

# Implementation of a Course Assessment Process for Continuous Improvement and Outcomes Assessment

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**Abstract** – A formalized course assessment process was adopted and implemented by The Citadel Department of Civil & Environmental Engineering (CEE) during the 2003/2004 academic year. The process is predicated upon submittal of individual course assessment reports generated by professors for each course taught within the departmental curriculum. A step-by-step methodology was established via the use of detailed flow charts that identify major activities, completion milestones, internal reviews, curriculum tabulations, summary reporting, multi-faceted feedback and continuous improvement. Results of the process are structured to directly connect with the larger goal of conducting comprehensive outcomes assessment for the department and serve as a significant component in meeting ABET criteria to foster systematic improvement in the quality of engineering educational goals and objectives.

**Keywords:** course assessment, program outcomes, continuous improvement

## INTRODUCTION

The Citadel Department of Civil & Environmental Engineering (CEE) developed a procedure to track, evaluate and chronicle course and curriculum improvements. The system is being implemented as an essential component of the larger comprehensive departmental assessment process as prescribed by *ABET 2004-2005 Criteria for Accrediting Engineering Programs* [1]. Five major categories of assessment tools are graphically depicted in Figure 1 and presented within the context of how these tools converge with formally adopted underlying objectives, values and mission statement of the Department. As indicated by symbol size in the schematic, the course assessment and outcomes assessment components are two of the most important tools in instituting rigorous analysis of data and evaluation of feedback for the purpose of comprehensive curriculum and program improvement. Certainly the remaining tools that involve surveys, committees and advisory input provide valuable sources of useful information; however, these individual means of assessment are not of comparable magnitude in terms of creating expansive data files and aggregated tabulations for an all-encompassing application towards a continuous cycle of enhancement and progressive evolution. All five of these assessment tools have been used by the Department in some form or another for some time and the results were reflected in the Self Study report prepared for the most recent ABET site visit held in 2002. Currently, course assessment and outcomes assessment are receiving more concentrated attention to further implement a usable and document-able process of continuous improvement. The focus of this paper is to present and discuss the current status of The Citadel CEE course assessment process and proposed steps that are being implemented to further facilitate process development and enhancement. In addition, the integration of this process with other departmental assessment efforts are described in order to fully support a comprehensive approach that is solidly founded upon creation and use of measurable educational outcomes.

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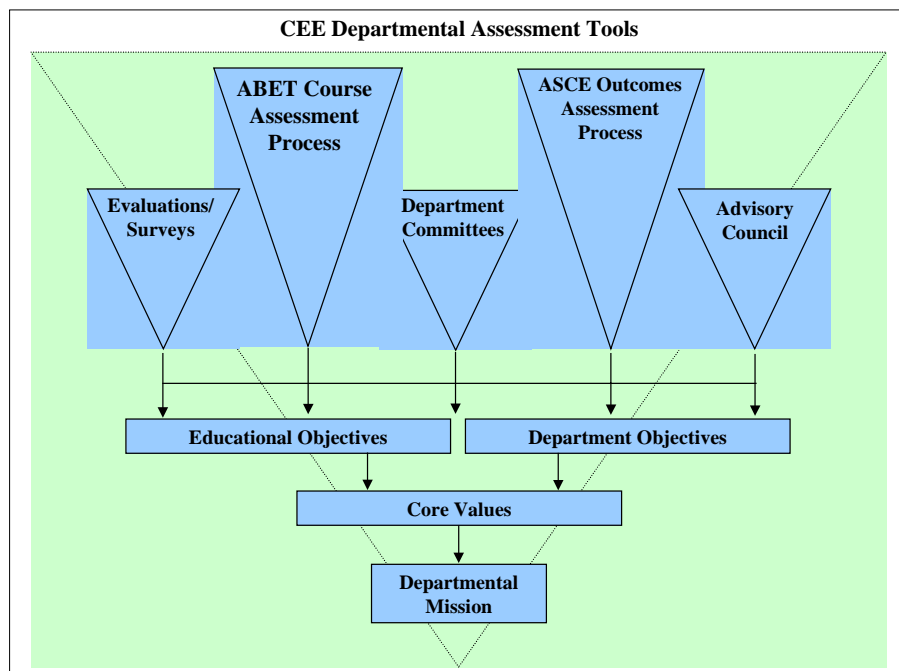


Figure 1. Department Assessment Tools

## LITERATURE REVIEW

A large amount of work has been conducted, and is currently underway, by engineering programs that are striving to improve methods and procedures to better address course assessment and development of measurable program outcomes. A course assessment plan developed by faculty in the Department of Civil and Mechanical Engineering at the United States Military Academy promote use of a detailed assessment plan outline for each course with specific emphasis on course continuity and inter-disciplinary course coordination [2]. Specific methods include tracking of class lecture and student assignment time spent on various course activities throughout the semester schedule and correlation of student feedback questions. An example course and program outcomes assessment process was developed by the college of engineering at University of Texas at San Antonio [3]. This procedure established a comprehensive map of outcomes throughout the program curriculum by categorizing courses and activities as either being a primary or secondary contribution towards a series of program outcomes. Purdue University Calumet uses a series of on- line student course assessment tools that are directly connected to program outcomes and result in a large amount of data strategically linked to summative and formative outcomes [4]. Furthermore the concept of continuous quality improvement has been addressed in an effort to apply these methods to interaction between program mission, objectives, outcomes and course goals [5].

A framework for continuous improvement is identified through use of process flow chart by professors at Rochester Institute of Technology [6]. They strongly encourage that issues and actions related to outcomes assessment be approached in a non-linear manner, carefully considering investments in various data aggregations, drawing for college-wide resources to meet multiple institutional needs, constructing collaborative partnerships with other academic units, etc. A phased approach for implementation of program continuous improvement was developed at Penn State University that identified four steps including awareness: training of key personnel, internal organizational assessment and outcome/objective development, team building process for control and implementation, and establishment of an action plan designed to perpetuate the program [7]. The Department of Mechanical Engineering at Ohio University has developed a series of flow charts and template assessment forms to help standardize the outcomes assessment process [8]. An underlying objective with this approach was to allow the faculty to focus more directly on student learning rather than administrative record keeping and documentation.

## TABULATION OF ASSESSMENT OUTCOMES

The CEE Department at The Citadel has worked for many years to populate course-by-course assessment files, which provide a collective evaluation of student performance with respect to specific course goals and ABET Program Outcomes and Assessment, Criterion 3, A-K. While these files are useful in documenting topics covered and assignments conducted in each individual course, a more systematic approach was needed to allow meaningful aggregation and analysis of data on a

curriculum-wide basis. ABET directs engineering programs to make use of discipline specific criteria developed by professional societies within associated engineering fields. For civil engineering, the American Society of Civil Engineers (ASCE) is a principal source of supplemental materials pertaining to curriculum learning objectives and educational evaluation criteria. In 2004, ASCE published a document through the efforts of the Committee on Academic Prerequisites for Professional Practice that provided a wealth of useful information for academicians working to prepare students to enter the field of civil engineering [9]. One of the tools for assessment presented in the document is represented in Figure 2, and is referred to as the Body of Knowledge (BOK) Outcomes Matrix. This matrix structure further expanded ABET Criterion, A-K, by adding four additional criterion/outcomes (12-15) and recommending the use of threshold levels for student learning relevant to each of the 15 outcome categories. Generally speaking, Level 1, Recognition, represents a reasonable level of familiarity with a concept, Level 2, Understanding, implies a thorough mental grasp and comprehension of a concept or topic, and Level 3, Ability, is capability to perform with competence [9]. The baseline for assessment of student learning and development is established at the level of knowledge needed for a graduate to effectively work as an entry-level engineer. One constraint in applying this matrix to an undergraduate program is that the matrix was developed with the underlying aim of supporting the need for a student to obtain both BS and MS degrees, or what is termed as BS plus 30 graduate credit hours, to be established at some point in the future as the minimum educational standard needed to gain entry into the field of engineering. Thus some modifications are necessary in applying this matrix solely to a 4-year BS program. Regardless, the ASCE framework is helpful to faculty embarked upon the endeavor of categorizing, measuring and improving outcomes.

ASCE BOK Outcomes Matrix															
3. Ability						Experience				Post-licensure Education & Experience					
												Experience			
2. Understanding															
1. Recognition															
	1	2	5	11	12	3	4	7	9	6	8	10	13	14	15
	Technical core	Experiments/analyze & interpret	Engineering problems	Engineering tools	Specialized area of CE	Design	Multidisciplinary teams	Communication	Life-long learning	Professional & Ethical Standards	Impact of engineering	Contemporary issues	Project Management, etc.	Business & public policy	Leadership

Figure 2. ASCE Body of Knowledge Outcomes Matrix [9]

## Outcomes Mapping

Based on the ASCE BOK outcomes matrix, an outcomes map was created to identify all of the educational activities that are either directly conducted or are indirectly facilitated through the collective efforts of the department. Obviously, the course curriculum constitutes the largest concerted effort aimed at educating students and contributing to the achievement of designated learning outcome thresholds. In addition, other continuous and systematic components of the program addressing specific educational objectives include student participation in ASCE Student Chapter activities, CEE Student Advisory Committee self governance, Corp of Cadets barracks life and military environment and student research/employment. Upon identification of these principal educational components of the CEE program, an outcomes assessment map, shown in Figure 3, was developed to indicate how each of these activities generally support ASCE BOK 1-15 Outcomes. Once finalized, this approach should allow a comprehensive view of what outcomes are being addressed, at what level they are being achieved and of where the source is originating. Not only will this help provide a meaningful view of the overall curriculum, it will also provide a usable framework for organizing assessment files needed for subsequent ABET site visits.

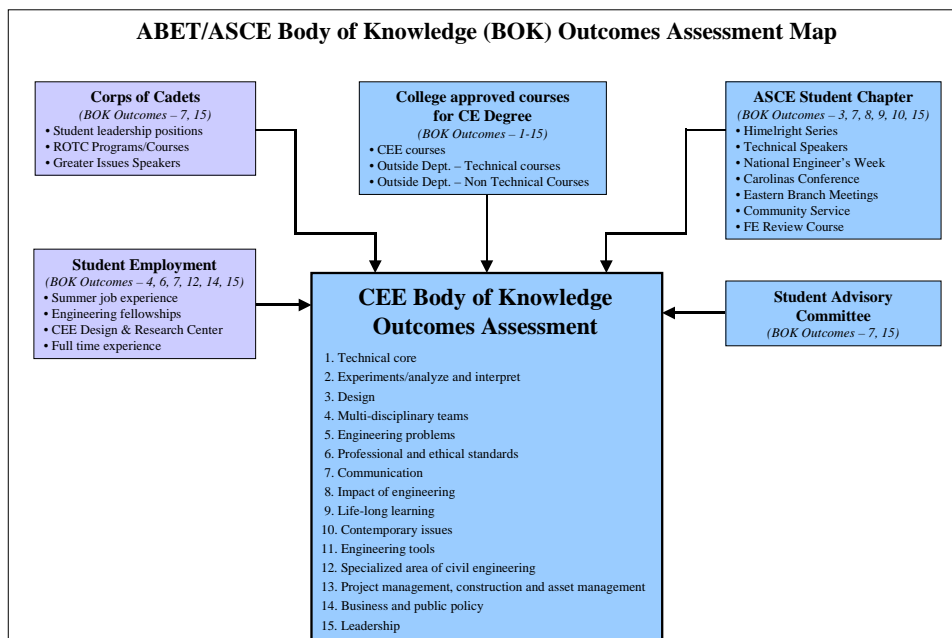


Figure 3. Citadel CEE Outcomes Assessment Map

## COURSE ASSESSMENT PROCESS

Continuous improvement of curriculum offerings and course material has been an inherent component of engineering education since the inception of higher education. The purpose of developing a course improvement process is merely to assist in the management, oversight and documentation of course improvements in a collective and consistent manner on a department-wide basis. An underlying objective in developing this process was to keep the responsibility of establishing course goals, assessing outcomes and implementing improvements solely under the authority of the professor. Any attempts to standardize course improvement through adoption of a formalized feedback system should be developed with caution so as to not hinder the unimpeded flow of less formal means professors have traditionally used to improve instructional methods and constructively incorporate feedback into subsequent offerings of the course curriculum. A course improvement process was adopted by The Citadel CEE faculty in 2004 and has recently been used to assimilate the first year's data. The process and aggregated data findings from the 2003/2004 school year are presented in the following sections.

### Process Approach

The process begins as courses are offered to the students through the adopted curriculum for a BS in Civil Engineering. The initial implementation of the course assessment process focuses solely on courses taught within the department. Once the process is established and useful assessment examples are generated, it is intended that the process be expanded to include all courses required to earn a degree. The CEE course assessment process is summarized via the flow chart shown in Figure 4. Courses taught outside the department are generally separated into two categories, technical and non-technical. As courses taught outside the CEE department are not as critical in meeting ABET/ASCE outcomes, it seemed logical to begin the process by concentrating on the principal course offerings within the curriculum, and not merely coincidental, these courses are where CEE faculty have the most direct input and control. At the end of the semester, after completion of the course, the professor prepares an itemized course assessment report that evaluates course goals and identifies future course improvements. The report is entered into a central filing system and the files are reviewed, classified and tabulated by the department's assessment committee. At the end of the academic year a summary report is produced that provides an overview of course improvement activities. This report is provided to a variety of CEE stakeholders for their review and comment, including the Dean of Engineering, CEE Department Head and CEE Advisory Council. A central aspect of the process is the tracking, evaluation and organizational approval of course assessment/improvement items through a series of feedback loops, which are described in the following section of this paper.

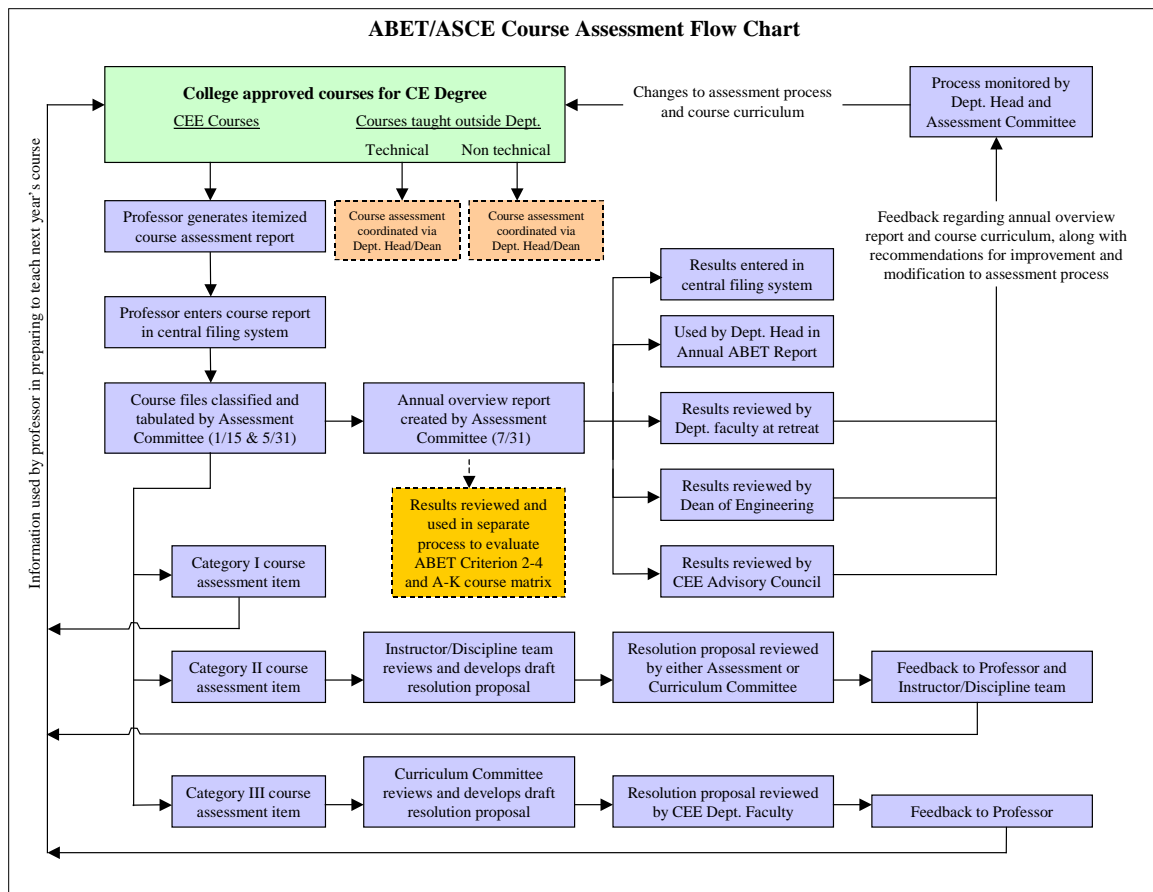


Figure 4. Citadel CEE Course Assessment Process

### 3-Tiered Course Assessment Feedback Loops

The most crucial component of the course assessment process is the creation of assessment/ improvement items by the professor and subsequent classification of these items into one of three categories by the Assessment Committee. The types of items intended for each of these categories are identified along with subsequent actions and approvals necessary for issues to be addressed and incorporated into the course curriculum are summarized as follows:

**Category I** – Minor items that can be addressed directly by professor to improve course content or student learning environment for subsequent course offerings. Typically involves professor notes and reminders to himself. No actions are required for review and approval. Tabulation of the quantity of these items is maintained through the Annual Course Assessment process.

**Category II** – Intermediate items require coordination with other professors teaching the same course. A classic example of this type issue would be changing the course textbook. Other issues such as agreeing upon common course goals and assessment criteria also fall into this category. A draft resolution proposal is developed by instructor/discipline team and is subsequently reviewed by the Assessment Committee.

**Category III** – Major items require coordination with the Department's Curriculum Committee and CEE faculty. Recent examples include increasing the number of credit hours for a course, significantly changing the course syllabus and course modifications that affect other courses. A draft resolution proposal is developed by instructors, reviewed by the Department's Curriculum Committee and approved by CEE Department Faculty. Major changes also require involvement and approval from The Citadel's college-wide Curriculum Committee.

## Results from 2003/2004 Implementation

Based on a systematic review of course assessment files submitted for the 2003/2004 academic year, a wide variety of findings were developed with respect to proposed improvements, assessment items, course goals, ABET/ASCE assessment criterion, and quality control of the overall process. This information was compiled and presented in an overview report created by the Department's Assessment Committee. Major findings from this effort are summarized as follows:

Course Folders – In conducting a quality control review of departmental course folder contents, files were determined to generally include the following: ABET report, course syllabus, course goals, measurement of course goals, cross tabulation of course goals with ABET assessment criteria and sample student work and/or professor solutions.

Number of Course Goals – On average CEE courses include 10 course goals, with 75% of courses containing 10 course goals or less, ranging from a high of 23 to a low of 3.

Distribution of Outcomes Criterion – On average CEE courses address 6 outcomes assessment criteria, ranging from a high of 14 to a low of 2. This tabulation is based on 15 ASCE outcomes (ABET a-k, plus 4.) Outcomes criteria measured for courses reported in the CEE curriculum are summarized in Table 1.

Course Assessment Results – Course assessment/improvement items generated from the 2002/2003 and 2003/2004 academic years are summarized in Table 2. It is important to note that the current system was only partially adopted at that time; otherwise actual totals would be higher for that year. Representative course assessment items for each of the three categories/levels are presented via course number and brief overview in Table 3.

Table 1 - Summary of ABET/ASCE Outcomes Criterion

ABET	ASCE	Curriculum Total	ABET	ASCE	Curriculum Total
a.	1	23	i.	9	5
b.	2	10	j.	10	9
c.	3	7	k.	11	21
d.	4	6		12	6
e.	5	20		13	2
f.	6	12		14	3
g.	7	13		15	1
h.	8	9			
<b>Notes:</b>					
1. At the time of this tabulation, use of ASCE outcomes 12-15 were under advisement and had not been fully adopted into the CEE curriculum.					
2. Tabulation does not reflect the occurrence that outcomes are often addressed multiple times within each course.					
3. Item 15, Leadership, is addressed extensively from others sources within the program such as the ASCE Student Chapter and Corps of Cadets.					

Table 2 - Summary of Course Improvement Items

Year	Level I	Level II	Level III
2002/2003	63	7	2
2003/2004	114	26	2

Table 3 - Representative Course Improvement Items

Level	Course No.	Summary of Item to be addressed
I	Civil 312	Incorporate an environmental related Geographic Information System (GIS) project into the course curriculum.
I	Civil 314	Schedule field trip/meeting with US Army Corps of Engineers to discuss benefit and cost evaluation of large infrastructure projects.
II	Civil 411	Evaluate effectiveness of <u>Project Management for Engineering and Construction</u> and consider changing course textbook.
II	Civil 314	Develop lectures and examples demonstrating value engineering techniques and application towards project improvement/cost savings.
III	Civil 305	Either provide increased emphasis on horizontal and vertical alignment homework assignments and classroom instruction, or wait and cover this topic in detail within the following course, Civil 302.
III	Civil 207	Expand course from 2 to 3 credit hours to cover GIS and GPS course subjects in more detail. Use external advisory committee to help review and modify the list of course subjects and goals in the syllabus.

### FUTURE IMPROVEMENTS AND ENHANCEMENTS

The Citadel CEE course assessment process is being developed and implemented on an incremental basis to allow faculty to balance the demands of teaching and administrative work, thus a considerable number of future improvements and enhancements are planned to further expand the overall process. One of the major objectives will be to better integrate the course assessment/improvement system with all other departmental assessment initiatives to create a comprehensive program evaluation procedure. Specific areas of system improvement and enhancement likely to be addressed via further system development are summarized in the following sections.

**Data Processing and Record Keeping** – As the course assessment system becomes more established and populated with data files from every semester, documentation will be organized within the context of a computer filing system, most likely structured and linked to a website style application. As additional information is added each year, tabulating assessment items, tracking improvement actions and comparing outcomes measurements will greatly benefit from system computerization. This will also help create transparency in the process which is anticipated to be advantageous as the department prepares for the next ABET accreditation site visit.

**Curriculum Continuity** – Review and display of the entire distribution of course goals across ASCE/ABET outcomes criterion and in sequence through a students' eight semesters in the program will be very useful in verifying an acceptable curriculum coverage of all 15 outcome criteria and at acceptable knowledge levels. Furthermore, sequenced course goal threads for major learning activities in civil engineering will be developed to ensure students are provided with a smooth and effective progression for activities such as; structural engineering design, land development design, drainage/stormwater design, water/wastewater design, highway/pavement design, etc. This approach could also be used to create sequenced course goals threads for supporting topics such as data collection/analysis, project management and communication. Finally this same approach could be applied to creating similar threads for individual outcomes criteria such as technical core, engineering problems and design.

**Outcomes Measurement** – Currently, Department faculty are using a wide variety of methods to measure or anecdotally justify students' attainment of specific course outcomes. The overall mission of improving outcome measurement is to identify a grab bag of methods that can be incorporated at the discussion of the faculty to reliably quantify the attainment of course outcomes. To that end, course objectives are in the process of being reformed within the context of the cognitive domain of Bloom's Taxonomy. In engineering education and the wider education environment, a large body of knowledge is being generated, rigorously justified, and validated on measuring student learning. A comprehensive literature review will be conducted during the summer 2005.

**Outcomes Assessment** – The ultimate goal is to link all course assessment/improvements efforts with the larger objective of creating meaningful outcomes assessment that can be used to steer the continuous improvement of the program curriculum. Based on the graphical depiction of departmental assessment tools shown in Figure 1, it can be concluded that course assessment and outcomes assessment are the two most significant means of generating feedback for program enhancement. As outcomes measures for course goals are further established, these findings will be aligned with appropriate program outcomes to provide a comprehensive evaluation of educational goals, objectives and departmental mission.

## CONCLUSIONS

Having completed the first year of implementation of the Citadel CEE course assessment process, initial results have been useful in tabulating and tracking course improvements as well as evaluating course goals. In connecting course goals with outcomes criterion, a useful distribution is being developed to help ensuring educational topics are being presented to students within a logical and effective manner. Further improvements to this process and integration with the outcomes assessment process will be very important tools in creating and managing the continuous change needed to keep an technical educational program current and relevant to the ever changing field of civil engineering.

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