported the assessment process and emphasized the importance of utilizing the results to make data-driven decisions in order to make improvements in the program. The CET department implemented two direct methods as follows:

1. Performance Appraisal with a Scoring Rubric
2. Locally Developed Exams (LDE).

The CET department planned, developed, and implemented appropriate direct methods to assess ABET Criterion 3. The College recognized that the assessment process should be faculty-driven since it is a vehicle for improving student learning. Faculty involvement was essential in the assessment process, and subsequently, for both assessment methods, faculty members were identified to work in teams to develop the instruments. After the draft of a particular instrument was constructed, the instrument was circulated among the remaining department faculty for feedback, providing department faculty with an opportunity to participate in the process.

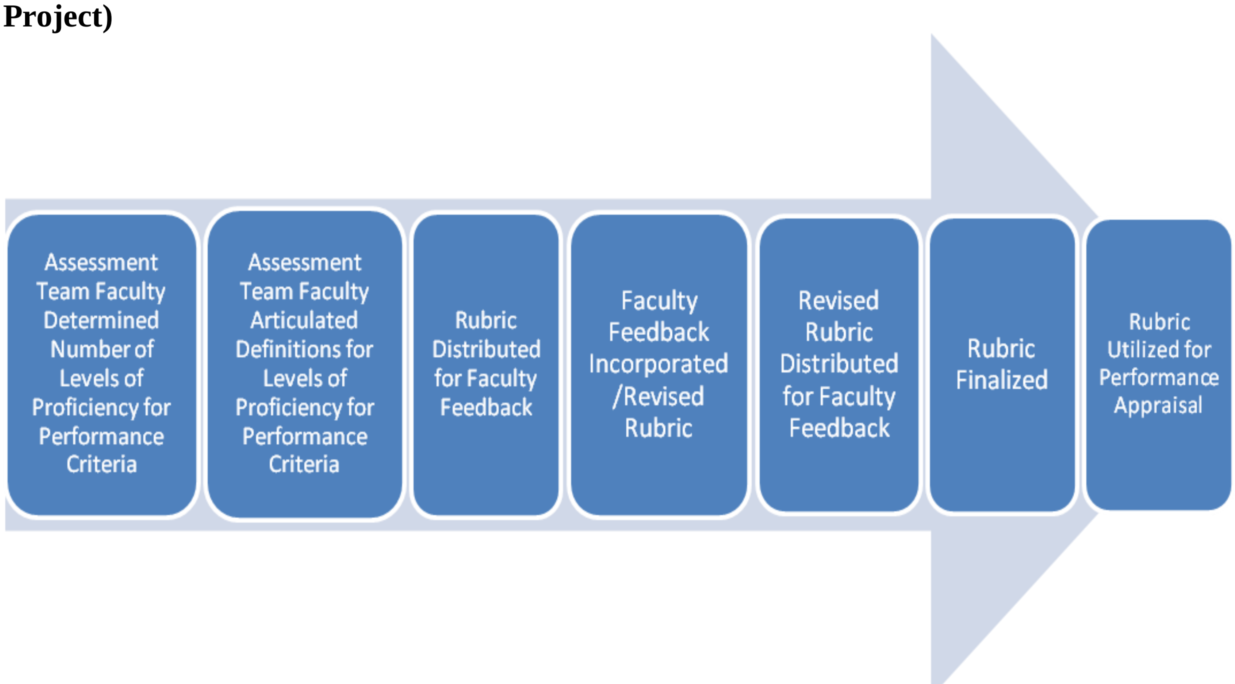
### 3.1. Performance Appraisal with a Scoring Rubric

A rubric, in general, is developed to articulate the performance criteria required to exhibit proficiency for a defined learning outcome and define the expectations for each level of proficiency. Typically, a rubric consists of four parts and is presented in a matrix format[4].

1. Task description (Performance Appraisal)
2. Levels of performance (rating scale)
3. Dimensions (performance criteria)
4. Descriptors

The department developed a Performance Appraisal for a comprehensive design project and a scoring rubric to address continuous quality improvement for the assessment of the program outcomes for Criterion 3 in order to address the ABET weakness. The capstone course for the program, CET 4811: Computer Controlled System Design II was selected as the source of data collection for the assessment for the specific Performance Criteria identified for ABET Criterion 3(a). As a team, the CET faculty organized and documented the assessment activities to develop the scoring rubrics for the performance appraisals. The process utilized to develop the rubric is presented in **Figure 1**.

**Figure 1: Rubric Development Process for CET Performance Assessment (Capstone Project)**




The rubric that was developed through this process for ABET Criterion 3a is presented in **Table 4**.

**Table 4: Performance Appraisal Scoring Specifications to Assess ABET Criterion 3(a):** **"*Mastery of the knowledge, techniques, skills and modern tools of their disciplines*[2]."**

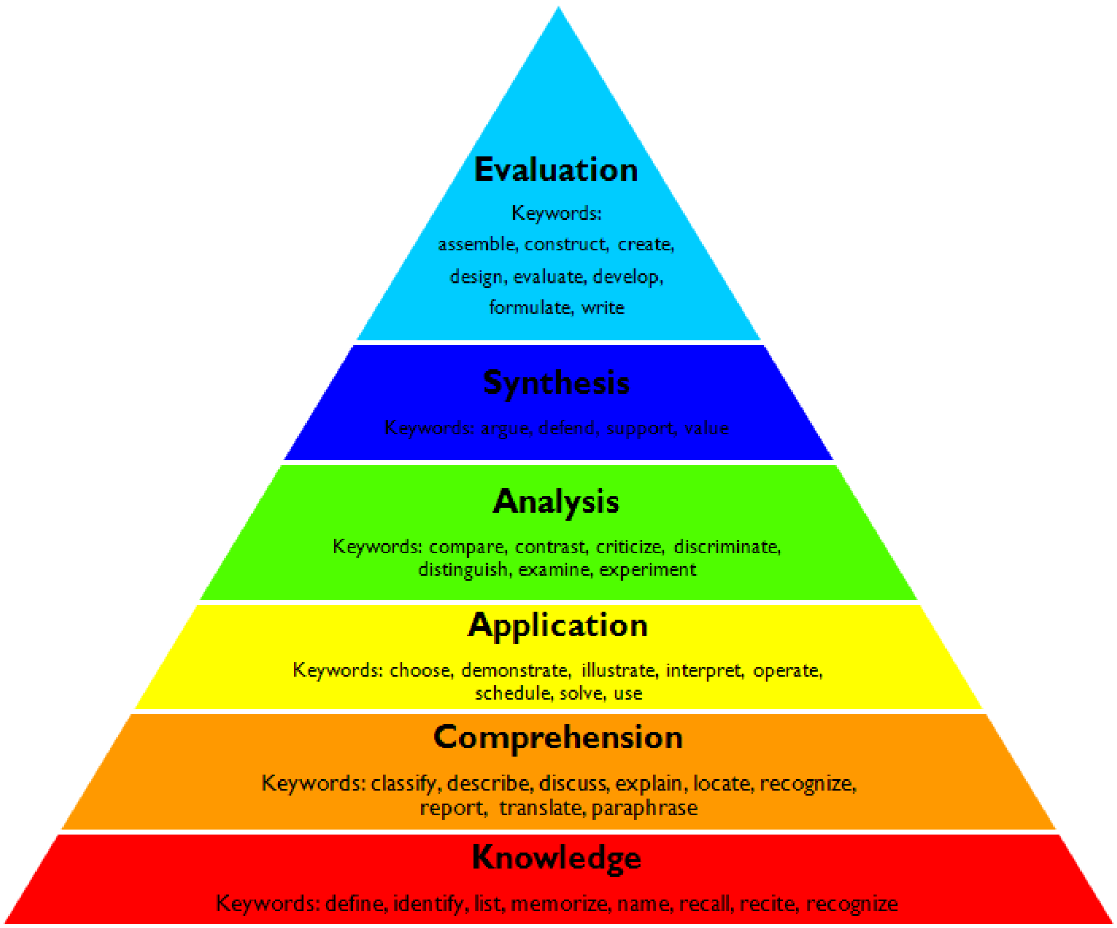
| Performance Criteria | ABET Criterion | Exceeds Criterion | Meets Criterion | Progressing toward Criterion | Below Criterion | Score |
|---|---|---|---|---|---|---|
| 1. Perform needs analysis by defining the problem | 3a | Identifies the problem to be solved with solution criteria | Identifies the problem to be solved with partial-solution criteria | Recognizes the problem to be solved, but does not provide sufficient information for the solution criteria | Unable to recognize the problem to be solved | |
| 2. Identify resources (parts, equipment, etc.) to build the systems | 3a | Identifies the necessary tools, instruments and schematic diagrams of the systems to be constructed | Identifies the needed tools and instruments, but lacks sufficient information on schematic diagrams of the systems | Provides sufficient information on schematic diagrams of the systems, but fails to correctly identify the necessary tools and instruments. | Fails to identify the necessary tools and instruments; does not provide information on schematic diagrams of the systems | |
| 3. Develop a procedure for constructing the systems | 3a | Presents well-organized, planned stages of operation and sequence of tests to be performed | Presents adequately planned stages of operation, but does not fully outline the sequence of tests to be performed | Provides partially planned stages of operation; does not provide complete outline of sequence of tests to be performed | Does not provide outline of stages of operation and has no sequence of tests to be performed | |
| 4. Analyze test results of computer-controlled systems | 3a | Results indicate well-functioning systems | Results indicate functioning systems with isolated errors in software | Results indicate systems failure due to critical errors in hardware | Results indicate systems malfunction due to failure of hardware and software | |

## 3.2. Locally Developed Exams (LDE)

According to Rogers[1,5] and the Middle States Commission on Higher Education[6] (MSCHE), the LDE is an acceptable form of direct assessment. The MSCHE further elaborates that an LDE must be constructed using a test blueprint in order to be considered a valid direct measure of assessment. This is consistent with Alaraje's[7] conclusion that test items must be mapped to the program outcomes in order to provide a valid Performance Criterion for program-level outcomes.

A Test Blueprint is a table of item specifications that documents the outcomes covered on the test on one axis and provides the specifications of items to be constructed with respect to the level of student proficiency on the other axis. Typically, the classification of the cognitive level of learning assessed is indicated by utilizing Bloom's Taxonomy[8]. Bloom's taxonomy consists of six general cognitive processes that vary from simple to complex: knowledge, comprehension, application, analysis, synthesis, and evaluation (see **Figure 2**). The categories can be thought of as degrees of difficulties. That is, the first one must be mastered before the next one can take place.

**Figure 2: Bloom's Taxonomy – Classification of Cognitive Learning**




Lastly, each cell in the table records the number of test items, and the relative weight that will be given for each outcome. By allocating a percentage to each of the outcomes, faculty members have a clear picture of the relative importance of each outcome represented on the test. A sample Test Blueprint is provided for a course (CET 3525 Electrical Networks) in **Table 5**.

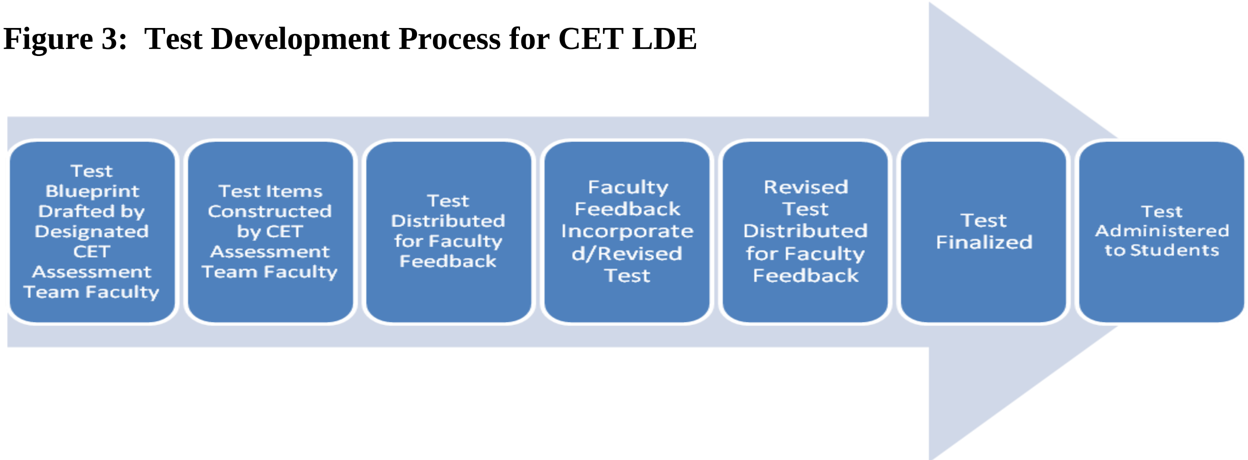
**Table 5: Locally Developed Exam Blueprint for CET 3525 Electrical Networks**

| Learning Outcomes | Course-Level Outcome | Relates to ABET Program Outcomes /Performance Criteria | Bloom's Taxonomy Classification | No of Test Items/ Questions #s | Point Value | (%) Weight of test |
|---|---|---|---|---|---|---|
| **Basic series and parallel ac circuits** | Use basic laws (Ohm's law, power law, Kirchhoff's law) to analyze and solve series circuits, parallel circuits, and series-parallel circuits | 3(b) – 3: Apply appropriate knowledge of scientific, mathematical, and engineering design tools toward the design and analysis of problem solutions | Knowledge<br>Comprehension<br>Analysis | 1/(30)<br>1/(29)<br>1/(24) | 2<br>3<br>5 | 1.89<br>2.83<br>4.72 |
| | Use circuit theorem (Thevenin's Theorem, Norton Theorem and Superposition Theorem) to analyze and solve circuit networks | 3(b) – 3: Apply appropriate knowledge of scientific, mathematical, and engineering design tools toward the design and analysis of problem solutions | Knowledge<br>Comprehension<br>Analysis | 1/(2)<br>1/(27)<br>1/(25) | 2<br>3<br>5 | 1.89<br>2.83<br>4.72 |
| **Capacitors, Inductors and Transients in R-C and R-L circuits** | Use the first order differential equation to analyze and solve free-source and step response in RC and RL circuits | 3(b) – 3: Apply appropriate knowledge of scientific, mathematical, and engineering design tools toward the design and analysis of problem solutions | Knowledge<br>Comprehension<br>Analysis | 1/(8)<br>1/(23)<br>1/(22) | 2<br>3<br>5 | 1.89<br>2.83<br>4.72 |
| **Basic electrical elements and phasors, and complex number mathematics** | Analyze and evaluate sinusoidal ac voltage characteristics, sine wave, general format for the sinusoidal voltage or current phase relationship, and response of basic R, L, and C elements to a sinusoidal voltage or current | 3(a) – 4: Analyze test results of computer-controlled systems | Knowledge<br>Comprehension<br>Analysis | 1/(5)<br>1/(12)<br>2/(15,16) | 2<br>3<br>10 | 1.89<br>2.83<br>9.43 |

| Learning Outcomes | Course-Level Outcome | Relates to ABET Program Outcomes /Performance Criteria | Bloom's Taxonomy Classification | No of Test Items/ Questions #s | Point Value | (%) Weight of test |
|---|---|---|---|---|---|---|
| | Analyze and solve sinusoidal steady-state circuit analysis using mesh analysis, Thevenin and Norton Equivalent circuits | 3(a) – 4: Analyze test results of computer-controlled systems | Knowledge<br>Comprehension<br>Analysis | 1/(9)<br>1/(11)<br>1/(10) | 2<br>3<br>5 | 1.89<br>2.83<br>4.72 |
| **More-complex series/ parallel ac networks** | Analyze and solve Series AC, parallel AC, series-parallel AC circuit networks using voltage or current divider rules and equivalent circuit | 3(b) – 2: Devise a process to solve problem | Knowledge<br>Comprehension<br>Analysis | 1/(28)<br>1/(26)<br>2/(13,14) | 2<br>3<br>10 | 1.89<br>2.83<br>9.43 |
| **Sinusoidal waveforms, and average and effective values** | Analyze and calculate AC power parameters (instantaneous and average power, maximum power transfer, effective or RMS value, and apparent power and power factor) | 3(b) – 2: Devise a process to solve problem | Knowledge<br>Comprehension<br>Analysis | 1/(1)<br>2/(3,4)<br>1/(6) | 2<br>6<br>5 | 1.89<br>5.66<br>4.72 |
| **Decibels Non-sinusoidal circuits** | Analyze and evaluate frequency response for transfer function, decibel scale, Bode plots, series and parallel resonance, and passive filters | 3(b) – 2: Devise a process to solve problem | Knowledge<br>Comprehension<br>Analysis | 1/(7)<br>2/(17,21)<br>3/(18,19,20) | 2<br>6<br>15 | 1.89<br>5.66<br>14.15 |
| | | | **Total** | 30 | 106 | 100 |

Once the Test Blueprint was developed, the faculty engaged in the test development process (see **Figure 3**). Again, it was recognized that faculty involvement was crucial for ensuring a successful assessment program within the department. When faculty were involved in the assessment process, they were more likely to understand the value of utilizing the assessment data for program improvement. Additionally, being involved in the development of the instruments to assess student learning provided faculty with an opportunity to give their feedback, and provide face validity to the entire assessment process. Face validity is important for faculty, as well as students, because it provides the validity of the instrument at "face value." In other words, the instrument is said to have face validity if it appears that is going to measure the outcomes that is constructed to measure. Having multiple faculty members involved in the process helps to ensure the face validity of the instrument.

**Figure 3: Test Development Process for CET LDE**




## 4. Challenging Issues

It was challenging to adopt direct assessment measures for assessment since we had historically relied upon survey data heavily in our program. According to G. Rogers[1], the program can utilize a combination of direct methods from **Table 3**, as well as indirect methods that that are applicable to our program. Another challenge the department experienced was collecting and analyzing the data, which is a crucial step in direct assessment. To achieve this, it required the coordination and cooperation among the faculty members and staff to gather the assessment data information. It is a continuous process to collect and analyze the data for each of the Program Outcomes. For instance, the timelines illustrated in **Table 1** for CET assessment cycle demonstrate a six year cycle where each program outcome is assessed every year. By defining the assessment cycle, **Table 1** provides a sustainable and systematic process to assess CET program outcomes for the long term. However, keeping the faculty engaged in assessment planning activities and having faculty document their efforts has continued to be somewhat of a challenge. Although, with the assessment cycle in place, we are confident that as we identify student strengths and weaknesses, recommend improvements, implement an action plan to address the areas identified for improvement, will motivate faculty as they can realize the utility of the assessment process for improving the program.

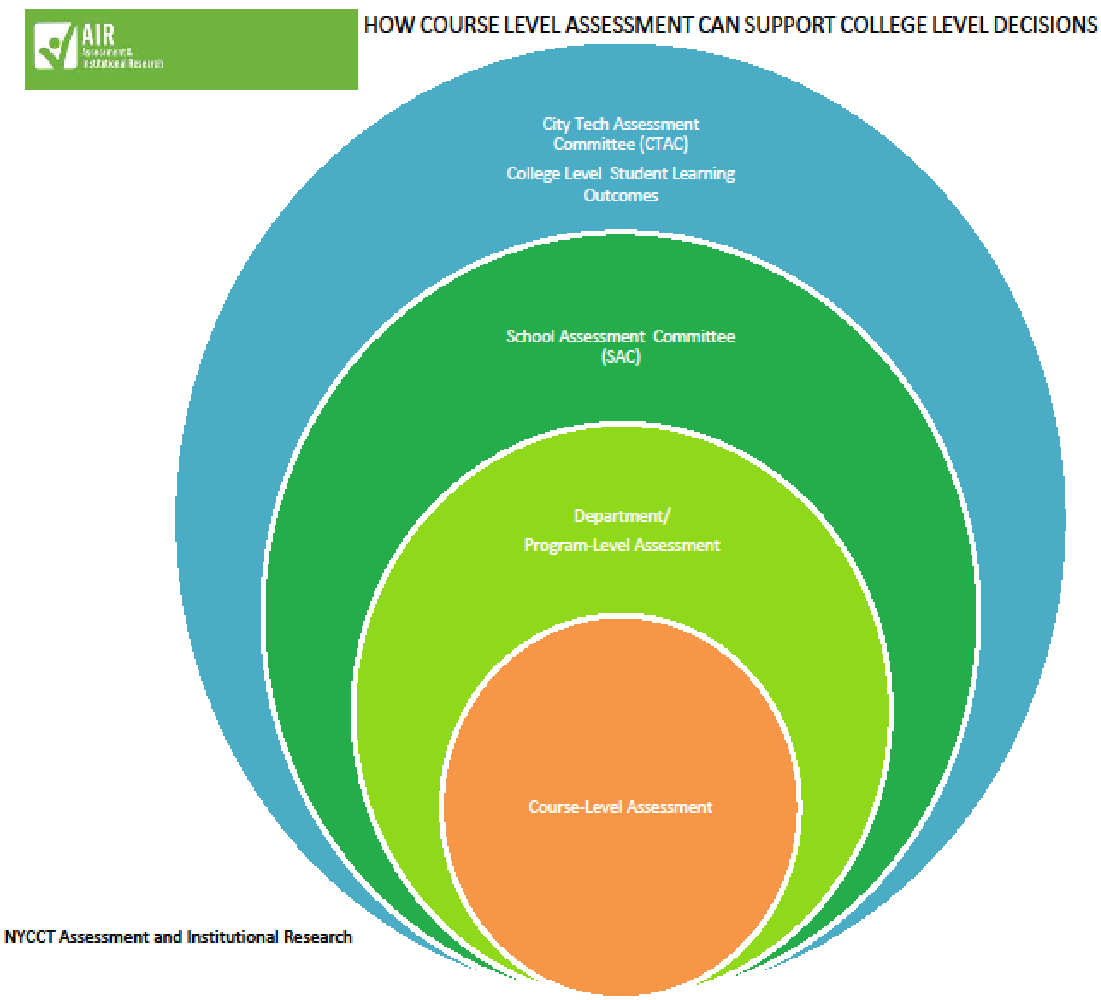
## 5. Overall Conclusions and Future Considerations

The program weakness identified by the ABET visit was taken very seriously. The institution ensured faculty they were supported in their assessment activities by providing resources from the Assessment and Institutional Research office and hosting an on-campus workshop with Gloria Rogers[1]. With these resources and assessment training, the faculty members have a better understanding of assessment and the CQI process for improving student learning outcomes.

TAC/ABET Program Outcomes Criterion 3 were evaluated using both summative and formative types of direct assessment to reveal the strengths and weaknesses of the program. The formative assessment included was conducted on a course considered a "critical" course in the department.

A critical course was defined as a key course in the curriculum or a course identified with a higher than anticipated drop rate. The logic behind, including the assessment of critical courses, was such that if student weaknesses could be identified prior to the capstone, the department could improve its curriculum and improve its program retention rates. The critical course assessment supports the program-level assessment, which in turn supports the School's assessment, as well as the College's assessment (see **Figure 4**).

**Figure 4: Course-Level Assessment to College-Level Assessment in a Comprehensive Assessment Model**




The actions taken by the CET department resulted in acceptable performance levels for all defined Performance Criteria for the program-level assessment.

An unanticipated benefit of the assessment activities was the ability to examine the differential performance of students in different sections in the mid-stage courses (CET 3510 and CET 3525) selected to assess students for the formative assessment component. This finding allowed for better faculty communication regarding course curriculum issues, and was well-received and particularly useful for adjunct faculty members.

The CET department plans to enhance the CQI process in the future by:

1. Maintaining the success metric or target of 75% for all Performance Criteria;
2. Conducting research on the adequacy of the pre-requisite mathematics and computer courses for the CET courses required for the degree;
3. Evaluating all program outcomes;
4. Evaluating the current Performance Criteria, with the goal of ensuring Performance Criteria are equally useful with multiple assessment measures;
5. Examining the reliability and validity of the assessment instruments developed for the program;
6. Investigating other appropriate assessment methods;
7. Adding performance indicators to the LDE blueprint in order to ensure better triangulation of the assessment results;
8. Expanding formative assessment activities to include a mid-stage level assessment within the CET full assessment cycle of activities; and
9. Continuing to consult with the Advisory Board members and inviting them to view student capstone project presentation. This invitation was well-received during Fall 2009, and the insight provided by Advisory Committee members was helpful to the program.

The CET department and CET faculty are confident that coordination with the Assessment and Institutional Research (AIR) office, and feedback from our program constituents, will make the program more effective and efficient resulting in a superior learning experience for our students.

## 6. Acknowledgement

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