AC 2011-1019: ADDRESSING PROFESSIONAL PRACTICE ISSUES WITHIN THE CURRICULUM

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Addressing Professional Practice Issues within the Curriculum

Abstract

Some programs struggle with how to accomplish all that is required in the current American Society of Civil Engineers (ASCE) Body of Knowledge (BOK) while planning for possible state-mandated decreased credit hours due to current budgetary issues. Many programs are beginning to investigate how to possibly add additional outcomes listed under the new ASCE BOK II document knowing that some of those outcomes will migrate eventually into the ABET CE program criteria. How to do more with less (people, time, and resources) is a common theme on many campuses across the country especially with the current economic crisis. If these challenges are not enough to worry about, some programs are still working on how best to demonstrate within their curriculum professional practice issues facing current graduates. This paper will provide a methodology that one civil engineering program is using to address professional practice issues within the curriculum.

This paper will present the program's current capstone course, the new senior level course, and adjustments to other courses in the curriculum that provide coverage of professional practice issues such as leadership, business practices, public policy and administration, asset management, ethics, contemporary issues, constructability, and solutions within a global and societal context. Through the sequencing of events and assessments of 10, 35, 100 percent submittals within the capstone as well as assignments within other courses, students are required to demonstrate their abilities associated with professional practice issues. The assessment of the capstone along side of selected embedded indicators in other courses and associated survey data provides a clear picture of the actual demonstrated performance of professional practice outcomes by students. A number of embedded indicator assessment methods for capstone experiences were assessed, evaluated and combined to build the resulting accumulation of rubric results from each submittal to allow the program to determine if the students within a team and the entire group of students have achieved the proper level of demonstration of an outcome by performance level and percentage of overall grade.

1.0 Introduction

The American Society of Civil Engineers (ASCE) recognized the lack of certain knowledge and skills among civil engineering graduates at about the same time many universities were experiencing pressure to decrease credit hours and decrease time to graduation. ASCE formed a committee to study and develop a Civil Engineering Body of Knowledge (BOK)[1] to document the requisite knowledge, skills, and attitudes necessary for future civil engineers. This new civil engineering BOK included the ABET[2] EC2000 3a-k outcomes (adopted in 1997). Two key issues associated with the BOK were: 1) a lack of a clear definition of expected performance levels by these new engineers even though the wording was consistent with ABET definitions which are generally difficult to define clearly, and 2) the addition of four new outcomes focused on additional professional topics and discipline depth. Very quickly it was determined by most

programs and ASCE that the discipline depth could only occur at the Master's level with larger breadth occurring at the undergraduate level. The addition of professional skills above what even ABET[2] EC2000 requires reflects greater recognition of the importance of the development of professional skills at the bachelor's level. How/Where are these supplementary professional topics to be included in the current curriculum? How are these additional topics to be covered if programs are required to decrease credit hours for faster graduation rates without decreasing the required CORE courses? The engineering programs within the University of Texas System decreased their credit hours to 128 or less in 2007 based on legislative requirements to decrease time to graduation. There are discussions to decrease the number of credit hours to 120 credit hours for all programs within publically supported programs to decrease the amount of funding being sent to schools of higher education as part of state-wide cost cutting measures.

ASCE also realized that adjustments to the first edition of the BOK[1] were needed based on the comments that arose from the ASCE Curriculum Committee [3] investigating how to implement the outcomes. The central issue was the lack of a methodology to determine how well and at what level a program needed to demonstrate accomplishment of outcomes. Some of the schools on the ASCE Curriculum Committee working towards implementation of the outcomes decided after reviewing many taxonomies that Bloom's Taxonomy[4] should be used to define the proper level of demonstration for each outcome. One of the first orders of business of the new BOK II committee[5] was the use of Bloom's Taxonomy (read action verbs) to define the level of demonstration of each outcome at not only the undergraduate level, but master's and experience levels as well. Another focus as a result of the earlier ASCE Curriculum Committee's work was the splitting of ABET outcomes into a larger number of smaller outcomes. For example, ABET Outcome 1 is "an ability to apply knowledge of mathematics, science, and engineering,"[2] which became in BOK II outcomes 1 Mathematics, 2 Natural Sciences, 5 Materials Science, and 6 Mechanics.

The previous discussion surrounding the addition of new outcomes to BOK I when reviewing skills needed by graduating engineers resulted in the addition of outcomes to BOK II when necessary entry level skills were readdressed. The new outcomes are: sustainability, historical perspectives, globalization, humanities, social sciences, risk and uncertainty, and breadth in civil engineering areas. Some of these may be considered professional practice issues (humanities, social sciences, historical perspectives, sustainability and globalization).The ASCE Fulfillment Committee[6] is currently studying implementation techniques for the new outcomes as well as implementation of adjusted levels of outcome demonstration at the undergraduate level using Bloom's Taxonomy. It is only a matter of time that these new outcomes and levels of demonstration occur within ABET general program criteria as is being called for by some[7] or CE program criteria as the new outcomes in BOK I did in 2008 just four years after BOK I was in print. Some even hint that changes every six years are reasonable to consider.[7]

1.1 Professional Outcomes

The ABET[2] EC2000 professional skills are: understanding professional and ethical responsibility (3.f), recognition of need by an ability to engage in life-long learning (3.i), ability to function on a multi-disciplinary team (3.d), ability to communicate effectively (3.g), and knowledge of contemporary issues (3.j). The CE program criteria professional outcomes are leadership, public policy and administration, business practices and asset management. What are the best methodologies and location for demonstrating these outcomes? Can programs successfully demonstrate these professional outcomes at the Bloom's Taxonomy levels indicated in the BOK II?

For UT Tyler, the professional topics emanate from Program Outcomes 4, 6, 7, 8, 9, 10, 11, and 14 (Table 1 (Bold)) which are derived from ABET Outcomes (3.d), (3.f), (3.g), (3.h), (3.i), and (3.j) (Table 2 (Bold)) and the CE program criteria with adjustments based on BOK II. PO 9 specifically incorporates the new undergraduate professional requirements located within the current CE program criteria (from BOK I). Outcomes 10-15 in Table 1 are the new program outcomes emanating from BOK II. UT Tyler has added the new outcomes and adjusted others now to begin experimenting with how best and where to implement and demonstrate them.

Table 1 UT Tyler CE Program Outcomes

Graduates:
1. Can apply knowledge of traditional mathematics, science, and engineering skills, and use modern engineering tools to solve problems.
2. Can design and conduct experiments, as well as analyze and interpret data in more than one civil engineering sub-discipline.
3. Can design systems, components, and processes and recognize the strengths and areas for possible improvement of their creative designs within realistic constraints such as regulatory, economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.
4. Can work independently as well as part of a multidisciplinary design team.
5. Can identify, formulate, solve and evaluate engineering design problems using engineering models in the four of the five sub-disciplines civil engineering: structural engineering, transportation engineering, construction management, hydrology and/or environmental engineering.
6. Can analyze a situation and make appropriate professional and ethical decisions.
7. Can demonstrate effective oral, written, and graphical communication skills.
8. Can demonstrate a commitment to learning and continued professional development outside the classroom, incorporate contemporary issues and historical issues during problem solving, and determine the impact of engineering solutions in a global and societal context.
9. Can explain professional practice attitudes, leadership principles and attitudes, management concepts and processes, and concepts of business, public policy, and public administration.
10. Can demonstrate the importance of humanities in the professional practice of civil engineering
11. Can demonstrate the incorporation of social sciences knowledge into the professional practice of civil engineering
12. Can use the knowledge of material sciences to solve problems appropriate to civil engineering
13. Can analyze and solve problems in solid and fluid mechanics
14. Can apply principles of sustainability to the design of traditional and emergent engineering systems
15. Can apply the principles of probability and statistics to solve problems containing uncertainties and risk assessment

When considering professional skills, the difficulty arises in how do students demonstrate or fully understand what these outcomes are asking when the demonstration is occasionally left to a single event such as a seminar within the senior year. These professional outcomes have been referred to as "soft" outcomes by many when they were first presented as part of ABET EC2000 Criterion 3.[2] Others have used the word "squishy" when considering how difficult it is to assess professional skills compared to the "hard" skills of engineering.[8] "Soft" or "Squishy", the professional skills are not as easily assessed and many times require multiple assessment methods, multiple activities within the academic setting as well as possible activities like Engineers Without Borders (EWB) or other service activities to be able to properly demonstrate accomplishment of the outcome.[9] However, not every student will participate in EWB. Another example of the difficulty is that students may properly assess a situation based on proper ethical reasoning, but there is no assurance that they will actually act ethically. Some define professional skills as how we perform in professional settings, but how do educators develop and assess such skills? Does the educator possess professional experience and a professional engineer (PE) license? Even a PE needs a methodology understood by all to continually and properly assess professional practice skills.

Table 2 ABET Criterion 3 (a-k)

Demonstration (incl. Process & Measurements) that Graduates have:
(a) ability to apply knowledge of math, engineering, and science
(b) ability to design and conduct experiments
(b) ability to analyze and interpret data
(c) ability to design system, component or process to meet needs within realistic constraints such as regulatory, economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.
(d) ability to function on multi-disciplinary teams
(e) ability to identify, formulate, and solve engineering problems
(f) understanding of professional and ethical responsibility
(g) ability to communicate effectively
(h) broad education
(i) recognition of need by an ability to engage in life-long learning
(j) knowledge of contemporary issues
(k) ability to use techniques, skills, and tools in engineering practice

2.0 A Possible Solution

The ABET professional outcomes (3.d) multi-disciplinary teams, (3.g) communicate effectively, (3.i) life-long learning, and (3.j) contemporary issues are being addressed in multiple courses and the two-semester senior design (capstone). ABET outcome (3.h) broad education is addressed within the confines of the healthy CORE (44 credit hours) at UT Tyler. ABET Outcome (3.f) professional and ethical responsibility is addressed in the senior design, but could students miss fully understanding and demonstrating this outcome since all of the work is completed in teams? What about the three new professional outcomes covering topics of leadership, public policy and administration, business practices, and asset management?

The UT Tyler Civil Engineering Program solution: a course added to the curriculum to ensure coverage of the professional topics in the title as well as integration of the other professional skills. The course is CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management (Figure 1, second semester, senior year) which provides coverage of the three new outcomes in the BOK I (represented by program outcome 9) as well as demonstration of parts of Outcomes 6, 7, and 8.[10,11,12] Formal assignment of embedded indicators to courses based on ability to demonstrate an outcome as well as annual assessment of these embedded indicators collected not only provided BOK compliance, but also accreditation through ABET.[13] CENG 4341 synergistically assisted students in seeing the big design picture and the nuances of teamwork, leadership and management required in the two-semester senior design (CENG 4115/4315) by analyzing and discussing solutions to leadership issues seen during the one credit hour CENG 4115 in the fall and public policy affecting engineering projects in Texas, business practices that could constrain their capstone project design as well as how well they have been managing their personnel assets within their team during CENG 4315 in the spring. Even though some public policy is being covered in environmental engineering, the in-depth coverage of public policy and administration within CENG 4341 along with leadership, business practices, asset management and other professional skills provides a synergistic meshing of these multiple professional practice issues as they occur within practice.

2.1 Leadership, Public Policy, Business Practices, Asset Management, CENG 4341

CENG 4341 is comprised of four modules each with papers and an exam leading to a comprehensive final exam. The original idea was to draw upon the expertise across campus and have the individual teaching a course covering the topic to develop a 10 lesson block with an exam. The length of each module was a quarter of the course which seemed reasonable considering the current focus of the course. Topic order was not important since each expert would teach their block (i.e., team teaching). When the issue of how to give credit to a teacher for one-fourth of a course became a stumbling block, the author decided to develop each block himself. Since now one teacher was going to teach all four blocks, the author decided to consider the order of topics to develop a richer experience as well as provide linkage to additional professional topics. Upon reflection, it was obvious that all of the professional topics focus on the engineer being a leader within their firm - so it is covered first. Public policy affects a firm's business practices and it takes leaders within government for public policy to be enacted. So it was taught next followed by business practices. Business leaders must understand public policy processes so that they can influence the process as appropriate. The key focus in small business practices (a large number of civil engineering firms are considered small) is the development of a business plan which is affected by public policy and the leaders within the firm. Once the business plan is in place, it once again requires leaders to manage firm assets to accomplish assigned tasks and missions to meet the desired level of business performance.

Department of Civil Engineering
Bachelor of Science in Civil Engineering
2008-2009 Curriculum

Freshman Year

Freshman—First Semester (Fall)		
POLS 2306	Intro. Texas Politics	3
ENGL 1301	Grammar & Composition I	3
MATH 2413	Calculus I	4
CHEM 1311	General Chemistry I	3
CHEM 1111	General Chemistry I Laboratory	1
ENGR 1200	Engineering Methods (with lab)	2
	Semester Credit Hours	16

Freshman—Second Semester (Spring)		
TECH 1303	Engineering Graphics	3
ENGL 1302	Grammar & Composition II	3
MATH 2414	Calculus II	4
PHYS 2325	University Physics I	3
PHYS 2125	University Physics I Laboratory	1
( )	Visual & Performing Arts	3
	Semester Credit Hours	17

Sophomore Year

Sophomore—First Semester (Fall)		
CENG 2336	Geomatics	3
POLS 2305	Introduction to American Government	3
ENGR 2301	Engineering Mechanics – Statics	3
MATH 3404	Multivariate Calculus	4
PHYS 2326	University Physics II	3
PHYS 2126	University Physics II Laboratory	1
	Semester Credit Hours	17

Sophomore— Second Semester (Spring)		
CENG 2353	Civil Engineering Measurement	3
MENG 3306	Mechanics of Materials	3
MATH 3305	Differential Equations	3
ENGR 2302	Engineering Mechanics –	3
ECON 2302	Microeconomics	3
PHIL 2306	Introduction to Ethics	3
	Semester Credit Hours	18

Junior Year

Junior—First Semester (Fall)		
CENG 3434	Civil Engr. Materials, Codes & Specs	4
MENG 3310	Fluid Mechanics	3
ENGR 3301	Probability & Statistics for Engineers	3
CENG 4339	CE Construction Management	3
( )	Additional Science Elective	3
	Semester Credit Hours	16

Junior—Second Semester (Spring)		
CENG 3361	Applied Engineering Hydrology	3
CENG 3351	Transportation Engr. Systems	3
CENG 3371	Intro to Environmental Engineering	3
CENG 3336	Soil Mechanics	3
CENG 3325	Structural Analysis	3
	Semester Credit Hours	15

Senior Year

Senior—First Semester (Fall)		
CENG 4351	Traffic Eng: Opns & Ctrl (w Lab)	3
CENG 4317	Structural Steel Design	3
CENG 4371	Environmental Engineering Design	3
CENG 4115	Senior Design I	1
HIST 1301	United States History I	3
ENGR 4109	Senior Seminar	1
	Semester Credit Hours	14

Senior—Second Semester (Spring)		
CENG 4341	Leadership, Business, Pub Pol,	3
CENG 4315	Senior Design II	3
HIST 1302	United States History II	3
( )	Tech Elective	3
( )	World/European Literature	3
	Semester Credit Hours	15

Total Program Credit Hours: 128

Figure 1: UT Tyler Curriculum

Even though the course is exceeding all expectations, the fact that much of the focus is on the senior design experience and the program is wrestling with how to cut eight credit hours out of the curriculum due to state budgetary issues without once again touching the CORE is leading the program to consider now inserting the content into the senior design experience without losing the effectiveness. The CENG 4341 professional skills course content and required demonstration was not included in the senior design initially since the senior design was being taught for the first time during the program's first ABET

record year.[13] Ensuring that the senior design met the "major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints"[2] was foremost and key to the program's success. Additionally, all faculty were new non-tenured, tenure-track faculty teaching for the first time. Just asking for the integration of as many outcomes as possible (the ultimate goal of the senior design), while not being the sole responsible location for those outcomes was critically important. Now that the senior design experience is maturing and has successfully integrated the demonstration of almost every outcome during development of a multi-disciplinary design solution, it is time to begin the process of investigating the coverage of professional topics primarily within the senior design experience and consider deletion of CENG 4341 as part of a possible reduction in credit hours.

2.2 Senior Design, CENG 4115-4315

The senior design experience (CENG 4115/4315) within the UT Tyler CE Program (many programs refer to this as a 'capstone' experience) is a 4 credit, 2 semester Senior Design course that has been conceived to do the following:

(1) Give students a real-world, design office design experience tackling an open-ended design scenario that encompasses high level[2] cognitive thinking across seven CE sub-disciplines
(2) Ensure students wrestle with professional issues such as communication with engineers, policy makers and the public
(3) Ensure students are faced with issues associated with typical design constraints such as regulatory, economic, environmental, social, political, ethical, health and safety, constructability, and sustainability in a multi-disciplinary design.
(4) Provide a platform where student performance against the ABET general criteria for engineering programs (3 a-k)[14] and civil engineering program specific criteria can be assessed (basically BOK I now and BOK II in the future).

The senior design experience was tailored to ensure coverage of the appropriate program material – items (1) – (3) in the above list suggests this. In some ways, constructing the appropriate assessment vehicle(s) was a more considerable challenge. The open-ended nature of realistic design does not always lend itself to concrete assessment methodologies. So the creation of a time effective assessment scheme that forces an experience that includes coverage of all outcomes to include professional skills was a focus.

The UT Tyler CE Program's senior design is a two course sequence, with CENG 4115 a one credit fall offering that introduces the students to the year's project through activities up to 35% design completion, and CENG 4315 a three credit spring offering that takes the project to 100% design completion. The experience centers around a multidisciplinary design project. Ideally, this project is aligned with an actual project being designed or constructed in the local area, so that at the end of the project students can review parallel plans and designs that have been professionally produced. The 2007-2008 project was a new art complex, 2008-2009 project was renovation and expansion of

the University Center, 2009-2010 project was an outdoor multi-use amphitheater, the 2010-2011 project is a realignment of Lazy Creek and Patriot Avenue, and the 2011-2012 project will be the development of a parcel of land for an intramural complex and campus shops and eateries.

CENG 4115 begins with a review of the 9 step engineering design process[15], and primarily revolves around targeted submittals at typical early project milestones – 10% and 35% submittals. A discussion of nine primary constraints to engineering design (sustainability, environmental, constructability, economics, ethics, political, social, technology, and public health and safety) follows, and these are emphasized throughout the experience such that the program requires consideration of all nine. In preparation for the 10% submittal, the course involves client meetings during which students gather needs, functionality requests and client driven constraints. A site orientation visit follows, and the class becomes fully enmeshed in the design project for the rest of the academic year. Each course (CENG 4115/4315) includes lessons, assignments and other activities supplemental to the design project. These are additional advanced design topics that prepare students to complete the design project (such as activities around wetland identification, ESA development, etc.) or that bridge sub-disciplines covered in other courses (such as parking lot material and section design that bridges structural, geotechnical and transportation concerns). These advanced topics also close holes in the program identified through other assessment vehicles or the previous year's senior design assessment. Other successful features of the experience are 'fact finding missions' (FFM) that task student design teams with finding information (e.g., local code requirements regarding architectural features, ADA building requirements, ESA interviews, traffic signaling requirements, etc.) on their own that has not been covered elsewhere in their curriculum. FFM simulate real-world design practice and give opportunity for self directed learning (lifelong learning 3i.).[14] CENG 4115 culminates with the submission of a 35% design package that is graded over the semester break.

The students are immediately enmeshed back in the project when they receive feedback on the 35% design package on the first day of CENG 4315 the next semester. They are required to present this design to faculty and clients within the next two weeks, after making necessary changes and developing an architectural and/or site model, a K'Nex structural model if a bridge or building is required, and a stand-alone presentation board. CENG 4315 continues to 100% design completion with an intermediate review at 65% that is structured to simulate a desk-side review with an engineering supervisor in a design office. The 65% review gives students practice in identifying the critical parts of a project to relay to a supervisor – there will usually not be time to cover every detail in a design review meeting, and identifying what is important is a critical skill. At 100% design completion, students submit their design package and deliver a final oral presentation. At this time they field questions from working engineers (evaluation panel) regarding their design, receive feedback from clients and faculty, and review actual plans from existing designs if they exist and time permits.[14]

2.3 Demonstration of Outcomes

During the 2007-2008 assessment cycle (the UT Tyler ABET record year), every assignment of the new course CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management was designated as a possible embedded indicator (Table 3) to cover the new professional skills listed in the CE program criteria. Embedded indicators are assigned to each course to ensure adequate demonstration of outcomes (e.g., Table 4,

Table 3 Embedded Indicators in CENG 4341

Assignment	**Outcome**
Paper 1 – define your leadership skills and attitudes.	9b - Leadership
Paper 2 – define your leadership goals while an intern using appropriate leadership theories such as equity, expectancy, etc.	9b - Leadership
Paper 3 – define your leadership strategies for ensuring your Capstone team is successful.	9b - Leadership
Exam 1, problem 1, define and explain leadership using appropriate theories	9b - Leadership
Paper 4 – Define public policy while considering T. Boone Pickens and West Texas Water rights	9e – Public Policy
Paper 5 – define and provide the pros and cons for wetland public policy	9e – Public Policy
Presentation – 10 minute presentation on what can they do as part of policy alternatives.	9e – Public Policy
Exam 2, problem 1, define and explain public policy using appropriate theories	9e – Public Policy
Paper 6 – define a business plan through the eyes of a junior engineer	9d – Business
Paper 7 – explain how you would improve the efficiency of asset use within the company you worked for this past summer	9c – Management
Exam 3, Problem 1, define and explain business practices	9d – Business
Exam 3, Problem 4, Define and explain asset management though lean six sigma and waste limitation	9c – Management
Final Exam, Problem 1, explain leadership using theory and examples	9b - Leadership
Final Exam, Problem 2, explain public policy using theory and examples	9e – Public Policy
Final Exam, Problem 3, explain business practices using theory and examples	9d – Business
Final exam, Problem 4, explain asset management using theory and examples	9c – Management

example of embedded indicator data collected for Outcome 9 for the ABET self-study). Only selected assignments were chosen as embedded indicators within CENG 4341 to limit how much data each course provides to the assessment process. The embedded indicators were assessed and filed into a notebook for each outcome. The assessment of the assessment process has slightly modified which assignments are being used as

embedded indicators. Additionally, the coverage in the senior design has increased and improved over time.

Table 4 Assigned Embedded Indicators Completed

Outcome 9c: Can explain management concepts and processes.		
Direct Measures	Standard	2007-8 Performance
CENG 4339, Final Exam, Question #27 (cradle to grave management)	80.0	100
CENG 4341, Final Exam Question (Lean Six Sigma, Eliminate waste)	80.0	81.7

Grading of each major milestone in the senior design (10%, 35%, 35% oral presentation, 65% Review, 100%, and 100% oral presentation) is done using 'cut sheets' – rubrics that incorporate the key features of the design. Figure 2 (asset management, construction

_____/10: _____/15 points. Existing Site Plan (focused on existing site)

_____/10: _____/10 points. Site Use Plan (focused on proposed site)

- ❑ (1) Footprint of building to scale overlaid on AUTOCAD topo map
- ❑ (2) Access to spaces shown
- ❑ (2) Vehicle circulation (roads) and parking lot (# spaces & sizes incl. handicapped)
- ❑ (2) Equipment access/egress (traffic lanes and routing plan)
- ❑ (2) Pedestrian Circulation and sidewalks
- ❑ (1) Trees / Setbacks

_____/10: _____/10 points. Site Prep and Demo Plan

- ❑ Structures to be altered/demolished are labeled and changes are noted
- ❑ Excavation for structure is shown
- ❑ Completed *existing* topo

: _____/10 Points. Water Resources

- ❑ Estimates of water needed and waste water generated are calculated

_____/10: _____/15 Points. Environmental Considerations – Green Buildings and Site Development

- ❑ "Green" Requirements outlined
- ❑ Target certification identified
- ❑ Table provided listing means to attain target certification
- ❑ Impact on cost of building addressed

_____/10: _____/10 Points. Construction Management Schedule

- ❑ Major categories of consideration outlined

❑ **_____/10: _____/15 Points. Existing Traffic Counts**

Figure 2 Portion of the grading rubric for 35% design submission

management schedule) shows a portion of the grading cut sheet from the 35% design submission as an example (modified from rubrics used at the United States Military Academy[16]). The major technical features of the experience are depicted in Table 5 with slight modifications based on the actual project.[14] The grading of the senior design is

accomplished by the assigned instructor and the discipline expert in the department for each section. The industry partner reviews the design using the rubrics for comment during the presentation and final submission.

Table 5 Major senior technical design project activities

	10%	35%	100%
Structural	-Gravity Scheme Lay-out	-Loads Estimation -LLRS System Lay-out	-Complete Gravity System Design (decks, beams, girders, columns, connections, baseplates) -Complete LLRS System Design
Geotech	-Identification of soil types	-Foundation System Identification	-Complete Foundation Design (slab, spread footings, etc.)
Transportation	-Existing traffic lay-out drafting -Identification of potential affected intersections	-Existing Traffic Counts -Estimates of New Traffic Generated -Parking Lot Sizing/Location	-Traffic Impact Study -Intersection Signal Warranting -Intersection Re-design -Parking Lot Detailing
Environmental	-ESA1	-"Green Building" Compliance -Asbestos Investigation -SWPPP	-Grit Trap Design -Asbestos Abatement Plan
Hydrology / Water Resouces	-Run-off Calcs for Existing Site	-Run-off Calcs for Proposed Site -Proposed New Contours -Water/wastewater demands	-Design of all run-off abatement structures
Construction Management	-Cost Estimate -Long-Lead Items	-Cut/Fill Diagrams -Construction Schedule -Cost Estimate	-Billable hours for engineering activities -Final Schedule -Final Cost -Grading Plan
Surveying	-Site Survey	-Utilities Location and Mapping	

3.0 Assessment Activities and Results

3.1 CENG 4341

The students felt that their understanding of professional topics improved due to the discussions in class on defining these skills, how these skills were applied first in their internships and analysis of their supervisors and companies, and then applying their understanding to their senior design teams improved their understanding and use of the newly acquired skills. Figure 3 displays the Fall 2007 (071S) and 2008 (081S) and Spring 2010 (092S) data of the students perception of how well they understood and demonstrated the new professional skills within the CE program criteria. Student

comments from Fall 2007 pointed to the need to increase the number of papers of smaller length to allow greater specificity for each paper when wrestling with the numerous topics within the course. They also asked for case studies and guest speakers.[12] The suggestions were applied during the next offering of the course with the resulting improvements (081S, Figure 3). Additionally, it must be noted that teaching the course the second time could have had some effect on the results. Student comments on the leadership section highlighted the limited ability to reflect on what was happening within the capstone teams (CENG 4115) with the leadership portion at the beginning of the fall semester, so CENG 4341 was moved to the spring semester of the senior year (Figure 1) and the second environmental engineering course was moved to the fall so that a portion of its key content is covered prior to fall FE exam. Even though the course was moved to the spring and the instructor taught three courses during that semester, the results stayed fairly consistent with the ability to apply leadership principles being rated the highest (Figure 3).

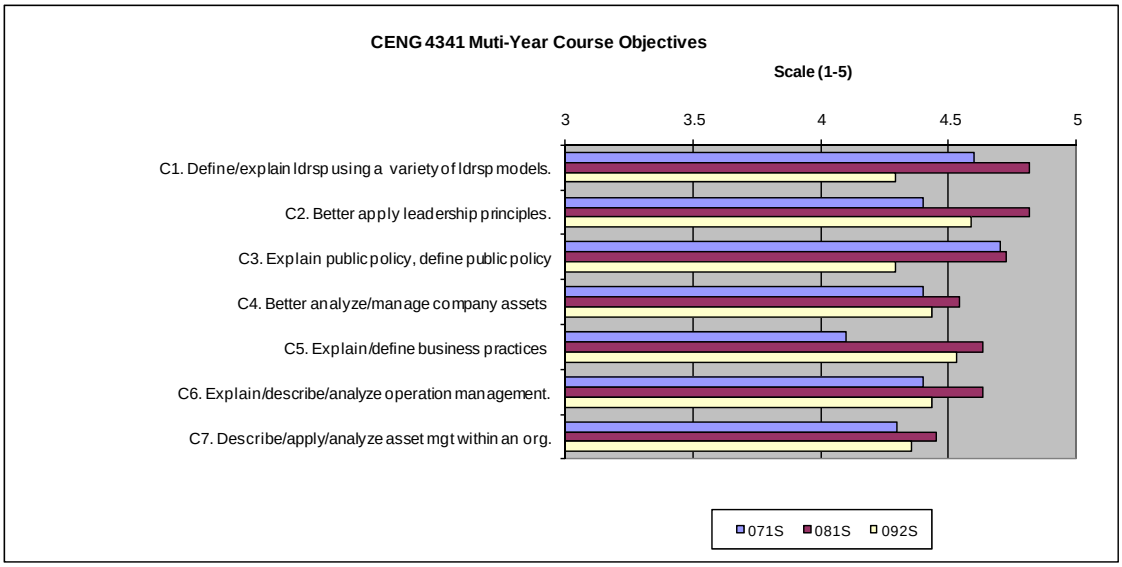

Figure 3 CENG 4341 Course Objectives Assessment

3.2 Senior Design

As noted, the UT Tyler CE program has embraced the 'embedded indicator' approach to assessment (supplemented by several other methods of assessment). However, in a large, open-ended design project, dilemma results – if too many separate submissions are required, this can cause the problem to be over-defined. A large part of open-ended design problems is that students must develop skills to properly define the scope and natural breaking points of the problem themselves. Assessment methods requiring subdividing the project into multiple predefined problem sets were thus eliminated. Furthermore, grading, managing and providing feedback to multiple student design teams as they pursue different solution strategies is already a time consuming endeavor for the

course director. The program administrator strongly desired an assessment method that did not add an undue administrative burden on to the course director.

Fortunately the faculty were able to evaluate a process followed at USMA for assessing their capstone course that focused heavily on 4 CE sub-disciplines.[16] Inspired by the USMA approach, the UT Tyler CE Program created a matrix that tied specific portions of the grade to specific program outcomes while covering 7 CE sub-disciplines. Items on each cut-sheet (Figure 2) were linked in the matrix to one or more program outcomes. As each item in a cut-sheet is graded, these grades accumulate in 'buckets' for each outcome. Appendix I depicts an excerpt of the matrix showing the activities accumulating in the 9c-9e bucket (construction management, business practices, and public policy and administration). The benefits of this approach are numerous:

(1) The overall weight of grade that is ultimately assigned to each program outcome can be readily identified. Like most of us, students typically focus their efforts where they identify the greatest impact on their grade can be made (i.e. the activities with the most points assigned). Thus, a review of all of the points assigned to each program outcome can reveal if areas without enough focused attention exist within the capstone. Of course this must be done in conjunction with other methods of assessment that look at the whole program. Sometimes areas that are covered extensively in other areas of the program must be lightly covered in the capstone to allow effort to be expended elsewhere.
(2) Areas where students achieve below an accepted standard of performance can be readily identified. Within the UT Tyler CE Program the performance standard is set as 70% - scores above the threshold are considered to demonstrate successful completion of an outcome. This allows a simple determination of which program outcomes need more attention within the program.

Appendix II shows the assessment matrix from 2007-2008, 2008-2009, and 2009-2010. It is shaded in several ways to show key features related to the two points noted above (color scheme within titles). The overall points allocated to a particular outcome is coded to show outcomes below 50 and 100 points (note that the exact number of points for this threshold is somewhat arbitrary and can vary from year to year depending on the overall points for the senior design project) to clearly show areas with minimal points assigned that need more emphasis in future years.

3.3 Assessment Results

Since the senior design experience is being used to try and assess all program outcomes, this allows points to be shifted to better reflect a distribution of points and desired effort across the outcomes. Additionally, the percentages earned by each design team and overall are shaded differently for scores below and above 70% and above 80%.

This methodology allows a quick determination of areas where students do not achieve an acceptable standard on an outcome, and areas where students are excelling in achieving outcomes. Note, the format changed in Table 6 from 2007-2008 to 2008-2009 because of the program's assessment of the assessment process and how the data should be displayed. Only small modifications to the format occurred for 2009-2010 assessment.

The strength of this approach is perhaps best illustrated by discussing the changes made as a result of this assessment vehicle. Several major changes to the course sequence from year 1 (2007) to year 2 (2008) to year 3 (2009) are highlighted:

(1) More Transportation Requirements Needed (Outcome 5b): In 2007-2008, the rubric clearly showed that the transportation sub-discipline was not well represented in the project. With the clarity engendered by the matrix, this was simple to identify, and the next year's design experience included intersection signal warranting, intersection redesign and parking lot/garage layout and lane configuration. 2010-2011 project is a road design.
(2) More Planning Experiments and Data Analysis Needed (Outcome 2): After the rubric showed lack of emphasis on these skills in 2007-2008, students were tasked with planning, executing and analyzing existing traffic counts around their site in 2008-2009. Additional effort was also included as part of asbestos abatement plan development.
(3) More Emphasis Needed in Recognition of Strengths and Areas for Improvement in Creative Designs (Outcome 3b): After noting this deficiency in 2007-2008, it was deemed to be an assessment issue rather than a content issue. Students were already wrestling with 9 primary engineering constraints – this effort was added to the next year's assessment matrix.
(4) More Emphasis Needed in Professional Practice Skills (Outcomes 4, 6-9): Faculty not totally pleased with overall professional skills development in 2008-2009, increased total points in outcomes 4 and 6-9 and moved CENG 4341 to spring semester.

The program has always had a structural steel design course to meet local structural design needs (Fig. 1). The faculty realized early that there was a need to cover reinforced concrete concepts within the curriculum somewhere to support not only structural needs, but geotechnical, water resources, and environmental design needs. The only place to include concrete design was as technical lessons within senior design. However, assessment from alumni, employers and the external advisory committee noted that the graduates needed to show coverage of reinforced concrete on their transcript to validate coverage for employers. The program decided to develop a four-credit hour reinforced concrete and steel design course to replace the three-hour structural steel course rather than add another structural course to the curriculum. Since ASCE is looking for breadth at the undergraduate level (BOK I and II), the program considers assessment input while maintaining a balance of CE sub-disciplinary courses (Figure 1).

The movement of concrete topics out of the senior design and the increased coverage of key topics in senior design courses on environmental, geotechnical, transportation, and water resources due to changes in response to annual course and program assessments have opened time slots within the senior design experience. Experience actually teaching CENG 4341 has provided insight into maximum efficient coverage required to meet professional practice program outcomes. With the requirement to possibly decrease the number of credit hours, the program is analyzing the conversion of ten hours on leadership in CENG 4341 to five hours with three in CENG 4115 and two in CENG 4315. Public policy could be completely covered in the two course environmental sequence with one hour in CENG 4315 to ensure a proper focus in the senior design solution on the current public policy issues. The program could convert ten hours on business practices in CENG 4341 to five lessons culminating in each team developing a business plan as part of the 100 percent submission in CENG 4315. The program could convert eight hours on asset management to four hours culminating in each team developing a construction management plan as part of the 35 and 100 percent submissions in CENG 4315 that includes management of people within the team. Some of the individual assignments from CENG 4341 will be used within the senior design to ensure each student can demonstrate accomplishment of the outcome before the team uses their skills to accomplish a team product within senior design. The increased requirements within the senior design coverage of the professional outcomes will be reflected with increased point totals.

Appendix III presents a representative excerpt from the annual program assessment for professional outcomes where the results of each assessment method are collated to allow an aggregate review of each outcome. As can be seen the outcome assessment within CENG 4341 and senior design are critical pieces demonstrating accomplishment of the professional outcomes. With forethought, the inclusion of individual assignments from CENG 4341 to be required within the senior design and the use of current senior design grading rubrics can lead to assessment data used within the annual assessment with little additional effort once the assessment tool is modified. Note also the use of survey results as part of the multiple assessment methods used to provide a clearer picture. Due to the age of the department, the survey data is from alumni and employees within one year of graduation.

3.4 Results

The portion of the author's CE program relating to the professional outcomes as discussed and measured wth the author's own measurement parameters shows students meeting the outcomes – success? The program has been able to adequately demonstrate knowledge, skills and attitudes associated with professional topics demonstrated within CENG 4341, the senior design experience and other senior year courses. The program continues to fully integrate professional topics across the curriculum and has already seen improvement in student skill development within each group of seniors as compared to the previous graduating classes. As can be seen from Appendix II, there were three professional outcomes below 80 percent and two with below 50 points in 2008-2009 compared with only one outcome with a result barely less than 80 percent and two with

less than 100 points in 2009-2010. The students are simply more comfortable with using their new skills due to more required repetition and focus. The CE program has determined that the best method to integrate and assess demonstration of professional skills is to insert embedded indicators in appropriate courses. Actual requirements to consider defined professional skills are needed within the sophomore and junior years, while the seniors must address the professional skills within the 10, 35, and 100 percent submittals.

The review of embedded indicators collected through May 2010 resulted in a 100 percent increase in embedded indicators for many of the professional topics in 2008-2009 and a slight decrease in embedded indicators in 2009-2010 (example 6 to 5, Table 6 vs. Table 4). The key has been identification of the required embedded indicators for each course before the assessment cycle begins and for each faculty member to establish which assignments before the semester begins will include demonstration of program outcomes, but especially professional outcomes like leadership, the impact of engineering solutions, consideration of contemporary issues, etc. Adequate thought is required to craft assignments that not only demonstrate course objectives that feed seamlessly into demonstrating the "hard" outcomes like design, modern tools, etc., but especially to demonstrate "professional" outcomes.[17]

Table 6 Current Assigned Embedded Indicators

Outcome 9c: Can explain management concepts and processes.				
Direct Measures	Tab	Standard	2009-10 Performance	Historical Average
CENG 4339, HW 3, Pr 2	1	80.0	81	
CEG 4339, Final Exam, Question #26 (cradle t grave management)	2	80.0	99.0	100
CENG 4341, Paper 8 (Six Sigma, Eliminate waste	3	80.0	89.7	
CENG 4341, Exam 3, Question 3 (Lean Six Sigma applied to a scenario)	4	80.0	88.8	
CENG 4341, Final Exam Question (Lean Six Sigma, Eliminate waste)	5	80.0	94.5	81.7
CENG 4315, 100% Submittal		80.0	87.2	86.9

4.0 Current actions

The faculty are experimenting with Public Policy coverage in the two course environmental sequence (CENG 3371 and 4371) since much of environmental activity is grounded in past and present public policy. Since the current level of Bloom's taxonomy for these three outcomes is Explain (PO 9, Table 1)[1,2] which could be covered by 2-3 lesson blocks rather than the current use of a 10 lesson block, the program is studying if the minimal coverage of leadership, business practices, and asset management within the senior design two-course sequence as listed in Section 3.3 of this paper as well as possible additional embedded indicators within prior courses will be satisfactory. The

entire modulization of certain professional outcomes allows the program to consider accreditation of its masters program as well.[11] Without it, any student wanting to graduate from an accredited program would need to complete the undergraduate program before starting the graduate program to ensure coverage of all of the outcomes. Requiring accomplishment of modules will allow students without an accredited undergraduate degree to take the accredited graduate degree and complete modules for outcomes not covered within their previous undergraduate program. This methodology will allow modules to be moved between courses without affecting the overall course structure or focus, while providing the program flexibility to meet defined outcomes as the technical body of knowledge advances and faculty skills improve. Since many non-accredited degrees do not require a capstone experience, the senior design will be ideal to provide demonstrated accomplishment of many outcomes with the insertion of individual assignments; thereby, decreasing the number of leveling courses and modules required by graduate students from non-ABET accredited undergraduate programs.

The initial effort to develop the matrix of coverage of professional skill outcomes for graduate leveling is shown in Table 7. The level of detail is whether a course or a module within a current course is required. As can be seen, the movement of condensed modules from CENG 4341 into the senior design experience is efficient, especially with the decrease in technical lessons currently needing to be covered in the senior design.

Table 7 Professional Outcome Matrix versus Course or Module

Outcome	**Course or Module**
Professional	
Communication	English I and II, paper and presentation in each graduate course
Public Policy	Module in CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management (moving to CENG 3371 Intro to Environmental Engineering)
Business and Public Administration	Module in CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management (moving to CENG 4315 Senior Design II)
Globalization	Senior Design, Module in ENGR 4109 Senior Seminar (to be completely covered in CENG 4315senior design)
Leadership	Module CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management, CENG 4115/4315 Senior Design (Moving completely to CENG 4115/4315 Senior Design)
Teamwork	CENG 4115/4315 Senior Design, projects in senior level design courses (CENG 4412, CENG 4351, CENG 4371, CENG 4381, etc.) (remain the same)
Attitudes	Module in CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management, CENG 4115/4315 Senior Design (Move completely to CENG 4115/4315 Senior Design)
Lifelong Learning	Projects in senior level design courses (CENG 4412, CENG 4351, CENG 4371, CENG 4381, etc.), CENG 4115/4315 Senior Design (remain the same)
Professional and Ethical Responsibility	Module in CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management, CENG 4115/4315 Senior Design (Move completely to CENG 4115/4315 Senior Design)

However, there will be a need for students to complete individual assignments on each professional outcome prior to applying in a team setting to ensure each graduate can demonstrate each outcome.

Many programs experience problems within the design experience and the PEV noted that the coverage of seven CE sub-disciplines and the assessment process working toward coverage and assessment of all outcomes within the senior design was the best he had seen in all of his numerous visits. The fact that the students must address demonstration of their skills for each outcome truly brings the entire process together and reinforces what skills they must have at the time of graduation. The comments have been reinforced by the engineering firms who have reviewed the senior design documents and provided comments on the wonderful design experience by the UT Tyler CE students. Increasing coverage of professional skills within the senior design will only strengthen the senior design since professional skills are critical during the design process and the profession has been active in demanding more professional skill development as evident with the additional outcomes generated from BOK I[1] and the increased level of Bloom's for professional skills within BOK II.[5]

5.0 Conclusions/Lessons Learned

The faculty team must determine together the courses that should be able to provide an embedded indicator for each program outcome. However, this is usually not enough; each professor must also develop a plan before the semester starts as to which assignments within the course will contain an embedded indicator. If the plan is not fully developed prior to the start of the semester, the normal day-to-day activities may (usually will) inhibit quality development of embedded indicators or prevent collection of embedded indicators that leaves some program outcomes without adequate demonstration of accomplishment. This is especially true for some of the professional outcomes which appear harder to demonstrate than other outcomes.

Currently the UT Tyler Civil Engineering program has successfully implemented a single synergistic course CENG 4341 Leadership, Public Policy, Business Practices, and Asset Management which includes multiple modules to demonstrate many of the professional outcomes. The offering of this course along side of the senior design allows for the students to wrestle with the concepts using their senior design experience as the focus. The single course provided a rapid solution to properly demonstrate multiple outcomes that do not naturally align with traditional technical courses. The experience has also enlightened the faculty to the possible use of modules to successfully level graduate students desiring an ABET accredited graduate degree without graduating from an ABET accredited undergraduate program.[10]

The current thought of moving accomplishment of the professional outcomes from CENG 4341 into the senior design would allow for the removal of CENG 4341 as the program wrestles with a possible mandated decrease in credit hours from 128 to 120. Additional embedded indicators for the professional outcomes in sophomore and junior level courses might be required to ensure multiple opportunities to apply skills and

develop confidence before the senior design since one of the opportunities maybe deleted (CENG 4341). The senior design is a solution in this process and as shown above can assess all outcomes rather than just multi-disciplinary design alone.

The senior design is already being taught and each assignment is being assessed. Once developed, the evaluation rubric only needs to be modified each year to improve the balance of points between outcomes. Many faculty within the UT Tyler CE Program are now part of the senior design grading since the design usually includes all seven traditional sub-disciplines of CE. Therefore, besides preparing the course assessment documents and filing embedded indicator data, the faculty is generally left to manage research and their courses with the exception of being part of the team to assess the collection of embedded indicators and senior design results at the end of each academic year.

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Appendix I. Matrix 'bucket' for program outcome 9c-9e (portion of CE Program Criteria Professional Outcomes). Dark Green – Acceptable, Light Green – Not enough points as assigned, Yellow – Marginal, Red – Not Acceptable, #Div/0! – highlights items not currently considered

9c	10%R Long Lead	0	/	5	0.0	**10%R**	8	0	14	57.1
	10%R Cost Estimate	8	/	9	88.9	**35%**	5	/	5	100.0
	35% Cost Estimate	5	/	5	100.0	**65%**				
	100% Cost	5	/	5	100.0	**100%**	5	/	5	100.0
	35% OP Prep	30.0		40.0	75.0	**35% Oral**	72.0		90.0	80.0
	35% OP Method	42.0		50.0	84.0	**100% Oral**	47.5		55.0	86.4
	100% OP Prep	21.3		25.0	85.0	**Total**	137.5	/	169	81.4
	100% OP Method	26.3		30.0	87.5					
9d	10%R Client Meetings	7.2		15.0	48.0	**10%R**	20.2	0	29	69.7
	10%R Cost Estimate	8.0	/	9.0	88.9	**35%**	19.5	0	20	97.5
	10%R Documentation	5.0	/	5.0	100.0	**65%**				
	35% Cost Estimate	5.0	/	5.0	100.0	**100%**	19	0	20	95.0
	35% Constraint (Econ)	4.5		5.0	90.0	**35% Oral**	122.0	0	150.0	81.3
	35% Documentation	10.0	/	10.0	100.0	**100% Oral**	66	0	75	88.0
	100% Title Block	4.0	/	5.0	80.0	**Total**	246.7	/	294	83.9
	100% Electronic Submission	5.0	/	5.0	100.0					
	100% Constrain (Econ.)	5.0		5.0	100.0					
	100% Cost	5.0	/	5.0	100.0					
	35% OP Prep	30.0		40.0	75.0					
	35% OP Method	42.0		50.0	84.0					
	35% OP Disc. Of Design	50.0		60.0	83.3					
	100% OP Prep	21.3		25.0	85.0					
	100% OP Method	26.3		30.0	87.5					
	100% OP Disc. Of Design	18.5		20.0	92.5					
9e	10%R Set-backs	0.0	/	5	0.0	**10%R**	18.4	0	29	63.4
	10%R Access/Eggress	2.4	/	5	48.0	**35%**	73.6	0	86	85.6
	10%R ESA1 not used in 2010	0.0	/	0	#DIV/0!	**65%**				
	10%R Life Safety	8.0	/	10	80.0	**100%**	34.2	0	38.2	89.5
	10%R Constraint (Politics)	3.0		4	75.0	**35% Oral**				
	10%R ADA	5.0		5	100.0	**100% Oral**				
	35% Trees-Setbacks	1.0	/	1	100.0	**Total**	126.2	/	153.2	82.4
	35% Life Safety	4.0	/	5	80.0					
	35% Green Buildings	11.0		15	73.3					
	35% Constraint (Politics)	4.6		5.0	92.0					

35% ESA 1	23.0	/	25.0	92.0
35% SPPP	30.0	/	35	85.7
100% setbacks	0.2	/	0.2	100.0
100% Life Safety	3.0	/	3	100.0
100% Env. Green Bldgs	11.0	/	15	73.3
100% Asbestos Not Used 2010				#DIV/0!
100% Constrain (Politics)	5.0		5.0	100.0
100% Social, Politica	15.0	/	15	100.0

Appendix II Assessment matrix: (a) 2007-2008; (b) 2008-2009; (c) 2009-2010.

(a) Dark Green – Acceptable, Light Green – Not enough points as assigned, Yellow – Marginal, Red – Not Acceptable, #Div/0! – highlights items not currently considered

	BS			NU			Average		
	Raw	Avail	Avg	Raw	Avail	Avg	Raw	Avail	Avg
1a	130.0 /	157.0	82.8	130.0 /	157.0	82.8	130.0 /	157.0	82.8
1b	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!
1c	193.0 /	225.0	85.8	195.5 /	225.0	86.9	194.3 /	225.0	86.3
1d	493.2 /	633.2	77.9	492.1 /	633.2	77.7	492.7 /	633.2	77.8
2	44.5 /	61.0	73.0	42.4 /	61.0	69.5	43.4 /	61.0	71.2
3a	195.0 /	206.0	94.7	175.3 /	206.0	85.1	185.1 /	206.0	89.9
3b	10.0 /	10.0	100.0	9.3 /	10.0	92.7	9.6 /	10.0	96.4
4	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!
5a	333.4 /	438.8	76.0	329.6 /	438.8	75.1	331.5 /	438.8	75.5
5b	32.3 /	51.3	62.9	31.2 /	51.3	60.8	31.7 /	51.3	61.9
5c	153.3 /	177.8	86.2	148.4 /	177.8	83.5	150.8 /	177.8	84.9
5d	139.7 /	169.7	82.3	140.0 /	169.7	82.5	139.8 /	169.7	82.4
5e	111.4 /	118.3	94.2	97.3 /	118.3	82.3	104.4 /	118.3	88.2
6a	402.2 /	440.4	91.3	369.9 /	440.4	84.0	386.1 /	440.4	87.7
6b	50.0 /	55.0	90.9	49.8 /	55.0	90.5	49.9 /	55.0	90.7
7	593.7 /	643.7	92.2	542.4 /	643.7	84.3	568.1 /	643.7	88.3
8a	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!
8b	113.8 /	125.0	91.0	112.4 /	125.0	89.9	113.1 /	125.0	90.5
8c	114.5 /	126.2	90.7	113.1 /	126.2	89.6	113.8 /	126.2	90.1
9a	436.7 /	475.4	91.9	387.8 /	475.4	81.6	412.3 /	475.4	86.7
9b	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!
9c	171.1 /	180.9	94.6	143.4 /	180.9	79.3	157.3 /	180.9	86.9
9d	271.9 /	290.4	93.7	236.3 /	290.4	81.4	254.1 /	290.4	87.5
9e	111.2 /	124.2	89.5	105.8 /	124.2	85.2	108.5 /	124.2	87.4

(b) Light Green – Acceptable, Yellow – Marginal, Red – Not Acceptable, #Div/0! – highlights items not currently considered

Outcome	Sekai			AAA			GMC			Average		
	Raw	Avail	Avg	Raw	Avail	Avg	Raw	Avail	Avg	Raw	Avail	Avg
1a	139.0 /	152.0	91.4	145.0 /	152.0	95.4	140.7 /	152.0	92.6	141.6 /	152.0	93.1
1b	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!
1c	192.1 /	220.0	87.3	205.0 /	220.0	93.2	197.1 /	220.0	89.6	198.1 /	220.0	90.0
1d	593.8 /	668.2	88.9	592.2 /	668.2	88.6	541.7 /	668.2	81.1	575.9 /	668.2	86.2
2	101.8 /	131.0	77.7	75.8 /	131.0	57.9	95.4 /	131.0	72.8	91.0 /	131.0	69.5
3a	253.6 /	281.0	90.2	230.6 /	281.0	82.1	229.3 /	281.0	81.6	237.8 /	281.0	84.6
3b	114.5 /	135.0	84.8	114.7 /	136.0	84.4	128.8 /	135.0	95.4	119.4 /	135.0	88.2
4	1061.3 /	1285.1	82.6	1035.7 /	1285.1	80.6	1069.0 /	1285.1	83.2	1055.3 /	1285.1	82.1
5a	415.2 /	450.5	92.2	420.1 /	450.5	93.2	383.3 /	450.5	85.1	406.2 /	450.5	90.2
5b	138.2 /	199.6	69.2	118.3 /	199.6	59.3	181.7 /	199.6	91.0	146.1 /	199.6	73.2
5c	234.8 /	294.0	79.9	218.2 /	294.0	74.2	232.0 /	294.0	78.9	228.3 /	294.0	77.7
5d	137.2 /	178.0	77.1	161.1 /	178.0	90.5	134.6 /	178.0	75.6	144.3 /	178.0	81.1
5e	136.0 /	163.0	83.4	118.0 /	163.0	72.4	137.3 /	163.0	84.3	130.4 /	163.0	80.0
6a	445.7 /	535.0	83.3	450.0 /	536.0	84.0	448.2 /	535.0	83.8	448.0 /	535.0	83.7
6b	34.0 /	39.0	87.2	33.8 /	39.0	86.6	36.1 /	39.0	92.5	34.6 /	39.0	88.8
7	626.4 /	672.0	93.2	590.3 /	672.0	87.8	572.2 /	672.0	85.1	596.3 /	672.0	88.7
8a	15.0 /	20.0	75.0	14.0 /	20.0	70.1	16.3 /	20.0	81.3	15.1 /	20.0	75.4
8b	99.0 /	110.0	90.0	188.0 /	246.0	76.4	215.0 /	245.0	87.8	167.3 /	245.0	84.7
8c	131.3 /	159.2	82.5	115.0 /	159.2	72.2	133.0 /	159.2	83.5	126.4 /	159.2	79.4
9a	482.2 /	545.0	88.5	484.1 /	545.0	88.8	444.7 /	545.0	81.6	470.3 /	545.0	86.3
9b	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!	0.0 /	0.0	#DIV/0!
9c	167.2 /	189.0	88.5	167.4 /	189.0	88.6	159.6 /	189.0	84.5	164.8 /	189.0	87.2
9d	279.8 /	314.0	89.1	278.3 /	314.0	88.6	264.3 /	314.0	84.2	274.1 /	314.0	87.3
9e	132.2 /	163.2	81.0	120.0 /	163.2	73.5	130.9 /	163.2	80.2	127.7 /	163.2	78.2

(c) Dark Green – Outstanding, Light Green – Acceptable, Yellow – Marginal, Red – Not Acceptable, #Div/0! – highlights items not currently considered

Outcome	FAMM			E9			Base			JDOT			Average		
	Raw / Avail	Avg		Raw / Avail	Avg		Raw / Avail	Avg		Raw / Avail	Avg		Raw / Avail	Avg	
1a	126.0 / 152.0	82.9		149.0 / 152.0	98.0		124.0 / 152.0	81.6		136.5 / 152.0	89.8		133.9 / 152.0	88.1	
1b	0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!	
1c	188.0 / 220.0	85.5		210.0 / 220.0	95.5		185.0 / 220.0	84.1		195.5 / 220.0	88.9		194.6 / 220.0	88.5	
1d	571.6 / 668.2	85.5		586.7 / 668.2	87.8		489.6 / 668.2	73.3		587.8 / 668.2	88.0		558.9 / 668.2	83.6	
2	78.5 / 91.0	86.3		73.5 / 91.0	80.8		56.5 / 91.0	62.1		82.5 / 91.0	90.7		72.8 / 91.0	79.9	
3a	241.2 / 281.0	85.8		202.0 / 281.0	71.9		204.5 / 281.0	72.8		245.0 / 281.0	87.2		223.2 / 281.0	79.4	
3b	115.5 / 136.0	84.9		129.8 / 136.0	95.4		118.0 / 136.0	86.8		119.3 / 136.0	87.7		120.6 / 136.0	88.7	
4	968.4 / 1152.1	84.1		951.5 / 1152.1	82.6		912.3 / 1152.1	79.2		1007.6 / 1152.1	87.5		959.9 / 1152.1	83.3	
5a	397.8 / 445.5	89.3		389.3 / 445.5	87.4		342.4 / 445.5	76.8		388.9 / 445.5	87.3		379.6 / 445.5	85.2	
5b	145.9 / 194.6	74.9		121.2 / 194.6	62.3		148.2 / 194.6	76.2		177.9 / 194.6	91.4		148.3 / 194.6	76.2	
5c	225.9 / 259.0	87.2		226.0 / 259.0	87.3		227.6 / 259.0	87.9		233.0 / 259.0	90.0		228.1 / 259.0	88.1	
5d	190.0 / 243.0	78.2		207.0 / 243.0	85.2		186.1 / 243.0	76.6		200.0 / 243.0	82.3		195.8 / 243.0	80.6	
5e	150.9 / 183.0	82.4		166.0 / 183.0	90.7		145.6 / 183.0	79.6		177.9 / 183.0	97.2		160.1 / 183.0	87.5	
6a	459.3 / 541.0	84.9		470.1 / 541.0	86.9		468.2 / 541.0	86.5		490.1 / 541.0	90.6		471.9 / 541.0	87.2	
6b	62.0 / 89.0	69.7		89.0 / 89.0	100.0		75.5 / 89.0	84.8		57.0 / 89.0	64.0		70.9 / 89.0	79.6	
7	500.9 / 662.0	75.7		582.9 / 662.0	88.1		490.6 / 662.0	74.1		607.6 / 662.0	91.8		545.5 / 662.0	82.4	
8a	60.0 / 60.0	100.0		56.0 / 60.0	93.3		52.0 / 60.0	86.7		60.0 / 60.0	100.0		57.0 / 60.0	95.0	
8b	231.0 / 271.0	85.2		254.0 / 271.0	93.7		225.5 / 271.0	83.2		254.5 / 271.0	93.9		241.3 / 271.0	89.0	
8c	156.7 / 184.2	85.1		167.2 / 184.2	90.8		148.4 / 184.2	80.6		177.7 / 184.2	96.5		162.5 / 184.2	88.2	
9a	404.7 / 525.0	77.1		455.6 / 525.0	86.8		395.6 / 525.0	75.4		462.2 / 525.0	88.0		429.5 / 525.0	81.8	
9b	0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!		0.0 / 0.0	#DIV/0!	
9c	143.1 / 169.0	84.7		137.4 / 169.0	81.3		137.5 / 169.0	81.4		151.8 / 169.0	89.8		142.4 / 169.0	84.3	
9d	256.8 / 294.0	87.3		241.1 / 294.0	82.0		246.7 / 294.0	83.9		262.6 / 294.0	89.3		251.8 / 294.0	85.6	
9e	122.6 / 153.2	80.0		125.2 / 153.2	81.7		126.2 / 153.2	82.4		140.3 / 153.2	91.6		128.6 / 153.2	83.9	

Appendix III Performance measures and results for Outcomes 9c-9e.

a. 2009-10 performance measures and results for CE program outcome 9c.

Outcome 9c: Can explain management concepts and processes.				
Direct Measures	Tab	Standard	2009-10 Performance	Historical Average
CENG 4339, HW 3, Pr 2	1	80.0	81	
CEG 4339, Final Exam, Question #26	2	80.0	99.0	100
CENG 4341, Paper 8	3	80.0	89.7	
CENG 4341, Exam 3, Question 3	4	80.0	88.8	
CENG 4341, Final Exam Question	5	80.0	94.5	81.7
CENG 4315, 100% Submittal		80.0	87.2	86.9
Indirect Measures		Standard	2009-10 Performance	Historical Average
Question A22. Senior survey		4/5	4.4/5	4.35/5
Question A22. Faculty survey		4/5	4.2/5	4.0/5
Question A22. Alumni survey		4/5	4.6/5	4.2/5
Question A22. Employer survey		4/5	4.5/5	3.75/5
Curriculum Measures		Standard	2009-10 Performance	Historical Average
Completion of CENG 4341, CENG 4339		5	5	5
2009-10 Assessment: 4+ (Remained the same)				

b. 2009-10 performance measures and results for CE program outcome 9d.

Outcome 9d: Can explain concepts of business practice.				
Direct Measures	Tab	Standard	2009-10 Performance	Historical Average
Ethics and Business Practices portion of F.E. exam		83[80]	74 (-9)[-6]	(-10)
CENG 4339, Final Exam Pr. 13	1	80.0	84.0	88.0
CENG 4341, Paper 7	2	80.0	89.4	89.8
CENG 4341, Exam #3, Question 1	3	80.0	94.8	92.3
CENG 4341, Final exam, Question 3	4	80.0	85.8	88.6
CENG 4315, 100% Submittal		80.0	85.6	87.4
Indirect Measures		Standard	2009-10 Performance	Historical Average
Question A23. Senior survey		4/5	4.3/5	4.4/5
Question A23. Faculty survey		4/5	4.2/5	4.0/5
Question A23. Alumni survey		4/5	4.5/5	4.2/5
Question A23. Employer survey		4/5	4.5/5	3.45/5
Curriculum Measures		Standard	2009-10	Historical

			Performance	Average
Completion of CENG 4341, CENG 4339		5	5	5
Completion of ECON 2302				

2009-10 Assessment: 4+ (Remained the same)

c. 2009-10 performance measures and results for CE program outcome 9e.

Outcome 9e: Can explain public policy and public administration.				
Direct Measures	Tab	Standard	2009-10 Performance	Historical Average
CENG 4341, Paper 5	1	80.0	78.0	87.8
CENG 4341, Paper 6	2	80.0	80.0	85.5
CENG 4341, Exam#2, Question 1	3	80.0	88.5	91.5
CENG 4341, Final Exam Question	4	80.0	79.7	86.9
CENG 4351, Project#1	5	80.0	88.1	94.3
CENG 3371, Exam 1, Question1	6	80.0	79.5	
CENG 4315, 100% Submittal		80.0	83.9	82.8
Indirect Measures		Standard	2009-10 Performance	Historical Average
Question A24. Senior survey		4/5	4.3/5	4.55/5
Question A24. Faculty survey		4/5	4.0/5	3.9/5
Question A24. Alumni survey		4/5	4.8/5	4.4/5
Question A24. Employer survey		4/5	4.5/5	3.2/5
Curriculum Measures		Standard	2009-10 Performance	Historical Average
Completion of CENG 4341 CENG 4351		5	5	5
Completion of CENG 4371, POLS 2305/2306, HIST 1301/1302				

2009-10 Assessment: 4 (4+ last year)