AC 2008-2827: A CASE STUDY OF STUDENT LEARNING IN CIVIL ENGINEERING TECHNOLOGY

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A Case Study of Student Learning in Civil Engineering Technology

Abstract

The curriculum of the four-year, TAC/ABET accredited Civil Engineering Technology Program at Georgia Southern University covers three traditional areas within the discipline of Civil Engineering. These areas are environmental, structures, and transportation. In an effort to implement the continuous improvement plan for the program, assessment and evaluation of the program objectives and outcomes are being done on an ongoing basis. The term "assessment" means one or more processes that identify, collect, use and prepare data that can be used to evaluate achievement of program outcomes and educational objectives. The term "evaluation" characterizes one or more processes for interpretation of the data and evidence accumulated through assessment practices that (a) determine the extent to which program outcomes or educational objectives are being achieved; or (b) result in decisions and actions taken to improve the program. Use of multiple assessment tools and measures is imperative for (a) the program outcomes, i.e., knowledge and capabilities of students at the time of graduation and (b) the program objectives, i.e., the expected accomplishments of graduates during the first few years after graduation.

The purpose of this paper is to critically examine the assessment data collected for a specific component of the curriculum (structures), over at least two consecutive offerings (usually a year apart), and draw inferences as to the extent the related program outcomes are met. Three required courses, Structural Analysis, Steel Design and Reinforced Concrete Design, constitute the coursework in this particular area. Several assessment tools have been used, and most of them are direct measures. Various rubrics with benchmarks (set prior to data collection) have been used for meaningful assessment and evaluation. The paper discusses, for each of the three courses, corrective actions taken following the assessment of the first-year data, and also the changes, if any, that occurred in student learning as a result of incorporation of those changes at the subsequent offering.

I. Introduction

Execution of a viable continuous improvement plan (CIP) is essential for enhancement of a program. The two key elements of a CIP are assessment and evaluation. The term "assessment" means one or more processes that identify, collect, and analyze data that can be used to evaluate achievement of program outcomes and educational objectives. The term "evaluation" characterizes one or more processes for interpretation of the data and evidence accumulated through assessment practices that (a) determine the extent to which program outcomes or educational objectives are being achieved; or (b) result in decisions and actions taken to improve the program. The program educational objectives are defined as broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve *during the first few years following graduation*. The program outcomes are defined as statements that describe what units of knowledge or skill students are expected to acquire from the program to prepare them to achieve the program educational objectives. These are typically demonstrated by the student and measured by the program *at the time of graduation*. The TAC/ABET designated (a – k) requirements must be included in some way in the program outcomes.

As a case study, an assessment and evaluation (partial) of the four-year, TAC/ABET-accredited undergraduate Civil Engineering Technology (CET) program at Georgia Southern University (GSU) is presented in this paper. The curriculum of the CET program at GSU includes coursework in three major areas within the discipline of civil engineering: environmental, structures and transportation. All CET majors are required to take three courses in this area – TCET 3142 Structural Analysis, TCET 4142 Reinforced Concrete Design and TCET 4146 Structural Steel Design. Each course has three hours of lecture plus one two-hour or three-hour computational laboratory per week, with four semester credit hours. The intent of the paper is not a comprehensive assessment of the program, but instead a focused assessment of student learning in the area of structures, that contributes to several program outcomes. The courses that contribute to the outcomes to varying degrees are summarized in Table 1, the Curriculum Mapping Worksheet.

II. Assessment Details

Data identification

While multiple courses within the CET curriculum contribute with varying degrees to each of the outcomes, only specific measures that are considered to be the strongest measure of the outcome are tracked, analyzed, and capable of triggering a continuous improvement action. These measures are agreed upon by the entire CET faculty at the end of each academic year. Although all measures are not necessarily applied to every given outcome, at least two measures for each outcome are attempted. Since the primary assessment of program outcomes is based on *direct* measures, i.e., student work related to coursework (final exam, exams, quizzes, homework etc.), only such measures are discussed.

Data collection

During the data Collection phase, assessment tools are administered to and collected from program constituencies, as shown in Figure 1. Table 2 summarizes the general types of assessment tools defined for evaluating program outcomes. Such data is collected every semester for CET courses.

Several of current tools that are being used to assess outcomes and objectives require a rubric-based analysis of an activity (final exam, homework, report, presentation, term project etc.). For the purpose of this document, a rubric is defined as a scoring guide that specifies the skill or category being assessed with an associated numerical rating scale indicating the level of student performance. For example, Table 3 is an illustration of a rubric developed to evaluate specific outcomes on a comprehensive final exam in TCET 3142 Structural Analysis course. The first column in this rubric identifies the performance categories or skills that are being addressed by this assignment. These performance categories are specified as course objectives and associated learning outcomes in the course outline (see Appendix). The next four columns indicate the ratings (from 1 to 4) a student can receive for this category based on their demonstration of this skill. Similar rubrics developed for the TCET 4142 and TCET 4146 courses are shown in Tables 4 and 5, respectively. (Several other rubrics have been developed for key homework

TABLE 1 - CURRICULUM-MAPPING WORKSHEET
An indication of the degree to which course-level outcomes contribute to the indicated program-level outcome.

Course Prefix	Course Number	Course Title	An appropriate mastery of the knowledge, techniques, skills and modern tools of civil engineering technology	An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology	An ability to conduct, analyze, and interpret, experiments and apply experimental results to improve processes	An ability to apply creativity in the design of systems, components or processes appropriate to CET program objectives	An ability to function effectively on teams	An ability to identify, analyze, and solve technical problems	An ability to communicate effectively	A recognition of the need for, and an ability to engage in lifelong learning	An ability to understand professional, ethical, and social responsibilities	A respect for diversity and knowledge of contemporary professional, societal, and global issues	A commitment to quality, timeliness, and continuous improvement
			(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**
ENGR	1133	Engineering Graphics	2	4		3							3
ENGR	1731	Computing for Engineers	2	4		3							3
TENS	2141	Statics	4	4				4					1
TENS	2142	Dynamics	3	3				3					1
TENS	2143	Strength of Materials	4	4	3	2	3	4	4		2		1
TENS	2144	Fluid Mechanics	4	4	4		3	4	4				1
TCET	2241	Surveying	4				3	4	3				2
TCET	3141	Environmental Pollution	4	3	4		3	3			4		4
TCET	3142	Structural Analysis	4	4			2						2
TCET	3233	Transportation Systems	4		2			3	2				
TCET	3234	Construction Materials	4		4		4	3	4				3
TCET	3236	Project Cost Analysis, Planning and Management	4					4			4	3	
TCET	4141	Water Supply Systems	4	3				4					4
TCET	4142	Reinforced Concrete Design	4	4		3		4	2	4			3
TCET	4146	Structural Steel Design	4	4		3		4	2	4			3
TCET	4243	Highway Design	4	4		4	4	4					
TCET	4244	Soil Mechanics and Foundations	4	3	4		4	4	4				
TCET	4245	Water-Wastewater Treatment	4	3	3	1		4			3		
TCET	4536	Senior Project	4	4		4	4	4	4	4	4	4	4
			Level of Contribution to outcome: 4 – Strong, 3 – Moderate, 2 – Some, 1 – Slight										

TABLE 2 - ASSESSMENT TOOLS		
Assessment Tool	Frequency of Assessment	Responsibility of Assessment
Assessment of Program Outcomes (Measurement Instrument):		
1. Rubric Analysis of Student Performance on a Key Homework Assignment (rubric summary)	Fall and Spring	Course Instructor
2. Rubric Analysis of Student Performance on a Final Exam (rubric summary)	Fall and Spring	Course Instructor
3. Rubric Analysis of a Laboratory Report Activity (rubric summary)	Fall and Spring	Course Instructor
4. Rubric Analysis of an Oral presentation (rubric summary)	Fall and Spring	Course Instructor
5. Rubric Analysis for Assessment of a specific Skill or Knowledge (rubric summary)	Fall and Spring	Course Instructor
6. Rubric Analysis of Senior Project (rubric summary)	Spring	Course Instructor
7. Rubric Analysis of Term Project Written Report(rubric summary)	Fall and/or Spring	Course Instructor
8. Course Exit Survey (survey summary)	Fall and Spring	Course Instructor
9. Senior Exit Survey (survey summary)	Fall and Spring	Course Instructor

assignments, laboratory reports, oral presentations, senior project etc., but are not included here.)

Each program outcome that is assessed using a rubric analysis (direct measure) for course related activities, such as, exams, quizzes, homework etc., will be rated on a rubric scale, typically a 4-point scale with 4.0 being the best rating. Each program outcome or objective that is assessed using a survey (indirect measure) will be rated on a five-point scale, with 5.0 being the best rating. In Tables 3, 4 and 5, the terms “ample evidence” and “adequate evidence” have been used with respect to ratings of 4 and 3 respectively. The expression “ample evidence” signifies, in the context of solving problems, demonstration of a student’s comprehension of the basic underlying principles, and ability to perform all computations to obtain correct answers, following the correct procedure.. The phrase “adequate evidence” means while a student has demonstrated understanding of the basic principles, and application of the correct procedure, only partially correct answers are obtained due to minor errors.

Data analysis

Following data collection, an assessment summary based upon the rubric is compiled—as shown in Table 6 for TCET 3142 Structural Analysis course. The summary contains rubric scores for each student for each skill category that is assessed. An average rubric score for each student is calculated, and used to determine if a particular student is performing significantly below expectation. An average rubric score for each outcome measure is also calculated and compared to a benchmark (see next section) adopted by the CET program faculty. Similar rubric analyses (summary) are provided in for the two other structures courses TCET 4142 Reinforced Concrete Design and TCET 4146 Structural Steel Design in Tables 7 and 8, respectively.

Figure 1: Data Collection Phase of the CIP with Measures and Frequency of Measures

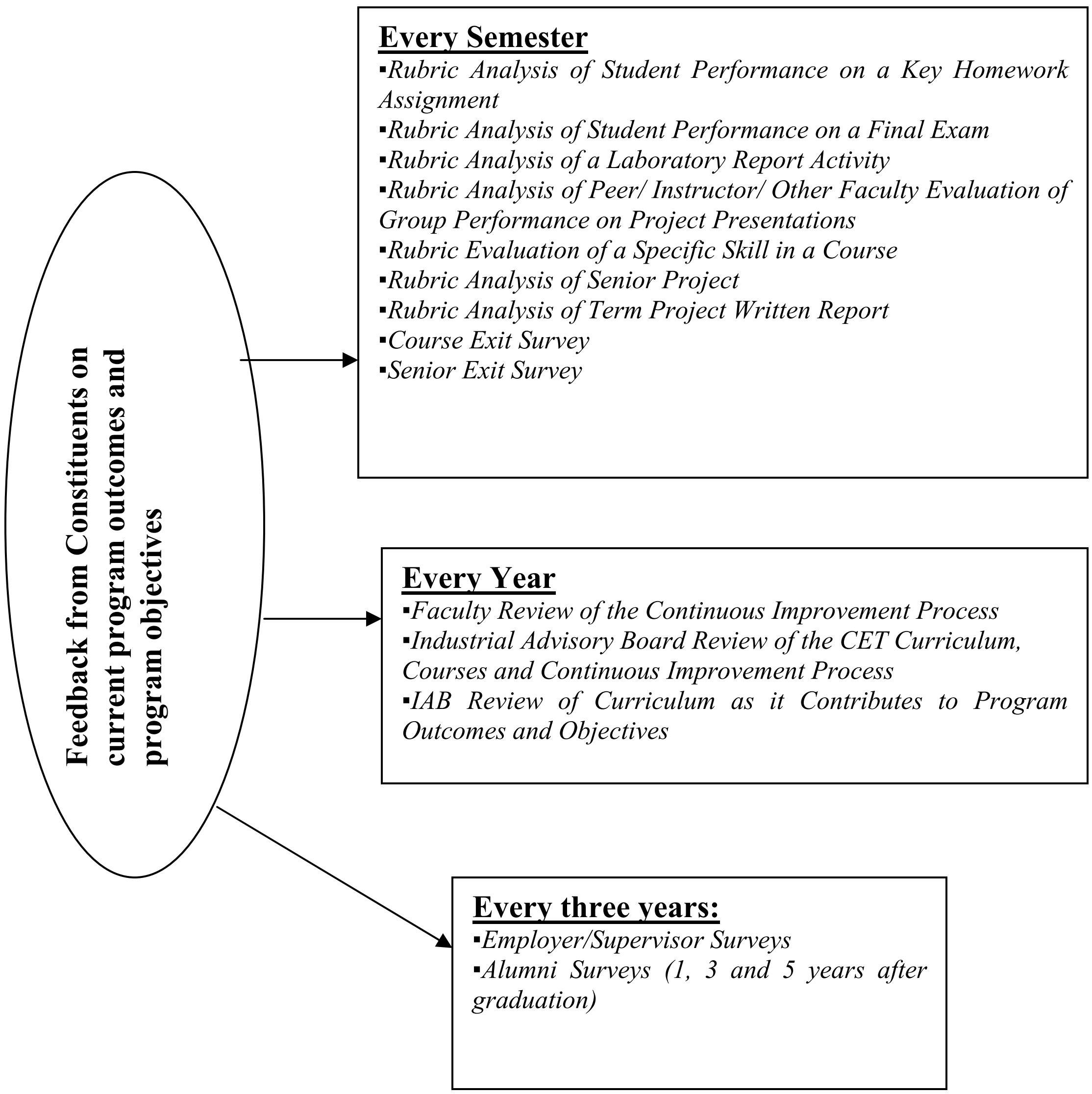


Table 3
Rubric for Final Exam – TCET 3142 Structural Analysis (Form M-2)

CATEGORY	4 – Exceeds Criteria	3 – Meets Criteria	2 – Progressing to Criteria	1 – Below Expectations	Points
Identify structure types and load types, and calculate various types of loads on structures.	Provides ample evidence of ability to recognize statically determinate vs. statically indeterminate structures, and to determine various loads on a structure with correct answers, including proper signs and symbols.	Provides adequate evidence of ability to recognize statically determinate vs. statically indeterminate structures, and to determine various loads on a structure with mostly correct answers, including proper signs and symbols.	Provides some evidence of ability to recognize statically determinate vs. statically indeterminate structures, and to determine various loads on a structure with only a few correct answers, including proper signs and symbols.	Provides little or no evidence of ability to recognize statically determinate vs. statically indeterminate structures, or to determine various loads on a structure with any correct answers, including proper signs and symbols.	
Solve for support reactions, and internal reactions in trusses, beams, and frames.	Provides ample evidence of ability to determine the external support reactions, and internal reactions (axial, shear and moment) in a structure using the correct procedure.	Provides adequate evidence of ability to determine the external support reactions, and internal reactions (axial, shear and moment) in a structure using the correct procedure, but not without some minor errors.	Provides some evidence of ability to determine the external support reactions, and internal reactions (axial, shear and moment) in a structure using flawed procedure.	Provides little or no evidence of ability to determine the external support reactions, or internal reactions (axial, shear and moment) in a structure using totally wrong procedure.	
Solve for deflections of statically determinate beams, trusses, and frames	Provides ample evidence of ability to determine the deflection (and slope) at a point in a structure using the correct procedure.	Provides adequate evidence of ability to determine the deflection (and slope) at a point in a structure using the correct procedure, but not without some minor errors.	Provides some evidence of ability to determine the deflection (and slope) at a point in a structure using flawed procedure.	Provides little or no evidence of ability to determine the deflection (and slope) at a point in a structure using totally wrong procedure.	
Solve for statically indeterminate beams, trusses and frames by approximate methods	Provides ample evidence of ability to solve statically indeterminate structures by approximate methods. Use of right procedure with flawless computations leads to correct answers.	Provides adequate evidence of ability to solve statically indeterminate structures by approximate methods. Use of right procedure with small computational errors leads to partially correct answers.	Provides some evidence of ability to solve statically indeterminate structures by approximate methods. Use of flawed procedure with or without computational errors leads to mostly incorrect answers.	Provides little or no evidence of ability to solve statically indeterminate structures by approximate methods. Use of wrong procedure with or without computational errors leads to all incorrect answers.	
Solve for statically indeterminate beams and frames by classical Slope-Deflection Method	Provides ample evidence of ability to solve statically indeterminate structures by Slope-Deflection method. Use of right procedure with flawless computations leads to correct answers.	Provides adequate evidence of ability to solve statically indeterminate structures by Slope-Deflection method. Use of right procedure with small computational errors leads to partially correct answers	Provides some evidence of ability to solve statically indeterminate structures by Slope-Deflection method. Use of flawed procedure with or without computational errors leads to mostly incorrect answers.	Provides little or no evidence of ability to solve statically indeterminate structures by Slope-Deflection method. Use of wrong procedure with or without computational errors leads to all incorrect answers.	
Solve for statically indeterminate beams and frames by classical Moment-Distribution Method	Provides ample evidence of ability to solve statically indeterminate structures by Moment Distribution method. Use of right procedure with flawless computations leads to correct answers.	Provides adequate evidence of ability to solve statically indeterminate structures by Moment Distribution method. Use of right procedure with small computational errors leads to partially correct answers	Provides some evidence of ability to solve statically indeterminate structures by Moment-Distribution method. Use of flawed procedure with or without computational errors leads to mostly incorrect answers.	Provides little or no evidence of ability to solve statically indeterminate structures by Moment-Distribution method. Use of wrong procedure with or without computational errors leads to all incorrect answers.	
Demonstrate mathematical skills including use of appropriate formulas, units, and symbols	Correct formula used to solve problems with correct answers given with proper units and symbols.	Correct formula used to solve problems with mostly correct answers given with proper units and symbols	Correct formula used to solve problems but with mostly wrong answers given with incorrect units and symbols	Wrong formula used to solve problems with answers that do not make sense with or without correct units and symbols	

Table 3
Rubric for Final Exam – TCET 3142 Structural Analysis (Form M-2)

CATEGORY	4 – Exceeds Criteria	3 – Meets Criteria	2 – Progressing to Criteria	1 – Below Expectations	Points
Faculty perception of student's ability to use knowledge and skills gained from pre-requisite courses	Demonstrates ample evidence of a thorough understanding of all key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates adequate evidence of understanding most of the key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates some evidence of understanding only a few of the key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates little or no evidence of understanding any key concepts and pertinent skills gained from the prerequisite courses.	
				TOTAL:	

Table 4
Rubric for Final Exam – TCET 4142 Reinforced Concrete Design (Form M-2)

CATEGORY	4 – Exceeds Criteria	3 – Meets Criteria	2 – Progressing to Criteria	1 – Below Expectations	Points
Comprehend the basic concept of Ultimate Strength Design (Required Strength, Design Strength, and the relationship between the two).	Provides ample evidence of understanding the basic premise of ACI Strength Design through the solutions to all types of problems.	Provides adequate evidence of understanding the basic premise of ACI Strength Design through the solutions to most, but not all, types of problems.	Provides some evidence of understanding the basic premise of ACI Strength Design through the solutions to only one or two particular types of problems.	Provides little or no evidence of understanding the basic premise of ACI Strength Design through the solution to any type of problem.	
Demonstrate proper use of various design aids (tables, graphs and charts) of the ACI Manual.	Shows ample evidence of ability to use the appropriate design aids correctly in solving various problems.	Shows adequate evidence of ability to use the appropriate design aids in solving various problems, but makes some errors.	Shows some evidence of ability to use the appropriate design aids in solving only one or two particular types of problems, with or without any errors.	Shows little or no evidence of ability to use the appropriate design aids in solving any type of problem without any errors.	
Demonstrate mathematical skills including use of appropriate formulas, units, and symbols	Correct formula used to solve problems with correct answers given with proper units and symbols.	Correct formula used to solve problems with mostly correct answers given with proper units and symbols	Correct formula used to solve problems but with mostly wrong answers given with incorrect units and symbols	Wrong formula used to solve problems with answers that do not make sense with or without correct units and symbols	
Perform design/analysis of one-way slabs.	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution contains significant errors and/or omissions with respect to design parameters.	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Perform design/analysis of beams for moment.	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution (s) contains significant errors and/or omissions with respect to design parameters.	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Perform design/analysis of beams for shear.	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution contains significant errors and/or omissions with respect to design parameters	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Perform design/analysis of columns.	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution contains significant errors and/or omissions with respect to design parameters	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Faculty perception of student's ability to use knowledge and skills gained from pre-requisite courses	Demonstrates ample evidence of a thorough understanding of all key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates adequate evidence of understanding most of the key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates some evidence of understanding only a few of the key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates little or no evidence of understanding any key concepts and pertinent skills gained from the prerequisite courses.	
				TOTAL:	

Table 5
Rubric for Final Exam – TCET 4146 Structural Steel Design (Form M-2)

CATEGORY	4 – Exceeds Criteria	3 – Meets Criteria	2 – Progressing to Criteria	1 – Below Expectations	Points
Comprehend the basic concept of LRFD (Required Strength, Design Strength, and the relationship between the two).	Provides ample evidence of understanding the basic premise of LRFD through the solutions to all types of problems.	Provides adequate evidence of understanding the basic premise of LRFD through the solutions to most, but not all, types of problems.	Provides some evidence of understanding the basic premise of LRFD through the solutions to only one or two particular types of problems.	Provides little or no evidence of understanding the basic premise of LRFD through the solution to any type of problem.	
Demonstrate proper use of various design aids (tables, graphs and charts) of the AISC Steel Manual.	Shows ample evidence of ability to use the appropriate design aids correctly in solving various problems.	Shows adequate evidence of ability to use the appropriate design aids in solving various problems, but makes some errors.	Shows some evidence of ability to use the appropriate design aids in solving only one or two particular types of problems, with or without any errors.	Shows little or no evidence of ability to use the appropriate design aids in solving any type of problem without any errors.	
Demonstrate mathematical skills including use of appropriate formulas, units, and symbols	Correct formula used to solve problems with correct answers given with proper units and symbols.	Correct formula used to solve problems with mostly correct answers given with proper units and symbols	Correct formula used to solve problems but with mostly wrong answers given with incorrect units and symbols	Wrong formula used to solve problems with answers that do not make sense with or without correct units and symbols	
Perform design/analysis of tension members.	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution contains significant errors and/or omissions with respect to design parameters.	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Perform design/analysis of compression members (columns).	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions .	Provides some evidence of application of appropriate design criteria to solve problems, but the solution (s) contains significant errors and/or omissions with respect to design parameters.	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Perform design/analysis of flexural members (beams).	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution contains significant errors and/or omissions with respect to design parameters	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Perform design/analysis of bolted/welded connections	Provides ample evidence of application of appropriate design criteria to solve problems without any errors.	Provides adequate evidence of application of appropriate design criteria to solve problems, but not without some minor errors and/or omissions.	Provides some evidence of application of appropriate design criteria to solve problems, but the solution contains significant errors and/or omissions with respect to design parameters	Provides little or no evidence of application of appropriate design criteria to solve problems; solutions provided are totally inconsistent with the design criteria.	
Faculty perception of student's ability to use knowledge and skills gained from pre-requisite courses	Demonstrates ample evidence of a thorough understanding of all key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates adequate evidence of understanding most of the key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates some evidence of understanding only a few of the key concepts and pertinent skills gained from the prerequisite courses.	Demonstrates little or no evidence of understanding any key concepts and pertinent skills gained from the prerequisite courses.	
				TOTAL:	

Table 6
C3142-Final-Rubric-F06
Rubric Summary of Final Exam

Course: TCET 3142 Structural Analysis **Term: Fall 2006** **Date: 12-15-06** **Evaluator: XXXX**

Last Name of Student	**Description of Outcome Measures:**								Average rubric score for each student on a scale of 1 to 4
	Identify structure types and load types, and calculate various types of loads on structures.	Solve for support reactions, and internal forces in trusses, beams, and frames.	Solve for deflections of statically determinate beams, trusses, and frames	Solve for statically indeterminate beams, trusses and frames by approximate methods	Solve for statically indeterminate beams and frames by classical Slope-Deflection Method	Solve for statically indeterminate beams and frames by classical Moment-Distribution Method	Demonstrate mathematical skills including use of appropriate formulas, units, and symbols.	Faculty perception of student's ability to use knowledge and skills gained from pre-requisite courses	
Student 1	1	1	2	1	2	2	2	2	1.625
Student 2	3	2	2	4	4	3	3	3	3.0
Student 3	2	1	2	2	1	1	2	2	1.625
Student 4	1	2	2	2	2	2	3	2	2.0
Student 5	3	2	2	2	2	1	2	2	2.0
Student 6	4	1	2	4	2	2	3	3	2.625
Student 7	4	4	3	3	4	3	3	3	3.375
Student 8	3	3	3	4	4	3	3	4	3.375
Student 9	3	3	4	4	4	3	3	4	3.5
Student 10	3	2	2	2	3	2	3	3	2.5
Student 11	2	2	1	1	4	1	2	2	1.875
Student 12	3	2	2	3	2	3	2	2	2.375
Student 13	1	2	2	3	2	2	3	3	2.25
Student 14	1	3	2	3	3	2	4	3	2.625
Student 15	2	2	3	4	3	4	3	3	3.0
Student 16	3	4	2	3	4	4	3	3	3.25
Student 17	1	1	2	1	1	1	1	1	1.125
Student 18	2	2	1	4	2	2	2	2	2.125
Student 19	1	3	4	4	3	2	4	4	3.125
Student 20	4	3	1	4	3	4	3	3	3.125
Student 21	1	2	2	4	2	2	2	2	2.125
Student 22	3	3	2	3	4	3	3	3	3.0
Student 23	1	1	1	1	1	1	1	1	1.0
Rubric Score Average	2.26	2.25	2.13	2.87	2.70	2.30	2.61	2.61	**2..47 (overall)**
Benchmark		If Rubric Score average falls below 2.5, an instructor review is initiated. If that trend is observed for 3 successive measuring periods, then a faculty wide review leading to an improvement strategy is initiated.							

Table 7
C4142-Final-Rubric-F06
Rubric Summary of Final Exam

Course: TCET 4142 Reinforced Concrete Design | Term: Fall 2006 | Evaluator: XXXX | Date: 12-15-06

Last Name of Student	Description of Outcome Measures							
	Comprehend the basic concept of ACI Strength Design (Required Strength, Design Strength, and the relationship between the two).	Demonstrate mathematical skills including use of appropriate formulas, units, and symbols.	Perform design/analysis of one-way slabs.	Perform design/analysis of beams for moment.	Perform design/analysis of beams for shear.	Perform design/analysis of columns.	Faculty perception of student's ability to use knowledge and skills gained from pre-requisite courses	Composite Rubric Score for each student on a scale of 1 to 4
Student 1	4	3	4	2	3	2	4	3.143
Student 2	3	2	2	2	1	1	2	1.857
Student 3	3	2	3	2	2	1	2	2.143
Student 4	2	2	3	2	1	1	2	1.857
Student 5	3	2	2	2	3	3	2	2.429
Student 6	3	3	3	2	3	2	3	2.714
Student 7	3	3	3	2	2	3	3	2.714
Student 8	4	3	3	3	3	3	3	3.143
Student 9	3	2	2	2	2	3	3	2.429
Student 10	3	3	3	2	3	3	2	2.714
Student 11	4	3	3	3	4	4	4	3.571
Student 12	4	3	4	3	4	3	4	3.571
Student 13	3	3	3	2	3	4	3	3.0
Student 14	3	2	3	2	2	4	3	2.714
Student 15	3	2	2	2	3	3	3	2.571
Student 16	3	3	4	3	2	3	3	3.0
Student 17	4	3	3	2	3	4	4	3.286
Student 18	3	2	2	1	2	3	3	2.286
Student 19	4	3	3	3	2	4	4	3.286
Rubric Score Average	3.31	2.58	2.89	**2.21**	2.53	2.84	3.0	2.77

Benchmark: If Rubric Score average falls below 2.5, an instructor review is initiated. If that trend is observed for 3 successive measuring periods, then a faculty wide review leading to an improvement strategy is initiated.

Table 8
C4146-Final-Rubric-S06
Rubric Summary of Final Exam

Course: TCET 4146 Structural Steel Design **Term: Spring 2006** **Evaluator: XXXX** **Date: 5-15-06**

Last Name of Student	Description of Outcome Measures								Composite rubric score for each student on a scale of 1 to 4
	Comprehend the basic concept of LRFD (Required Strength, Design Strength, and the relationship between the two).	Demonstrate proper use of various design aids (tables, graphs and charts) of the AISC Steel Manual.	Demonstrate mathematical skills including use of appropriate formulas, units, and symbols.	Perform design/analysis of tension members.	Perform design/analysis of compression members (columns).	Perform design/analysis of flexural members (beams).	Perform design/analysis of bolted/welded connections.	Faculty perception of student's ability to use knowledge and skills gained from pre-requisite courses	
Student 1	4	3	3	3	2	4	3	4	3.25
Student 2	4	4	4	2	2	3	2	3	3.00
Student 3	4	4	3	3	3	4	2	3	3.25
Student 4	4	4	3	3	4	2	3	3	3.25
Student 5	3	3	2	3	3	1	3	2	2.5
Student 6	4	4	4	4	2	4	3	4	3.625
Student 7	4	4	3	3	4	2	3	3	3.25
Student 8	2	2	2	1	2	2	2	1	1.75
Student 9	4	4	3	2	3	3	2	2	2.875
Student 10	4	4	3	3	2	3	2	2	2.875
Student 11	4	4	3	4	3	4	2	4	3.5
Student 12	4	3	3	3	2	3	2	2	2.75
Student 13	4	3	3	4	3	3	3	3	3.25
Student 14	2	2	2	1	3	1	2	1	1.75
Student 15	4	3	2	3	3	2	2	3	2.75
Student 16	4	3	2	3	3	3	2	2	2.75
Student 17	4	3	3	4	4	4	4	4	3.75
Student 18	4	4	3	4	2	4	4	4	3.625
Student 19	4	4	3	4	4	2	4	4	3.625
Rubric Score Average	3.74	3.42	2.89	3.0	2.84	3.0	2.63	2.89	3.02
Benchmark		If Rubric Score average falls below 2.5, an instructor review is initiated. If that trend is observed for 3 successive measuring periods, then a faculty wide review leading to an improv3ement strategy is initiated.							

III. Evaluation of Assessment Data and Follow-up Actions

As stated before, evaluation is interpretation of the data collected through a systematic assessment process, to determine the quality of the program and also to what extent improvements are needed. Evaluation is necessary for every program outcome and educational objective. For the purpose of interpretation of data, benchmarks (i.e. performance expectations or standards) need to be established. A benchmark is typically a numerical value, and a consensus among the Civil Engineering Technology program faculty is reached as to every such value used in the evaluation process. A benchmark of 2.5 has been adopted by the CET faculty.

In a rubric analysis, if an average score falls below 2.5, the corresponding measure is flagged, an instructor review is triggered, the continuous improvement effort (CIE) report is completed by the instructor and submitted to the program coordinator, improvements are implemented the next course offering, and the outcome is again measured. The CIE report identifies the triggered benchmark, the related program-level outcome, and the proposed plan of action to raise future ratings If the measure falls below the benchmark for three successive course offerings, a CET faculty-wide review is initiated leading to a documented improvement strategy. In the example of TCET 3142 (Table 6), four rubric score averages fell below the benchmark. The course instructor completed a Continuous Improvement Efforts (CIE) report which documented a strategy for instructional improvement and submitted it to the program coordinator. A copy of the actual CIE report is shown in Table 9 as a sample. Similar CIE reports are prepared for other courses as well.

Next, for each of the three courses, the evaluation of assessment data from final exams is presented in the following pages. The corrective actions warranted for program improvement are also included.

IV. Results of Implementation of Continuous Improvement Plans

Upon incorporation of all the changes discussed in the preceding section for the three courses in their subsequent offerings (spring 2007 for TCET 4146, and fall 2007 for TCET 3142 and TCET 4146), another cycle of assessment and evaluation has been completed. For TCET 3142, the rubric score averages ranged from 2.62 to 3.01 (overall 2.85). For TCET 4142, the rubric score averages ranged from 2.76 to 3.42 (overall 3.04). From these data, it is observed that all of the previous shortcomings have disappeared. Also, for TCET 4146, the rubric score averages ranged from 2.82 to 3.68 (overall 3.23).

Table 9 Continuous Improvement Efforts (CIE) Report	
Course/Activity Measured: TCET 3142 Final Exam	**Semester: Fall 2006**
Prepared by: Dr. Nirmal Das	**Date: 12-15-2006**
What *issue* was triggered that prompted change?	Course Learning Outcome #7: Ability to solve for deflections of statically determinate beams, trusses, and frames
What *tool* was used that prompted the change? (For example, student feedback, faculty observations, IAB suggestions, rubric analysis of Student performance, etc)	Rubric analysis of student performance on TCET 3142 Final Exam.
What was the *change* or improvement?	The instructor has devised the following plan: - Focus on the application of Virtual work method. - Increase the time dedicated to this topic. - Administer a quiz to test students' performance in this area.
What was the *result of implementing* the change? (i.e. did the change correct the issue?)	The instructor has recommended the above measures be taken next time the course is offered. The grading on the assignment or quiz should indicate improvement before final exam.

TCET 3142 Structural Analysis
Evaluation of Assessment Data and Plan for Continuous Improvement

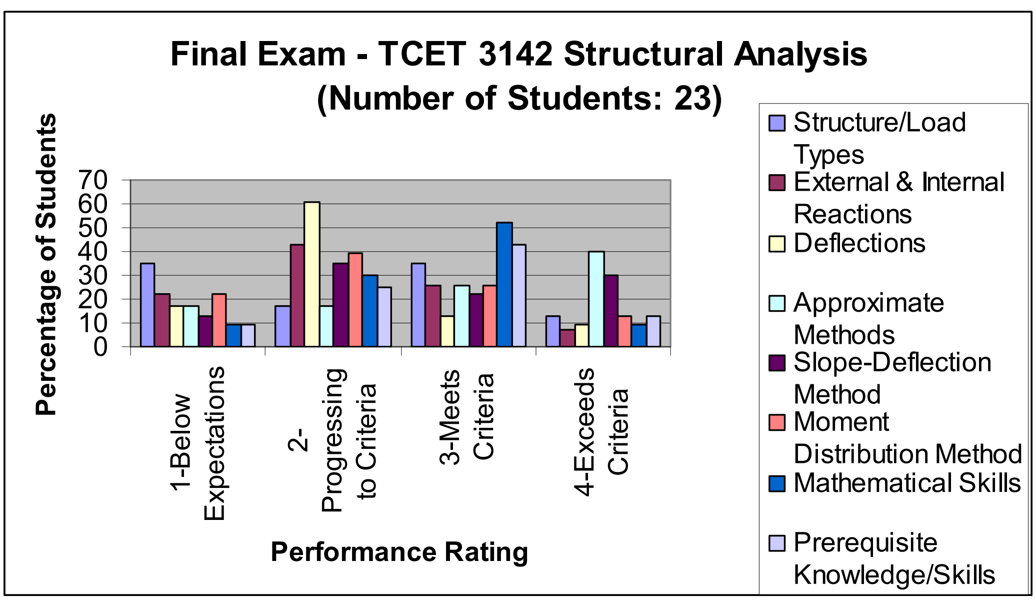
The Rubric Summary of final exam (fall 2006) indicates that the stipulated benchmark of a rubric score average of 2.5 is met with respect to four out of eight measurable outcomes. The four others fall short of 2.5 (2.26, 2.25, 2.13 and 2.30). All these course outcomes contribute to the course objectives which in turn contribute to the program outcomes (a, b, f, and k) as shown in the course outline. Also, the overall rubric average of 2.47 falls slightly short of benchmark of 2.5.

A further analysis with the aid of the figure below reveals that for the four specific outcome measures with rubric score average less than 2.5, the percentage of students either meeting or exceeding the criteria falls below 50%, as shown below.

Identify structure types and determine loads:	48%
Solve support reactions and internal reactions:	45%
Solve for deflections:	22%
Use of Moment Distribution method:	39%

Evidently there is room for improvements in the above areas. After careful introspection of the course content, and feedback from students, the following changes are planned to be implemented in the subsequent course offering (fall 2007):

1. Additional homework and quizzes in those particular areas of weakness.
2. Explore possibility of adopting a better textbook, if available.
3. More time to be spent in instruction of topics of deflections and Moment Distribution method.
4. A short review of certain essential topics from the prerequisite courses during the first week of classes.

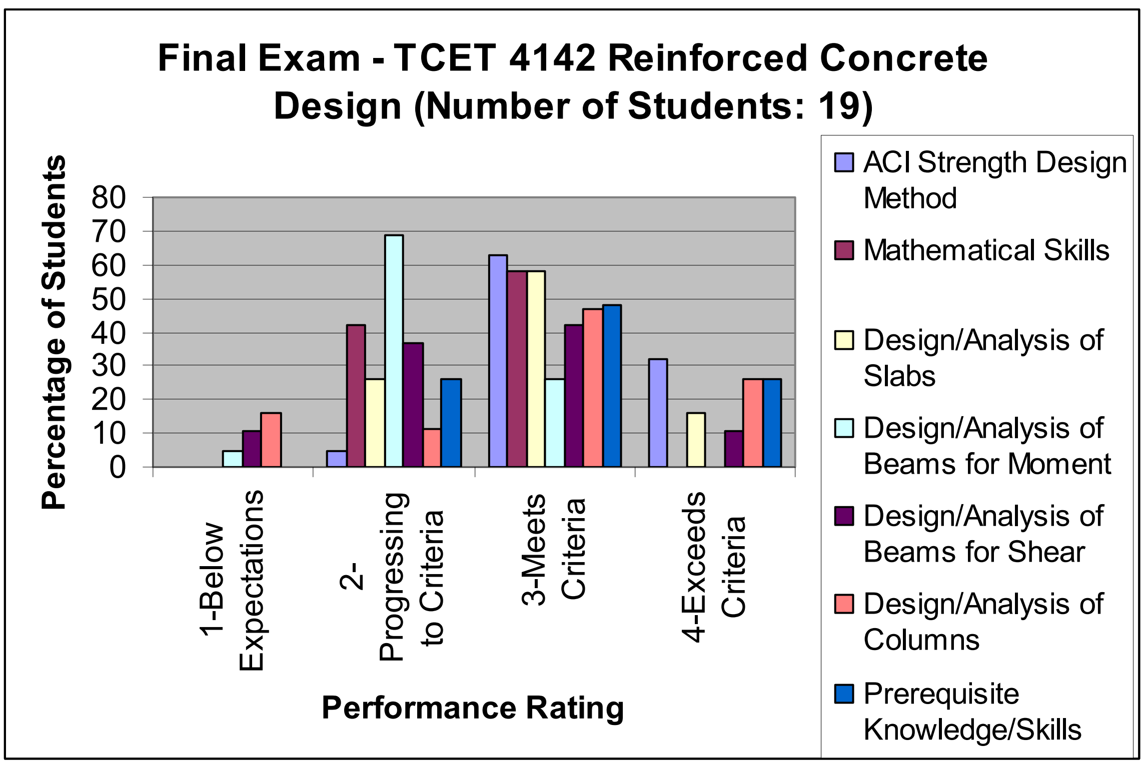


TCET 4142 Reinforced Concrete Design
Evaluation of Assessment Data and Plan for Continuous Improvement

The Rubric Summary of final exam (fall 2006) indicates that the stipulated benchmark of a rubric score average of 2.5 is met with respect to six out of seven measurable outcomes, also reflected in the overall rubric average of 2.766. These course outcomes contribute to the course objectives which in turn contribute to the program outcomes (a, b, d, f, g, h, and k) as shown in the course outline.

It appears no major changes are warranted at this time. However, a further analysis with the aid of the figure below reveals that there is room for improvement for the particular outcome measure of design/analysis of beams for moment (rubric average of 2.21) that falls short of the benchmark of 2.5. After careful introspection of the course content, and feedback from students, the following change is planned for implementation in the subsequent course offering (fall 2007):

> Additional coverage on design/analysis of beams (especially doubly-reinforced beams and T-beams) for moment with more examples and homework, and follow-up quiz.

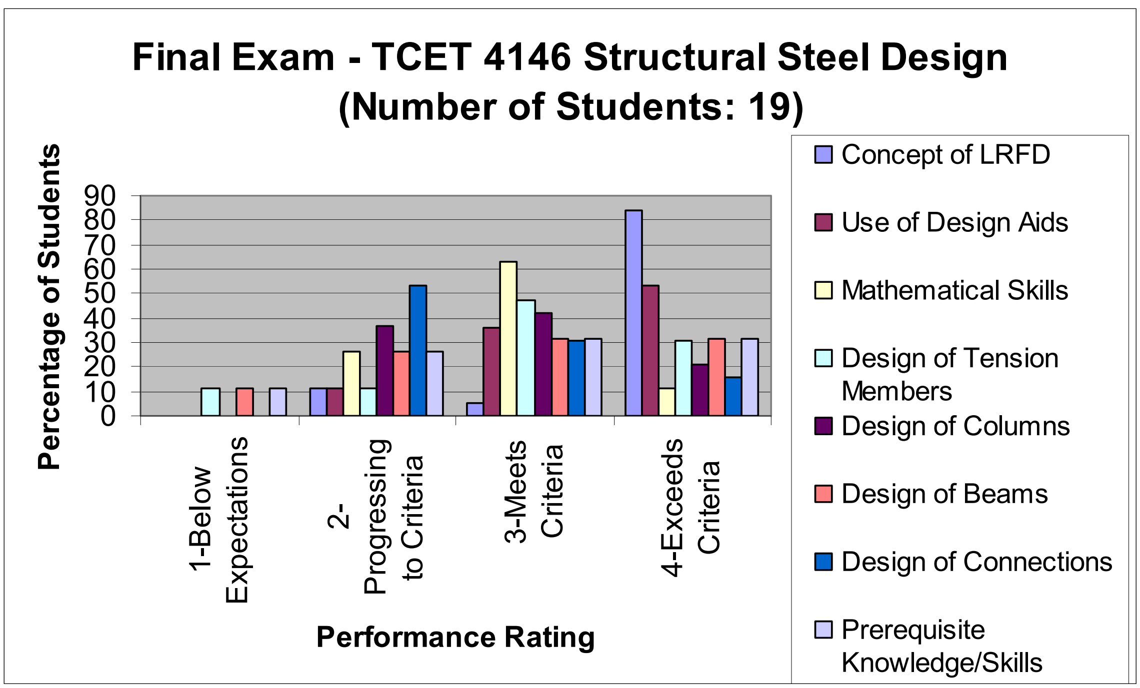


TCET 4146 Structural Steel Design
Evaluation of Assessment Data and Plan for Continuous Improvement

The Rubric Summary of final exam (spring 2006) indicates that the stipulated benchmark of a rubric score average of 2.5 is met with respect to eight measurable outcomes. These course outcomes contribute to the course objectives which in turn contribute to the program outcomes (a, b, d, f, g, h, and k) as shown in the course outline..

However, a further analysis with the aid of the figure below reveals room for improvements. First, a weakness in the topic of design of connections is observed - about 53% of students' performance did not meet the criteria (i.e., ratings were 1 or 2). Second, about 37% of students' performance was rated as not meeting the criteria with respect to design of columns or beams. Third, a gap in the knowledge of prerequisite subject area is also noticed in about 37% of the students. This was mainly in the area of determining the required strengths for structural members, which is essentially done based on the knowledge of structural analysis (the prerequisite course). After careful introspection of the course content, and feedback from students, the following changes have been implemented in the subsequent course offering (spring 2007):

1. A new textbook has been adopted. This particular text has the unique feature of addressing the required strength aspect in great details. In addition, it has a significant number of illustrative examples on various structural elements.
2. More time is being spent in the classroom to address the required strength aspect; also the sequence of instruction for different topics is modified somewhat.



V. Summary

Effective implementation of a viable continuous improvement plan is crucial to maintain and improve the quality of a program in compliance with the TAC/ABET TC 2K criteria. Assessment and evaluation of program outcomes and program educational objectives constitute two key elements of the plan. Both short-term and long-term well-defined assessment activities at specified frequencies involving multiple constituencies are essential. The continuous improvement plan adopted by the Civil Engineering Technology program at Georgia Southern University is discussed in this paper with particular emphasis on the use of direct measures for assessment and evaluation of program outcomes. These primarily include quantitative evaluation of student learning in a specific area (structures) of the curriculum, which in turn indicates the extent to which program outcomes are achieved.

Bibliography:

1. TAC/ABET *Criteria for Accrediting Engineering Technology Programs* (Effective for Evaluations During the 2006-2007 Accreditation Cycle)
2. *ABET Program Evaluator Training* (TC2K Training), sponsored by ABET Education and Information Services during the 2002 American Society for Engineering Education Annual Conference and Exposition in Montreal, Canada.

Appendix:

Course Objectives of TCET 3142 Structural Analysis
Course Objectives of TCET 4142 Reinforced Concrete Design
Course Objectives of TCET 4146 Structural Steel Design

Course Objectives of TCET 3142 Structural Analysis

Objective #1: To understand structure types, load types and corresponding forces. (a, f, and kf)*

Learning Outcomes:

1. Identify various types of structures and the corresponding structural elements
2. Identify, categorize, and calculate various types of loads.

Objective #2: To understand application of reactions and internal forces in trusses, beams, and frames. (a, f, and k)

Learning Outcomes:

3. Solve for support reactions and internal forces including shear and moment diagrams.
4. Solve for internal vertical shear and moments due to moving loads.
5. Produce influence lines for beams and trusses.
6. Interpret the shear and moment influence lines, for maximum values of shear and moment at a given location, due to a series of moving loads, concentrated or uniform, in a beam. Determine the locations and absolute maximum values of shear and moment in a beam.

Objective #3: To understand the relationship among load, shear, moment and deflection of statically determinate structures (beams, frames and trusses). . (a, f, and k)

Learning Outcomes:

7. Calculate deflection of statically determinate structures using conjugate beam method/ virtual work method.
8. Determine stiffness coefficients and fixed-end moments for beams using conjugate beam method.

Objective #4: To understand the relationship among load, shear, moment and deflection of statically indeterminate structures by solving for support reactions using approximate methods. . (a, f, and k)

Learning Outcomes:

9. Solve for support reactions for building frames due to gravity loads, using approximate deflected shape.
10. Solve for support reactions for building frames due to lateral loads using portal method.
11. Solve for support reactions for building frames due to lateral loads using cantilever method.

Objective #5: To understand the relationship among load, shear, moment and deflection of statically indeterminate structures by solving for internal moment through a variety of methods. . (a, f, and k)

Learning Outcomes:

12. Identify and calculate internal moments in continuous beams using slope deflection method.
13. Identify and calculate internal moments in frames with or without side-sway using

slope deflection method.
14. Identify and calculate internal moments in continuous beams using moment distribution method.
15. Identify and calculate internal moments in frames with or without side-sway using moment distribution method.
16. Demonstrate moment, shear, and axial force diagrams for frames.
17. Identify and perform analysis of beams and plane frames using matrix method.

Objective #6: To verify manual solutions to problems using a computer software. (b and k)
Learning Outcomes:
18. The computer program STAAD-PRO will help students in verifying their solutions.

(* Characters within parenthesis represent TAC/ABET designated program outcomes 'a' through 'k' accomplished by the course objective.).

Course Objectives of TCET 4142 Reinforced Concrete Design

Objective #1: To understand the basic concept of Strength Design Method of ACI-318 Building Code. (a, b, f, g, h, and k)
Learning Outcomes:
1. Comprehend the relationship between required strength and design strength for various structural components (beams, one-way slabs, columns and footings).
2. Identify and categorize various types of loads, load combinations, and the associated load factors.
3. Identify the capacity reduction factors applicable to various structural components..

Objective #2: To perform analysis of reinforced concrete members (cast-in place). Members include beams, one-way slabs, columns and footings. (a, b, f, g, h, and k)
Learning Outcomes:
4. Conduct routine analysis of reinforced concrete members under various combinations of dead, live and wind loads.

Objective #3: To perform design of reinforced concrete slabs and beams analyzed under Objective #2. (a, b, d, f, g, h, and k)
Learning Outcomes:
5. Select the required size and steel reinforcement for beams (singly-reinforced rectangular, doubly-reinforced rectangular and T-beams) and slabs (one-way), in accordance with the current ACI 318 Building Code.
6. Produce detailed drawings of design.

Objective #4: To perform design of reinforced concrete columns analyzed under Objective #2. (a, b, d, f, g, h, and k)
Learning Outcomes:
7. Select the required size and steel reinforcement for short columns and slender columns, in

accordance with the current ACI 318 Building Code.
8. Produce detailed drawings of design.

Objective #5: To perform design of reinforced concrete footings analyzed under Objective #2. (a, b, d, f, g, h, and k)
Learning Outcomes:
9. Select the required size and steel reinforcement for continuous footings and spread footings, in accordance with the current ACI 318 Building Code.
10. Produce the detailed drawings of design.

Objective #6: To verify manual solutions to problems using a computer software. (b and k)
Learning Outcomes:
11. The computer program SABLE32 (or some other) will help students in verifying their solutions.

Course Objectives of TCET 4146 Structural Steel Design

Objective #1: To understand the basic concept of Load and Resistance Factor Design (LRFD) Method. (a, b, f, g, h, and k)
Learning Outcomes:
1. Comprehend the relationship between required strength and design strength for various structural components (tension members, compression members, beams, and beam-columns), and connections.
2. Identify and categorize various types of loads, load combinations, and the associated load factors.
3. Identify the resistance factors applicable to various structural components.

Objective #2: To perform analysis of steel members. Members include tension members, beams, columns, and beam-columns. (a, b, f, g, h, and k)
Learning Outcomes:
4. Conduct routine analysis of steel members under various combinations of dead, live and wind loads.

Objective #3: To perform design of structural steel members and their connections, using LRFD. (a, b, f, g, h, and k)
Learning Outcomes:
5. Select economical steel members(tension members, columns, beams and beam-columns) in accordance with the most current AISC LRFD Manual
6. Design efficient welded and bolted connections.

Objective #4: To be able to use the computer as a design aid. (a, b, h, and k)
Learning Outcomes:
7. Perform analysis and design of steel members using STAAD-PRO/ RAM Structural System software.