AC 2010-1448: ASSESSMENT OF ABET 3 A-K IN AN OPEN-ENDED CAPSTONE?

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Abstract

The University of Texas at Tyler Department of Civil Engineering is a relatively new CE program; graduating its first class in 2008 and achieving its first ABET accreditation in 2009 (retroactive to 2008). The senior design experience was conceived as one that touches seven sub-disciplines of civil engineering – hydrology, structures, transportation, environmental, geotechnical, construction management, and surveying, and is organized around a major project design (building and site development, bridge and roadway design, etc.) from initial needs gathering in client interviews through completion of the 100% design activities. The Civil Engineering program took the position that all of the program outcomes could be assessed during the two-semester senior design experience. Through the sequencing of events and assessments of 10%, 35%, and 100% design package submittals and oral presentations of their design results, students should be able to demonstrate their abilities associated with all of the ABET 3 a-k outcomes. Assessment of this type of senior design experience coupled with selected embedded indicators in all other courses, survey data, and Fundamental Exam results provides a clear picture of the actual demonstrated performance of an outcome 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 teams and the entire cohort have achieved the proper level of demonstration of an outcome by performance level and percentage of overall grade. A large portion of this assessment process involved matching graded activities with specific ABET outcomes, weighting the importance of each activity toward demonstration of outcome accomplishment, and evaluating accomplishment based on grade percentages. A time consuming, but well conceived upfront process yielded valuable program assessment results that could be compiled in a reasonable time frame.

The process, rubrics, data collected over two cycles, assessment of the results and changes instituted is presented. The program results of the 2008 fall ABET visit will be presented as well as how the use of the senior design as an assessment of ABET 3 a-k was viewed by the program evaluator and effected the overall program results.

1.0 Introduction

The Department of Civil Engineering began hiring faculty and admitting students in 2005. The students who made up the first graduating class in 2008 were actually admitted into the mechanical engineering program in 2004 with the anticipation of hiring the first CE faculty member. There were twelve students declared as Civil Engineering (CE) students before the department officially existed. These students were on the path to a May 2008 graduation. The timing could not have been better considering that the next scheduled ABET visit for UT Tyler was fall 2008 based on the first ever ABET accreditation visit for UT Tyler in 2002 for the electrical and mechanical programs. A program must have at least one graduate to be considered for accreditation at the time of the ABET visit. Therefore, only one student needed to make it to graduation – ten students walked across the stage in May 2008.

With such a short time period to prepare a program for accreditation and authorization to gradually hire six faculty over a three year period of time, there was one question that had to be asked: Is program accreditation beyond the regional accreditation that exists for the university really necessary? The answer is a resounding YES if one considers the state requirements of graduation from or attendance at (senior status) an ABET accredited program to sit for the Fundamentals Exam (FE) and become an Engineer-in-Training (EIT) and engineering companies writing into contracts the need to pass the FE within 12 months of hiring (if one has not already passed the exam as a senior, but waiting for the results) which again requires graduation from an ABET accredited program to sit for the exam. Perhaps the most important reason is the first question coming from parents of potential students of a new program such as the one at UT Tyler – "When are you going to be ABET accredited?" The parents are very savvy shoppers. The simple answer was that the team being assembled had ABET accreditation as its first priority – two were ABET evaluators, three had Professional Engineering (PE) licenses, and all could teach in multiple CE sub-disciplines.

The August 2008 hire brought the faculty total to six with an average time of nine months at UT Tyler when the self-study was submitted. The faculty team had an average time of five months at UT Tyler when the ABET record year began. Can a program successfully prepare and pass an ABET visit in one and one-half years with no current assessment process in place, one tenure track assistant professor on staff (the first hire had moved on to being Dean), and teaching the senior level courses for the first time during the ABET record year? This paper does not present traditional educational research by any means, or does it? This was an experiment with high stakes as to whether a program can be built, assessed, and changes made to meet current ABET criteria and CE program criteria based on the ASCE Body of Knowledge (BOKI).[1] This was the challenge facing the new faculty in spring 2007.

To meet that challenge, the assessment process needed to be rigorous, thorough, and implemented immediately. The program did not have time to slowly add new assessment techniques, but had to rely on the experiences of the two faculty who were ABET evaluators to quickly establish the assessment techniques to include using the senior design experience and train the rest of the assembled team to seamlessly be part of the process.

The current paper focuses on providing insight into assessment of senior design activities. The senior design experience 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.
(4) Provide a platform where student performance against the ABET general criteria for engineering programs 3 a-k and civil engineering program specific criteria can be assessed.

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. The rest of this paper briefly outlines the UT Tyler CE program and overall assessment philosophy (to provide a the framework within which the senior design experience operates), describes the senior design experience, reviews the creation of a time effective assessment scheme for the experience that includes coverage of all of the ABET 3a-k outcomes, and then relates assessment data collected over the first two years. This program's approach to the thorny issue of senior design assessment is related for the purpose of providing a roadmap for others. The insight provided by external ABET evaluators is reviewed. Finally, the paper provides lessons learned regarding assessment of senior design activities.

2.0 Background – The UT Tyler CE Program

ABET provides guidelines for program educational objectives and outcomes based on best practices and the desire to turn out capable and effective civil engineering (CE) graduates.[3] However, it is still up each individual program to build an educational experience that accomplishes outcomes and positions graduates to achieve program educational objectives. The first step at UT Tyler was the development of program outcomes (PO) that would guide the program to demonstrate accomplishment of the knowledge, skills, and attitudes outlined within the first edition of the BOKI.[1] In 2005, this document, which incorporates Bloom's Taxonomy[2] to define the level of student activity, was gaining acceptance to be the basis for the next round of updates to the CE program criteria. Additionally, the momentum of Policy 465[4] and efforts to change the NCEES model law[5] had to be considered since they called for a broader undergraduate education with technical depth to be accomplished through a Masters degree or thirty credit hours of post baccalaureate study before sitting for the P.E. With an eye on the future and an image of what the East Texas constituencies were asking for, the program outcomes (Table 1) and resulting curriculum were developed (Fig 1).

Table 1: UT Tyler CE Program Outcomes

Graduates:
1. Apply knowledge of traditional mathematics, science, and engineering skills, and use modern engineering tools to solve problems.
2. Design and conduct experiments, as well as analyze and interpret data in more than one civil engineering sub-discipline.

3. 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. Work independently as well as part of a multidisciplinary design team.
5. Identify, formulate, and solve engineering design problems using engineering models in four of the five sub-disciplines civil engineering: structural engineering, transportation engineering, construction management, hydrology and/or environmental engineering.
6. Analyze a situation and make appropriate professional and ethical decisions.
7. Demonstrate effective oral, written, and graphical communication skills.
8. Demonstrate a commitment to learning and continued professional development outside the classroom, incorporate contemporary issues during problem solving, and determine the impact of engineering solutions in a global and societal context.
9. Explain professional practice attitudes, leadership principles and attitudes, management concepts and processes, and concepts of business, public policy, and public administration.

A diversion from the well known ABET criterion 3 a-k (Table 1, Outcomes 1-8) was Outcome 9, that covers Outcomes 13-15 in the BOKI (answering the call for a broader curriculum and additional focus on professional skills), as well as a curriculum that provides one course in all seven traditional CE sub-disciplines. Many programs focus on providing only coverage of four CE sub-disciplines as required by the CE program criteria based on faculty resources.

The desirable accreditation changes being considered in 2005 materialized in 2008 with adjusted ABET general criteria and new CE program criteria for 2008 accreditation visits mirroring the undergraduate focused outcomes listed in BOKI as well as adjustments to NCEES model law requiring a masters or thirty post baccalaureate credit hours (technical depth) prior to sitting for the P.E. exam.[5] In the same time period, a second edition to the ASCE Body of Knowledge (BOKII)[6] was issued, and committees were wrestling with how to fulfill (demonstrate accomplishment of) an expanded list of equally desirable future CE program outcomes.[7] Since the CE Program at UT Tyler could not properly assess either ABET a-k or their own nine outcomes as written (multiple requirements lumped under a single outcome; i.e., mathematics, science, and engineering science in ABET outcome 3.a as well as in UT Tyler PO 1 in Table 1), the outcomes were broken into a larger number of smaller outcomes for their assessment plan. This type of expansion of outcomes is mirrored in the BOKII outcomes such that ABET Outcome 3a is broken into three separate outcomes.

The UT Tyler CE curriculum (Figure 1) provides a broad undergraduate experience as envisioned by the Body of Knowledge (BOKI) and implied in Policy 465 with technical depth coverage in a masters or 30 additional post baccalaureate credit hours. However, the question of the hour for the faculty team was how best to assess some of the developed outcomes? All outcomes were not necessarily aligned with a single assessment method. Some cannot be assessed until senior year. Since the department had no assessment history and the new faculty were not vested in any assessment techniques (most had not done any before), the process presented below had less resistance than might occur in more established departments. One objective of this paper however, is to present a narrative of positive program assessment creation – programs motivated to be successful during upcoming ABET visits or to simply improve their program through a detailed look at quality assessment data can use this narrative as a roadmap for their own success.

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

Freshman Year

Freshman—First Semester (Fall)			Freshman—Second Semester (Spring)		
POLS 2306	Intro. Texas Politics	3	TECH 1303	Engineering Graphics	3
ENGL 1301	Grammar & Composition I	3	ENGL 1302	Grammar & Composition II	3
MATH 2413	Calculus I	4	MATH 2414	Calculus II	4
CHEM 1311	General Chemistry I	3	PHYS 2325	University Physics I	3
CHEM 1111	General Chemistry I Laboratory	1	PHYS 2125	University Physics I Laboratory	1
ENGR 1200	Engineering Methods (with lab)	2	( )	Visual & Performing Arts	3
	Semester Credit Hours	16		Semester Credit Hours	17

Sophomore Year

Sophomore—First Semester (Fall)			Sophomore— Second Semester (Spring)		
CENG 2336	Geomatics	3	CENG 2353	Civil Engineering Measurement	3
POLS 2305	Introduction to American Government	3	MENG 3306	Mechanics of Materials	3
ENGR 2301	Engineering Mechanics – Statics	3	MATH 3305	Differential Equations	3
MATH 3404	Multivariate Calculus	4	ENGR 2302	Engineering Mechanics–Dynamics	3
PHYS 2326	University Physics II	3	ECON 2301/2	Macro/Microeconomics	3
PHYS 2126	University Physics II Laboratory	1	PHIL 2306	Introduction to Ethics	3
	Semester Credit Hours	17		Semester Credit Hours	18

Junior Year

Junior—First Semester (Fall)			Junior—Second Semester (Spring)		
CENG 3434	Civil Engr. Materials, Codes & Specs	4	CENG 3361	Applied Engineering Hydrology	3
MENG 3310	Fluid Mechanics	3	CENG 3351	Transportation Engr. Systems	3
ENGR 3301	Probability & Statistics for Engineers	3	CENG 3371	Intro to Environmental Engineering	3
CENG 4339	CE Construction Management	3	CENG 3336	Soil Mechanics	3
( )	Additional Science Elective	3	CENG 3325	Structural Analysis	3
	Semester Credit Hours	16		Semester Credit Hours	15

Senior Year

Senior—First Semester (Fall)			Senior—Second Semester (Spring)		
CENG 4351	Traffic Eng: Operations & Control (Lab)	3	CENG 4341	Ldship,Business,Pub Pol,Asset Mg	3
CENG 4317	Structural Steel Design	3	CENG 4315	Senior Design II	3
CENG 4371	Environmental Engineering Design	3	HIST 1302	United States History II	3
CENG 4115	Senior Design I	1	( )	Technical Elective	3
HIST 1301	United States History I	3	( )	World/European Literature	3
ENGR 4109	Senior Seminar	1		Asset	
	Semester Credit Hours	14		Semester Credit Hours	15

Total Program Credit Hours: 128

Figure 1: UT TYLERX Curriculum

The UT Tyler CE Program philosophy is based on multiple sources of data, with surveys (perhaps one of the more popular methods at other institutions) being the least desirable (too subjective). Table 2 presents the essential assessment techniques used, and depicts a comprehensive approach, the backbone of which is the 'embedded indicator.[8]

An embedded indicator is a graded event or a portion that directly demonstrates student accomplishment of a program outcome. Within the department, an embedded indicator package is defined as the assignment, the solution, a cut-scale or grading rubric used to grade the assignment or portion of it, an assessment of the students performance that includes how to adjust the course content to improve performance or how to adjust the assignment to better assess the students understanding and sometimes both, and examples of student work: the best performance, the average performance, and the worst performance. These embedded indicators from each course are filed in a notebook for each program outcome. A two member team evaluates the data collected for each embedded indicator to determine whether students demonstrated accomplishment of each outcome, which embedded indicators to keep, which should be adjusted, which should be removed, and which courses should add an embedded indicator to ensure the data collected adequately demonstrates accomplishment of the outcome (i.e., assessment of the assessment process).

Table 2 – A condensed version of all of the assessment methods used (a detailed description in reference 8)

Assessment Methods	**Short Description**
Embedded Indicator	An embedded indicator is a graded event or a portion that directly demonstrates student accomplishment of a program outcome
Course Assessments	Annual assessment of each course with a document that has the following three sections: course description, assessment of the course, and recommended changes
External Exams	A normalized, national exam (Fundamentals Exam)
Internal Exams	An FE like exam given at the conclusion of the sophomore and junior years
Surveys	Subjective survey of constituents: students, alumni, employers, and faculty
External Advisory Committee	An external committee that mirrors the program's constituency base and provides advice
External evaluators	Local engineers who evaluate senior design presentations and designs
Senior Design	Two-semester senior design experience composed of small assignments and 10, 35, 65, and 100 percent design submittals and presentations

It is apparent from Table 2 that the faculty also understood the need for multiple assessment methods beyond course assessments and embedded indicators for each outcome to provide a clear level of outcome accomplishment. They chose external exams (the engineering fundamentals exam with the students highly encouraged to take the afternoon CE portion), internal exams (gateway exams that mirror the FE but taken at the end of the sophomore and junior years), senior design assessment rubrics (two course sequence present in curriculum), external evaluation of senior design and associated presentations, surveys, and external advisory committee input (meet once a year). The goal was to limit the faculty requirements to activities they would already be doing in their courses since they would be teaching many of their courses for the first time during the record year (faculty focus only on embedded indicators and course assessments). This selection of data collection methods would provide multiple varied assessment techniques that should provide program insight and trend observation.

The senior design experience was created with the philosophy that it should bring all of the student's skills to bear on a large, multi-discipline CE design project. It might be unreasonable to expect a single experience to assess all outcomes, but should a capstone experience try to do that? The UT Tyler CE faculty team decided to make it happen through the grading of the senior design experience.

3.0 UT Tyler CE Senior Design

The UT Tyler CE Program's senior design is a two course sequence, with CENG 4115 a 1 credit fall offering that introduces the students to the year's project through activities up to 35% design completion, and CENG 4315 a 3 credit spring offering that takes the project to 100% design completion. The experience centers around a multidisciplinary design project (typically a building and site development that also incorporates traffic considerations). 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.

CENG 4115 begins with a review of the 9 step engineering design process[9], and primarily revolves around targeted submittals at typical early project milestones – 10% and 35%. 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. In preparation for the 10% submittal, the class 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, 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.). 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 a foam board model, a K'Nex structural model, 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 regarding their design, receive feedback from clients and faculty, and review actual plans from existing designs if they exist and time permits.

Grading of each major milestone (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 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[10]). The major features of the experience are depicted in Table 3. 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 for comment during the presentation and final submission.

_____/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

It is important to place the UT Tyler senior design experience in context with the historical evolution of capstone courses. Many have championed the movement of capstone courses toward experiences that encompass much more than narrow exercises of knowledge acquired in earlier course work. In 1995 Knox et. al. suggested that desirable course characteristics include:

1) "Industrial involvement and/or real world problems should be used as the focus of the course;
2) The students should work in teams rather than individually;
3) Written and oral presentations should be required of each individual; and
4) In addition to the use of open-ended real world problems, the course should address some of the non-technical (non-traditional) topics associated with engineering design (e.g., ethics and litigation)."[11]

In 1999, Marin et. al. gave additional guidelines toward creating the "optimal" design experience:

1) "Instructor mentors should inspire students to take ownership;
2) Instructor mentors should foster creative tension;
3) Students must be given the opportunity to fail as well as succeed."[12]

Table 3 Major senior 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	

The authors believe that the UT Tyler senior design experience has been formulated according to these and many other sound pedagogical principles. Thus the authors believe that the description of the UT Tyler experience provides a successful roadmap for the others to follow. However and perhaps most importantly, few papers address the mechanics of using the senior design experience as a major vehicle in the assessment process. Although papers designed to discuss assessment note the importance – "capstone courses provide excellent examples of [opportunities for assessment]. Settings or exercises where student performance is rated using defines scoring rubrics as part of the grading process… can quickly be exploited for wider assessment purposes,"[13] few give details of how this can work to assess program outcomes. Other papers[14] discuss the historical forces leading toward the current climate of outcomes based engineering curricula, but again with little guidance toward direct assessment of these in light of senior design activities. The next sections of this paper provide these details as practiced by UT Tyler.

4.0 Assessment Activities and Results

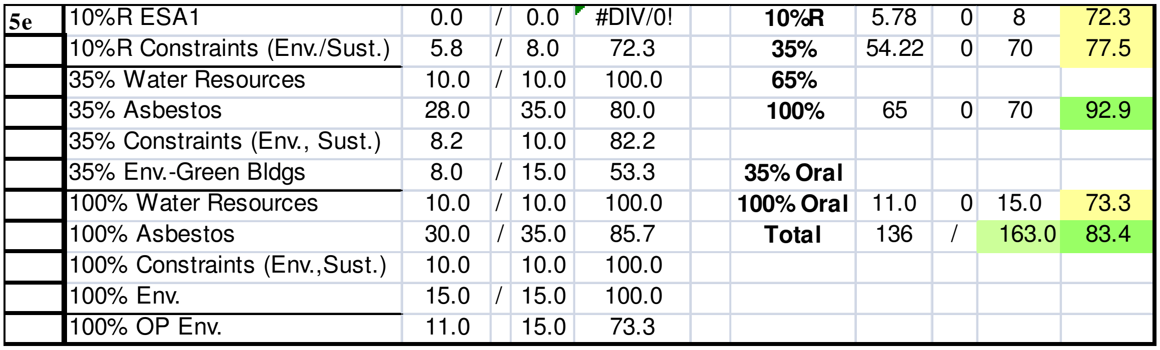
As noted, the UT Tyler CE program has embraced the 'embedded indicator' approach to assessment (as supplemented by several other methods of assessment). However, in a large, open-ended design project, dilemma results – if too many separate submissions are required, this can cause the problem to be over-defined. 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 instructor. 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.[10] Inspired by the USMA approach, UT Tyler CE Program created a matrix that tied specific portions of the grade to specific program outcomes. Items on each cut-sheet (see previous section) 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. Figure 3 depicts an excerpt of the matrix showing the activities accumulating in the 5e bucket. 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 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.



5e	10%R ESA1	0.0	/	0.0	#DIV/0!		**10%R**	5.78	0	8	72.3
	10%R Constraints (Env./Sust.)	5.8	/	8.0	72.3		**35%**	54.22	0	70	77.5
	35% Water Resources	10.0	/	10.0	100.0		**65%**				
	35% Asbestos	28.0		35.0	80.0		**100%**	65	0	70	92.9
	35% Constraints (Env., Sust.)	8.2		10.0	82.2						
	35% Env.-Green Bldgs	8.0	/	15.0	53.3		**35% Oral**				
	100% Water Resources	10.0	/	10.0	100.0		**100% Oral**	11.0	0	15.0	73.3
	100% Asbestos	30.0	/	35.0	85.7		**Total**	136	/	163.0	83.4
	100% Constraints (Env.,Sust.)	10.0		10.0	100.0						
	100% Env.	15.0	/	15.0	100.0						
	100% OP Env.	11.0		15.0	73.3						

Figure 3 Matrix ‘bucket’ for program outcome 5e (Environmental Design)

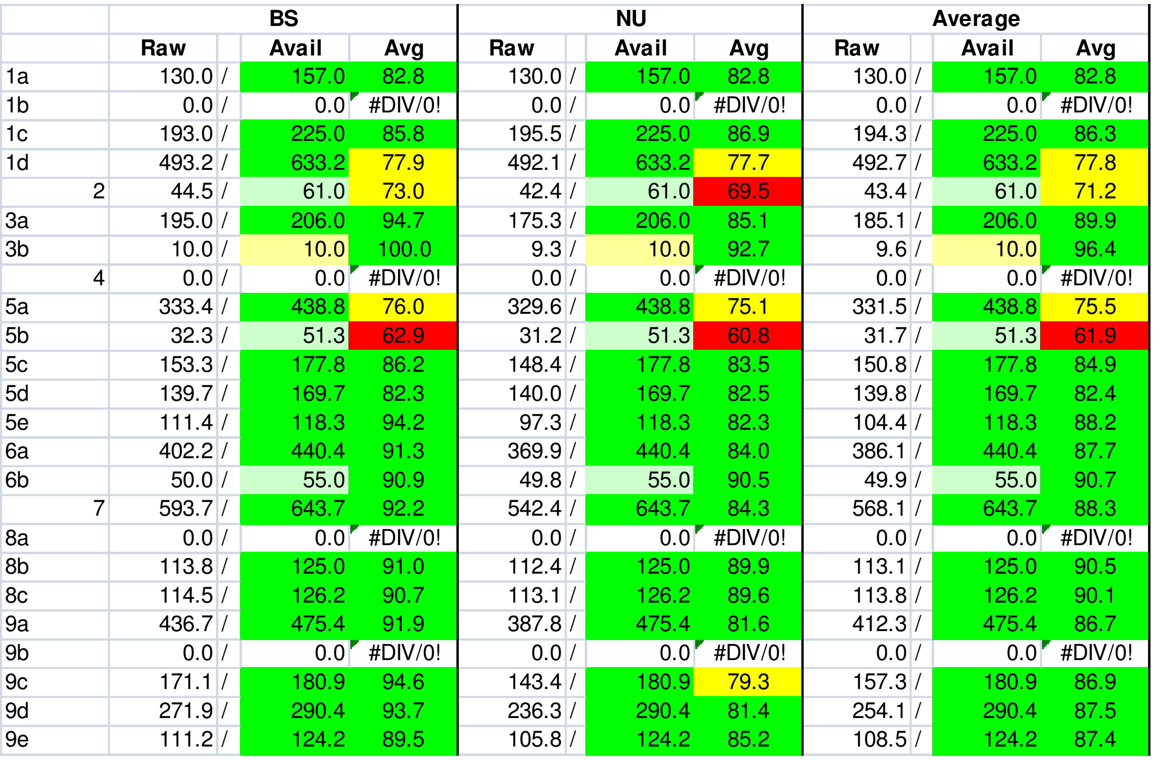
Table 4 shows the assessment matrix from 2007-2008 and 2008-2009. It is shaded in several ways to show key features related to the two points noted above. The overall points allocated to a particular outcome is coded to show outcomes below 50 and 100 points (note that the exact number of points for this 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.

Since the senior design experience has been used to 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 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 4 from 2007-2008 to 2008-2009 because of the program’s assessment of the assessment process and how the data should be displayed.

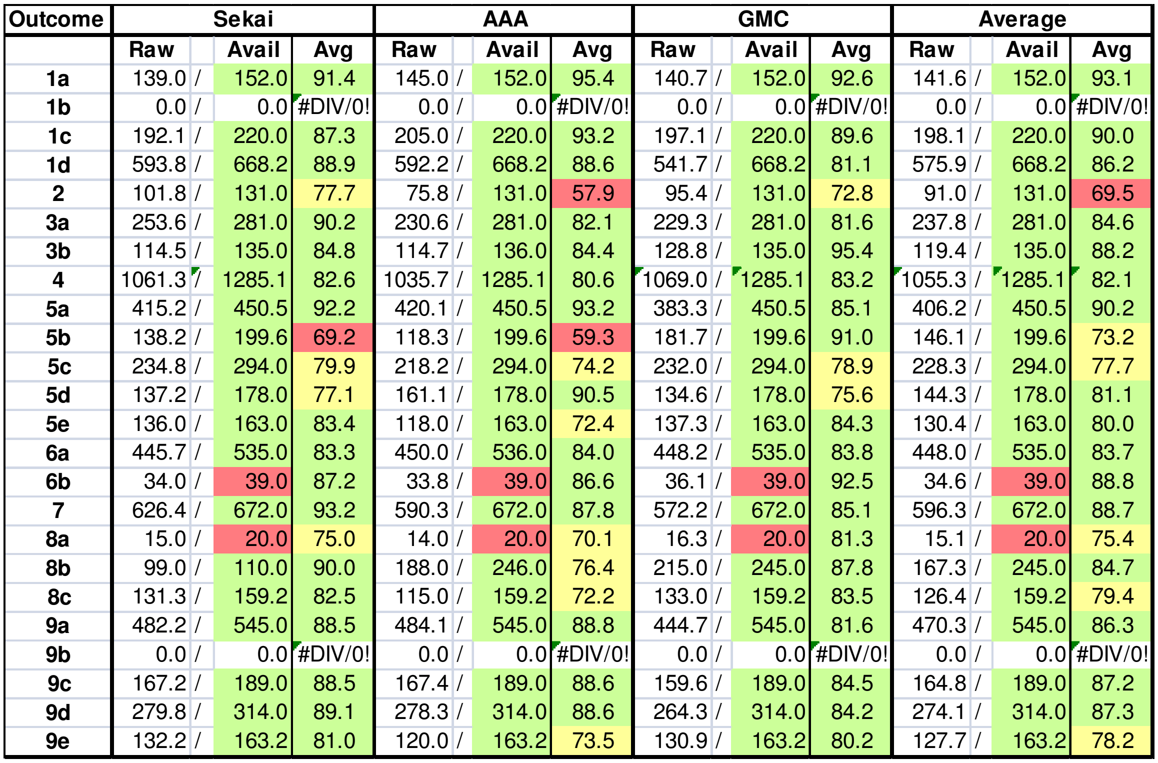
Table 4 Assessment matrix: (a) 2007-2008; (b) 2008-2009

(a)



	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)



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

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 to year 2 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.

(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.

A short description of the other assessment methods was presented above, but how does it all come together in an annual program assessment? Table 5 and 6 are a representative excerpt from the annual program assessment where the results of each assessment method are collated to allow an aggregate review of each outcome. There is always survey data, but it is the least desirable. At times the embedded indicators and senior design provide the only other assessment data while the FE and Gateway exams provide coverage of technical outcomes. As can be seen the outcome assessment within senior design is a critical piece demonstrating accomplishment of outcomes. With forethought, the actions required within the senior design can lead to assessment data used within the annual assessment with little additional effort once the assessment tool is developed.

Table 5 2008-9 performance measures and results for CE program outcome 1a.

Outcome 1a: Can apply knowledge of traditional mathematics to solve problems.				
Direct Measures	Tab	Standard	2008-9 Performance	Historical Average
Mathematics portion of F.E. exam		69[66]	59 (-10)[-7]	(-7)
Prob and Stats portion of F.E. exam		67[63]	70 (+3)[+7]	(-5)
Statics portion of F.E. exam		66[64]	66 (+0)[+2]	(+2)
Strengths of Materials portion of F.E. exam		56[55]	58 (+2)[+3]	(-6)
Material Science portion of F.E. exam		41[38]	42 (+1)[+4]	(+2)
CENG 2336, HW#5 Prob #2	1	80.0	83.9	
MENG 3310, HW#5 Prob# 2	2	80.0	81.1	
ENGR 2301, HW #2 Pr.#3	3	80.0	87.5	

CENG 3336, Exam 1, Pr 3	4	80.0	91.9	
CENG 3325 HW 1	5	80.0	93.9	
ENGR 2301, Exam 4 - Problem 4	6	80.0	80.4	
ENGR 2301, Final Exam , Problem 4	7	80.0	91.4	
CENG 4315, 100% Design Submittal		80.0	93.1	82.8
Gateway exam - Statics		80.0	63.8	57.0
Gateway exam - Measurements		80.0	79.1	74.6
Gateway exam – Strengths of Materials		80.0	54.6	67.0
Indirect Measures		Standard	2008-9 Performance	Historical Average
Question A1. Senior survey		4.0/5	4.8/5	4.9/5
Question A1. Faculty survey		4.0/5	4.4/5	4.4/5
Question A1. Alumni survey		4.0/5	4.8/5	
Question A1. Employer survey		4.0/5	4.0/5	4.4/5
Question D13. Senior Survey (apply math)		4.0/5	4.7/5	4.4/5
Curriculum Measures		Standard	2008-9 Performance	Historical Average
Completion of ENGR 2301, CENG 3351, CENG 4371		5.0	5	5
Completion of MATH 2413/2414/3404/3305; ENGR 3301, PHYS 2325/2125/2326/2126; CHEM 1311/1111				
2008-9 Assessment: 4+ (4- last year)				

Table 6 2008-9 performance measures and results for CE program outcome 5e.

Outcome 5e: Can identify, formulate, and solve engineering design problems using engineering models in the sub-discipline of environmental engineering.				
Direct Measures	Tab	Standard	2008-9 Performance	Historical Average
Chemistry portion of F.E. exam		60[56]	49 (-11)[-7]	(-10)
Environmental Engineering portion of F.E.		56[51]	47 (-9)[-4]	(-7)
CENG 4371, HW 9, 11-1	1	80.0	88.1	
CENG 4371, HW 10	2	80.0	92.0	
CENG 4315, 100% Submittal		80.0	80.0	88.2
Indirect Measures		Standard	2008-9 Performance	Historical Average
Question A13. Senior survey		4/5	3.1/5	4.0/5
Question A13. Faculty survey		4/5	4.4/5	4.2/5
Question A13. Alumni survey		4/5	3.8/5	
Question A13. Employer survey		4/5	3.0/5	3.2/5
Curriculum Measures		Standard	2008-9 Performance	Historical Average
Completion of CENG 4371		5	5	5

2008-9 Assessment: 3+ (3+/4-)

5.0 Assessment by External ABET Evaluators

During the ABET evaluation visit only 11 questions were formally presented by the PEV after arrival at UT Tyler. Normally if there are major issues the list of questions are usually presented weeks prior to the evaluation team's arrival. Most questions were just requests for clarification or assistance on locating the data collected and becoming familiar with how it was organized in the assembled notebooks. At the out brief, there were NO presented deficiencies or weaknesses! There were two concerns and four observations. So the experiment was a huge success!

One of the concerns could not be prevented since the program did not have any alumni to survey to determine whether PEOs were being accomplished. The program had piloted the process to collect, document and demonstrate the degree that the PEOs are attained with trial groups of constituents, but there had been no real opportunity to collect and evaluate actual assessment data from alumni and their employers. Therefore, the potential did exist that the program might not be able to demonstrate compliance if the presented assessment process is not carried out. The other concern focused on the wording of one of the PEOs (PEO 3 – Graduates have effective oral, written, and graphical communication skills). The wording gave the impression that it was describing skills and knowledge that students should have at the time of graduation rather than future career and professional accomplishments. The piloted process discussed in the paragraphs above did satisfy the criterion, but future changes in the wording of the objective or focused data collection by the program could cause non-compliance.

The observations (paraphrased) focused on 1) having the civil engineering profession (ASCE) as one of the six defined constituencies leading to a consideration to a more streamlined approach to defining constituencies; 2) some of the embedded indicators tried in the first year did not always have a strong relationship with the outcomes and some were used for multiple outcomes (writing assignment used for communication, while the content focused on ethics) within a very extensive set of measures that possibly could become burdensome; 3) chair has done an outstanding job developing a complete and comprehensive outcomes and objectives assessment process and the program is encouraged to develop additional informed and capable faculty leaders in assessment; and 4) based on current departmental growth and increased research requirements, there may be a need to hire additional faculty and increase support resources.

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.

6.0 Lessons Learned and Conclusions

Desired results, data collection, assessment, making decisions, and assessing the results of those decisions are hard, tedious work. However, it is no different than the research processes that most of us use on a daily basis. The difference is using the process for teaching and the end result – student learning. Many programs can get their faculty to rise to the occasion and collect some data during the record year, but how about the non-record years? The key is limiting the data collection process to a minimum and tying it to what they are already doing or should be doing. The faculty must be convinced that they need to assess each course assignment and exam to ensure that each activity is accomplishing the desired result. If they are already assessing a course requirement, then the assessment of the assignment or a portion to be used as an embedded indicator is just an extension of something they are already doing. Faculty must assess and document their research to determine if they obtained good results and what future adjustments are required, so why not teaching? If the faculty team can ultimately boil down the number of embedded indicators to the irreducible minimum, resulting in an equal spread of embedded indicators across all courses, then they are really just adding a few additional minutes to the tasks they should already be doing.

The senior design is already being taught and each assignment is being assessed. Once developed, the rubric only needs to be tweaked 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 senior design is a part of this), 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 at the end of each academic year.

The goal is a faculty driven irreducible minimum list of embedded indicators that includes the assessment products of the senior design that demonstrate accomplishment of outcomes without overloading any one course. The senior design is a major piece of this process and can assess all of ABET 3a-k and the civil engineering program criteria rather than just design alone. Thinking about how to demonstrate accomplishment of an outcome is critical in assignment, course, and program design. The presented process is a great tool to assess the seniors prior to their entrance into the real world of the engineering firm.

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