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Teaching and Assessing Professional Skills in an Undergraduate Civil Engineering Curriculum

Dr. William J. Davis P.E., The Citadel

William J. Davis is a professor in Civil & Environmental Engineering at The Citadel in Charleston, SC. He received his Ph.D. in civil engineering from Georgia Tech and is a registered professional engineer. His research interests focus on transportation infrastructure planning and design, highway safety, and active living by design. He teaches courses in engineering management, transportation engineering, geographic information systems, and land surveying.

Dr. Dimitra Michalaka, The Citadel

Dr. Dimitra Michalaka is an Assistant Professor at the department of civil and environmental engineering at The Citadel. Dr. Michalaka received her undergraduate diploma in civil engineering from the National Technical University of Athens (NTUA), after which she entered into the transportation engineering graduate program at UF. She graduated with a Master's of Science in May 2009 and with a Ph.D. in August 2012. Her research is primarily focused on traffic operations, congestion pricing, traffic simulation, and engineering education.

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Abstract

"A Vision for Civil Engineers in 2025" was adopted by American Society of Civil Engineers (ASCE) that broadens the scope of student outcomes to better prepare graduates to lead society in establishing a sustainable world and improving the global quality of life. Future practicing civil engineers are envisioned to be master builders, stewards of the environment, innovators, managers of risk, and leaders of public policy. The ASCE Body of Knowledge (BOK) 2 provides a significant foundation for how engineering programs should prepare civil engineering students to meet ever increasing societal demands. Nine of 24 outcomes are focused on professional skills, describe student skills needed to meet career challenges, and include target levels of cognitive development required to prepare students for professional practice.

Based on this vision for future engineers set forth in ASCE BOK 2, faculty in The Citadel Department of Civil and Environmental Engineering (CEE) adopted 22 student outcomes, eight of which are directly focused on developing student professional skills and competencies. These outcomes are mapped across a subset of the 34 courses offered in the civil engineering curriculum. Embedded indicators are used to measure student attainment of the material and results are compared to established Department standards. Year-to-year results are tracked and incorporated into the Department's Assessment Process. Improvements are systematically implemented as course improvements and are focused on enhancing student learning and retention.

This paper describes assessment methods and techniques used to develop, teach, track, integrate, and assess student professional skills and competencies. Mapping of professional skill course goals across the undergraduate curriculum will be described and summarized. Evidence-based assessment results are being used to track student cognitive performance levels aligned with professional skills development outcomes. A review of course goals, teaching methods, and assessment will be provided for two specific courses, Engineering Management (CIVL411) and Professional Sustainability (CIVL317), which collectively represent roughly half of the professional skill curriculum and are largely structured for the purpose of addressing professional skills needed for graduates to successfully enter the engineering profession.

Introduction

The Citadel Civil and Environmental Engineering (CEE) Department's curriculum has traditionally placed a premium on preparing graduates to serve as principled leaders through their service to society as technical leaders of design, construction, maintenance and operation of built-environment facilities needed by society to establish safe, healthy, equitable and vibrant communities. In support of this vision, CEE Department faculty adopted a series of outcomes focusing on equipping students with professional skills needed to prepare graduates to for careers in the engineering profession. Course materials focus on development of professional skills needed to function as a successful practicing engineer. The overarching goal is to establish a purposeful multi-course, multi-year approach for concept mapping, knowledge construction, and

educational scaffolding of principles needed for graduates to attain the foundational professional skills needed to successfully enter the engineering profession.

Outcome maps aligning curriculum along professional skills outcomes have been created to link course goals across a comprehensive CEE Department strategy for student development. An essential component of establishing this plan was adoption of embedded indicators, aligned with CEE Department outcomes, and mapped across all four years of the undergraduate curriculum. As part of the CEE Department's assessment process, 28 course-specific professional skills embedded indicators are aligned with eight outcomes. Each embedded indicator is mapped to appropriate Blooms' Taxonomy levels and organized sequentially to provide a progression of student development under these important outcomes focused on professional practice.

Background

American Society of Civil Engineers (ASCE) Vision 2025, states civil engineering students are entrusted by society to help achieve a sustainable world, and to raise the global quality of life [1,2]. A path for accomplishing this major reform in education and pre-licensure experience in the engineering profession is further described by Walesh [3]. Furthermore, longstanding ethical cannons of engineering practice require that civil engineering graduates serve the profession and society as principled leaders [4]. To prepare students to meet an increasing demand for professional skills in the engineering profession, undergraduate programs are responding through modification of academic curriculum material and course content [5]. The American Society of Civil Engineers published an expanded set of 24 civil engineering outcomes in the Civil Engineering Body of Knowledge for the 21st Century, which undergraduate programs are adopting as evidence of continuous improvement in fulfillment of ABET, Inc. (formerly know as Accreditation Board for Engineering and Technology) Criterion 5 [6,7]. Roughly one-third of ASCE civil engineering outcomes, correlate with development of professional skills.

Development of professional and leadership skills has been shown to improve through the college experience [8]. Leadership principles covered in the curriculum have proven to make improvements in student development and studies have indicated faculty interaction also has a positive effect [8]. Assessing student obtainment of fundamental professional skills and leadership concepts at lower levels of Blooms Taxonomy within the classroom is relatively straightforward according to Welch who provides some ideas of how this might be accomplished [9,10]. This paper will explore approaches being piloted in undergraduate curriculum on this important challenge facing academia. Using a subset of ASCE BOK outcomes, student attainment is measured through application of Bloom's Taxonomy to provide an effective tool for mapping and improving student readiness in the crucially important area of professional skills development.

Civil Engineering CEE Department Outcomes

22 outcomes were developed and adapted from ABET, Criterion 3, student outcomes A-K [7] and ASCE Body of Knowledge [6]. Each outcome provides a succinct statement describing material students are expected to learn over a four-year development period before graduation. Attainment of proficiency for each outcome is measured using embedded indicators based on mapping to the six levels of Bloom's Taxonomy [11,12]. Table 1 summarizes the 22 CEE

Table 1 Summary of Citadel Civil Engineering CEE Department Program Outcomes

Dept. Program Outcome	**Dept. Program Outcome with Professional Skills Linkage**
1. Mathematics 2. Science 3. Solid & Fluid Mechanics 4. Experiments 5. Problems Solving a.) Techniques b.) Tools Design 6. a.) Environmental 7. b.) Structural 8. c.) Land Development 9. d.) Transportation 10. Contemporary Issues	
11. Project Management	Explain what a project is and key elements of **project management**.
Engineering Problems 12. a.) Environmental 13. b.) Structural 14. c.) Land Development 15. d.) Transportation	
16. Communication **a.) Graphical** **b.) Verbal** **c.) Written**	Organize and deliver effective **graphical**, **verbal** and **written communication**.
17. a.) Public Policy	Discuss and explain key concepts involved in **Public Policy and Public Administration**.
18. b.) Business	Explain key **concepts and processes used in business.**
19. Leadership	Explain the **role of a leader and leadership principles and attitudes**.
20. Interdisciplinary Teams	Function effectively as a **member of an interdisciplinary team**.
21. Self Directed Learning	Demonstrate the ability for **self-directed learning**.
22. Ethical Responsibility	Apply standard of **professional and ethical responsibility** to determine an appropriate course of action.

Department outcomes and identifies eight specific outcomes that are being used to assess profession skills. Course embedded indicators on tests, assignments, and projects are used to evaluate each of the 22 CEE Department outcomes. Results from embedded indicators and other measures are evaluated to ensure overall desired performance standards are met and to develop targeted solutions when problems are identified. Solutions often include modification to instructional material, improvements to increase student understanding and scaffolding of knowledge construction. Curriculum-based solutions often extend across multiple courses and can be used to address learning objective scaffolding, along with thread continuity issues, to help students' progress in their skill level growth along the Bloom's Taxonomy scale.

Professional Skills Development in Civil Engineering Curriculum

As shown in Tables 2 and 3, student development of professional skills link across 13 courses, 28 course objectives, all four years of the curriculum, and involve over one-third of the 34 required courses taught within the CEE Department. Development of professional skills culminates in a civil engineering capstone class were students work on multidisciplinary teams to achieve common design project goals and communicate their engineering findings to a professional and public audience. Specific CEE courses that develop student professional skills are identified in Table 2 and are further described in an accompanying matrix provided in Table 3 that summarizes mapping of 28 course objectives to levels of Bloom's Taxonomy. Course objectives are mapped to Bloom's Taxonomy levels and provide a collective view of curriculum mapping for professional skills development. Half, 14 of 28, of the course goals aligned with professional skills development are from Professional Sustainability (CIVL 317), and Engineering Management (CIVL 411), the two courses that are the focus of this paper.

Table 2 Summary of Civil Engineering Courses linked with Professional Skills Development

Civil Engineering Course	Academic Year
Engineering Drawing, CIVL 101 Introduction to Civil Engineering, CIVL 103	**Freshman**
Surveying, CIVL 205 Computer Application for Civil & Environmental Engineering, CIVL 210 Surveying I Laboratory, CIVL 235	**Sophomore**
Highway Engineering, CIVL 302 Transportation Engineering, CIVL 305 Engineering Economy, CIVL 314 Professional Sustainability, CIVL 317	**Junior**
Reinforced Concrete Design, CIVL 404 Engineering Management, CIVL 411 (1) Fluid Mechanics Laboratory, CIVL 418 Environmental Engineering Laboratory, CIVL 419	**Senior**
Notes: 1.) This course is focused on professional skills development; however, embedded indicators are not yet fully linked to outcome assessment. Linkage efforts are in progress.	

Table 3 Bloom's Taxonomy Levels of Cognitive Achievement for Course Objectives Focusing on Leadership Development

Course No.	Course Goals	Leader ship	Ethics	Com. Graph	Com. Oral	Com. Write	Bus Policy	Team work	Self-dir. Learning	Public Policy	Project Man.
CIVL 317	**7 - attitudes supportive of PE practice**	**2**									
CIVL 317	**8 - leadership principles**	**2**									
CIVL 103	2 - ethical cannons, licensure		1								
CIVL 205	4 - surveying ethical responsibilities		1								
CIVL 210	3 - software ethics		3								
CIVL 235	5 - use of professional standards		3								
CIVL 411	**6 – ethical and legal aspects**		**2**								
CIVL 101	1 – sketching and lettering			3							
CIVL 235	3 –Surveying Plat preparation			3							
CIVL 317	**4 – effective oral communication**				**2**						
CIVL 404	9 – contemporary concrete paper				2						
CIVL 418	6 – laboratory report preparation					4					
CIVL 419	6 – composition for tech. audience					3					
CIVL 314	3 – capitalized cost analysis						3				
CIVL 314	4 – rate of return analysis						3				
CIVL 317	**2 – direct and indirect bus. costs**						**2**				
CIVL 411	5 – proposals, consultant selection						2				
CIVL 103	5 - projects and team dynamics							1			
CIVL 317	**1 - multidisciplinary teams**							**2**			
CIVL 103	3 - life long learning								1		
CIVL 210	1 - self directed learning								3		
CIVL 317	**6 - life long learning skills**								**2**		
CIVL 305	2 - government and transportation									2	
CIVL 314	5 - b/c ethical considerations									3	
CIVL 317	**5 - public policy concepts**									**2**	
CIVL 302	4 - highway construction contracts										3
CIVL 317	**3 - project management**										**2**
CIVL 411	**4 - project scheduling**										**3**

Note: Levels of Bloom's Taxonomy Levels include: 1.) Knowledge; 2.) Comprehension; 3.) Application; 4.) Analysis; 5.) Synthesis; 6.) Evaluation

Department Assessment and Use of Embedded Indicators

A major emphasis of The Citadel CEE Departmental assessment process is explicitly focused on systematic evaluation of all courses within the curriculum. End of term course reviews are used along with an embedded indicator process to support Department's continuous improvement and link course goals with outcomes [13]. Faculty work collectively on a course-by-course basis to adopt common course goals, link outcomes, and determine competency, via Bloom's Taxonomy, levels. Course material is aligned with an embedded indicator process described in Table 4. Evaluation tools are determined prior to instruction. Average class grades are calculated for each embedded indicator and compared with an adopted Departmental Standard of 75% or higher. If this is achieved, students are deemed to have collectively achieved the requirement of the course goal and to have met the departmental standard. When the standard is not met, faculty are required to flag as "not met", identify problems, address concerns, implement improvements, and reflectively track progress in future offerings of the course.

Table 4 Summary of Embedded Indicator Tools and Bloom's Taxonomy Linkage

Appropriate Application of Embedded Indicator Tool for desired Bloom's Levels	**1. Knowledge**	**2. Comprehension**	**3. Application**	**4. Analysis**	**5. Synthesis**	**6. Evaluation**
True/ False Questions	X	X				
Matching Questions	X	X				
Fill In Questions	X	X				
Multiple Choice Questions	X	X	X			
Short Answer Questions	X	X	X	X		
Calculation Based Problems	X	X	X	X		
Essay Questions	X	X	X	X		
Research Papers	X	X	X	X	X	X
Lab Reports	X	X	X	X	X	X
Design Problems	X	X	X	X	X	X
Capstone Projects	X	X	X	X	X	X

Professional Sustainability (CIVL317) Course Overview and Instructional Materials

Overview of Course – This one-credit hour course was created in 2010 as a response to the expanded number of outcomes identified in the ASCE Body of Knowledge [6] that focus on development of professional skills needed for successful engineering practice. All CEE students are required to take this course. Course topics focus on preparing students to serve with distinction as technical leaders in addressing the needs of society and include: teamwork, public administration, communication, public policy, ethics, life long learning, attitudes, and leadership.

Course Goals – Upon completion of CIVL 317, Professional Sustainability, students should have proficient knowledge and understanding of the following learning objectives:

1. Describe factors affecting the ability of multidisciplinary teams to function effectively.
2. Describe key concepts and processes used in business and public administration.
3. Explain what a project is and the key aspects of project management.
4. Describe characteristics of effective verbal, written, virtual, and graphical communication.
5. Discuss and explain key concepts and processes involved in public policy.
6. Explain the need for lifelong learning and describe skills required of a life long learner.
7. Explain attitudes supportive of the professional practice of civil engineering.
8. Explain the role of a leader and leadership principles and attitudes.

Due to the fact that this course is offered as a one-credit hour course, course subjects and instructional materials are covered at a lower Bloom's Taxonomy Level 2, Comprehension, but students are engaged to achieve a workable perspective of the more robust forms these professional skill outcomes take as graduates advance through the early stages of their engineering careers. The eight CIVL317 course goals are mapped to CEE Department outcomes and shown with accompanying levels of Bloom's Taxonomy as indicated in Table 5.

Table 5 Mapping of CIVL 317 Course Goals to CEE Department Outcomes

Course Goals	CEE Dept. Outcomes	Bloom's Taxonomy Level
1. Multidisciplinary teams	20. Interdisciplinary Teams	Level 2 (Comprehension)
2. Business and Public Administration	18. Business	Level 2 (Comprehension)
3. Project Management	11. Project Management	Level 2 (Comprehension)
4. Verbal, written, virtual, and graphical communication	16. Communication: a.) Graphical, b.) Verbal, c.) Written	Level 2 (Comprehension)
5. Public Policy	17. Public Policy	Level 2 (Comprehension)
6. Lifelong Learning	21. Self Directed Learning	Level 2 (Comprehension)
7. Attitudes supportive of professional practice	19. Leadership	Level 2 (Comprehension)
8. Leadership principles	19. Leadership	Level 2 (Comprehension)

Embedded Indicator Results – Student attainment of learning objectives and mastery of academic material for each of the eight CIVL317 course goals is evaluated through the use of the Department's embedded indicator process the results of which are summarized for the past three years. All eight-course goals met Department Standards for each of the three academic years with the exception of Course Goal 2, in 2014-15, which achieved an embedded indicator outcome (74) slightly below the Department Standard of 75. These overall results provide

evidence students are obtaining appropriate knowledge of these course goals and outcomes, which are all connected with student development of professional skills.

Table 6 Tracking CIVL 317 Performance of Embedded Indicators

Course Goals	**Embedded Indicator**	**2012-13[1] (30)[2]**	**2013-14[1] (56)[2]**	**2014-15[1] (83)[2]**
1. Multidisciplinary teams	Exam question	92	95	83
2. Business and Public Administration	Exam question	80	78	74 [3]
3. Project Management	Exam question	80	85	80
4. Verbal, written, virtual, and graphical communication	Exam question	85	90	78
5. Public Policy	Exam question	84	78	78
6. Lifelong Learning	Exam question	88	83	83
7. Attitudes supportive of professional practice	Exam question	88	87	83
8. Leadership principles	Exam question	86	87	82

Notes: 1.) Average course grade for all students from embedded indicator.
2.) Number of students taking course during academic year.
3.) CEE Department Standard of 75 average was not achieved for embedded indicator.

Teaching Methods – To prepare students for future career success and cover materials prior to evaluation of their knowledge through previously described embedded indicator measures, a variety of teaching methods are deployed to help students grasp the concepts and instruction materials covered in the course. As this is survey-oriented course, students are not required to purchase a textbook. Course materials are comprised of on-line materials, TED videos, interactive in-class exercises, short essay assignments, and in-class essay style exams. Relevant to review of the feedback below, is that 63% of students taking the class earned an "A." Representative student comments and feedback include the following:

- "I liked learning the different principles on what it means to be a professional with principled leadership in my future career as an engineer."
- "Made me think and evaluate different situations in the professional work environment so that I was able to see the problem and understand it on my own as well as how to avoid it."
- "More than just a lecture. It was interactive and the use of videos to support the lessons were good as well."
- "I liked talking about leadership in engineering and the videos about it."
- "Lots of thought provoking topics."

Engineering Management (CIVL 411) Course Goals and Instructional Materials

Overview of Course – This three-credit hour course has been taught for over 25-years in the curriculum. It is an elective course, however, over 90 percent of civil engineering majors enroll for this course. Course topics focus on: project management, scheduling, contracts, ethics, accounting methods, legal aspects, marketing, and role of consultants. The student population most often includes students majoring in civil (~85%) and electrical (~15%) engineering.

Course Goals – Upon completion of CIVL 411, Professional Sustainability, students should have proficient knowledge and understanding of the following learning objectives:

1. Knowledge of terminology used in business and engineering management.
2. Understanding of engineering management concepts as related to self-management.
3. Understanding of project management concepts and process groups as defined by the Project Management Body of Knowledge.
4. Application of Work Breakdown Structure (WBS), project scheduling and network analysis through the use of CPM and PERT methodologies.
5. Knowledge of consultant selection, engineering marketing, business development and proposal submittal.
6. Understanding of ethical and legal aspects of engineering.
7. Demonstration of management techniques, decision economics, engineering organization, and business accounting methods.
8. Understanding of value engineering and total quality management concepts.

Eight CIVL 411 course goals are mapped to CEE Department outcomes and shown with accompanying levels of Bloom's Taxonomy as indicated in Table 7. The focus of the class is generally on lower levels of Bloom's, even though this is a senior course. Higher levels of Bloom's Taxonomy are used for course instruction and student assignments, even though assessment mapping has not been adjusted to reflect this more rigorous level of engagement. Ill-structured, open-ended project assignments, and presentations related to design, public involvement and proposals are used to engage students at higher levels of Blooms' Taxonomy, typically involving Levels 3, 4, and sometimes 5.

Embedded Indicator Results – Student attainment of learning objectives and mastery of academic material for each of the eight CIVL 411 course goals is evaluated through the use of embedded indicators. The embedded indicators and the performance of the students over three years are illustrated in Table 8. It was identified that the Departmental Standards were "Not Met" in four instances. In each case, corrective actions were taken by faculty to improve student understanding of course material. In the case of Course Goal 7, two-years were eventually required for corrective actions to produce the desired performance. These overall results provide evidence that students are obtaining appropriate knowledge of these course goals and outcomes, which are all connected with student development of professional skills.

Table 7 Mapping of CIVL 411 Course Goals to CEE Department Outcomes

Course Goals	CEE Dept. Outcomes	Bloom's Taxonomy Level
1. Business and engineering management	11. Project Management	Level 1 (Knowledge)
2. Self- management concepts	11. Project Management	Level 1 (Knowledge)
3. Project Management	11. Project Management	Level 2 (Comprehension)
4. Project Scheduling, network analysis, CPM, PERT	5. Problem Solving	Level 3 (Application)
5. Consultant Selection, marketing, proposal submittal	18. Business	Level 2 (Comprehension)
6. Ethical and legal aspects	22. Ethical Responsibility	Level 2 (Comprehension)
7. Management techniques and business accounting	5. Problem Solving	Level 2 (Comprehension)
8. Total Quality Management	11. Project Management	Level 1 (Knowledge)

Table 8 Tracking CIVL 411 Performance of Embedded Indicators

Course Goals	Embedded Indicator	2012-13[1] (23)[2]	2013-14[1] (14)[2]	2014-15[1] (31)[2]
1. Business and engineering management	Exam question	79	91	89
2. Self- management concepts	Exam question	84	88	85
3. Project Management	Exam question	81	66[3]	78
4. Project Scheduling, network analysis, CPM, PERT	Exam question	89	90	90
5. Consultant Selection, marketing, proposal submittal	Exam question	76	78	80
6. Ethical and legal aspects	Exam question	63 [3]	90	92
7. Management techniques and business accounting	Exam question	73 [3]	65[3]	78
8. Total Quality Management	Exam question	79	98	95

Notes: 1.) Average course grade for all students from embedded indicator.
2.) Number of students taking course during academic year.
3.) CEE Department Standard of 75 average was not achieved for embedded indicator.

Teaching Methods – A variety of teaching methods/ activities are deployed to keep students motivated in learning class material and helping students understand the concepts and instructional materials covered in the course. More traditional teaching methods include, PowerPoint slides, direct lecture, homework assignments, and in-class quizzes. However, as the course is focused on developing students' professional skills in engineering, several new interactive teaching activities have also been incorporated for this course. A summary of new activities with objectives, student assessment methods, and representative student feedback as extracted from the course evaluations are provided in Table 9. Information included in Table 9 is from 2014-2015 were multiple changes in course instruction were implemented. Relevant to review of this data, is that 56% of students taking the class earned an "A."

Summary and Conclusions

Leaders in the engineering profession, elected officials, policy/decision makers, members of the general public, and representatives of press/media outlets, all express desire for civil engineers to exhibit better communication skills in explaining crucial details of the infrastructure design process, complicated analytical findings, application of design standards, and results of engineering evaluations. Furthermore, the highly-advanced nature of today's engineering projects require: expertise in interdisciplinary teamwork, accurate scheduling of project deliverables, applications of advanced technologies, and increasing corporate demands for progressive business practices. These unyielding expectations for the civil engineering profession can be addressed, in part, through preparation of graduates possessing well-founded professional skills needed to complement long-standing traditionally strong technical proficiencies. The following provides a summary of observations resulting from efforts to systematically provide professional skills student development in the curriculum:

- Of 22 adopted CEE Department Outcomes, eight (36%) are focused on professional skills including: project management, communication, public policy, business, leadership, interdisciplinary teams, self-directed learning, and ethical responsibility.

- Of 34 offered CEE Department courses, thirteen (38%) contain instructional material to help students develop knowledge, understating and application of professional skills.

- Through use of embedded indicators for program assessment, 28 course goals in the CEE Department curriculum are being used to teach, assess and evaluate development of student professional skills.

- Of 28 course goals focusing on professional skills, and linked with program assessment, fourteen (50%) are derived from the courses: Professional Sustainability (CIVL 317) and Engineering Management (CIVL 411).

- Based on assessment results from the previous three academic years in CIVL 317 and CIVL 411, CEE Departmental Standards for student attainment of course goals and embedded indicator-measured materials were achieved 90 percent of the time (43 of 48 course goals).

Table 9 Interactive Teaching Activities Incorporated in Engineering Management course

Teaching Activity	Objective	Student Assessment	Student Feedback
Fully interactive lectures by presenting key concepts/ topics, then students worked in groups to logically construct reasoning for the concepts presented.	Better understand concepts/ topics presented in class. Encourage students to ask questions and share opinions.	Biweekly quizzes (usually 20-min long).	"The class was very interactive."
TED talks, other motivational material related to engineering management talks/ videos.	Help students picture the engineering management reality from different perspectives.	Short class quizzes on videos or short presentations on opinions stated in videos.	"Videos inspired us for lifelong learning & how to develop ourselves." "TED videos were very good."
In-class group activities such as providing an answer to an ethical dilemma or identifying risks of a certain project.	Promote teamwork.	Class discussions, presentations, and debates.	"I learned a lot in a social aspect."
'Students-teach-students' class sessions where students were assigned few pages in advance from the textbook and were required to come up with creative ways to teach assigned material to the class.	Improve students' public speaking and presentation skills. Keep students more engaged in material presented in class. Make students study class material prior to class.	Professor evaluation of the presentation. Peer student evaluation of the presentation. Self-evaluation.	"I enjoy as it keeps us engaged, but should not be every week." "Effective as it requires knowing topics to a degree that we can teach others." "Very good as far as public speaking."
Teambuilding exercises like the marshmallow challenge is a "fun and instructive design exercise that encourages teams to experience simple but profound lessons in collaboration, innovation and creativity."[14]	Develop student team relationships and dynamics.	Students identify best team project.	None via end of term assessment
Course project. Student teams were formed based on the Jung Typology Personality Test™, a test based on Carl Jung's and Isabel Briggs Myers' typological approach.	Work in diverse groups to further develop teambuilding abilities. Develop students' engineering management and presentation skills	Multiple project deliverables, two team presentations and a debate.	"Learned things about being professional and mainly how to give a descent presentation."

- Teaching methods: Active teaching techniques have proven effective for CIVL 317 and CIVL 411 so students not only learn about professional skills, but also require students to directly apply concepts learned through team building exercises, communication, self-directed learning and leadership. As these courses are not a rigorously demanding as analytically based technical courses, active learning is an effective means of keeping students engaged in course concepts and instructional material.

- Course and curriculum improvements: Incorporating new teaching methods in these courses has served to kept students more motivated during class periods and encouraged students to work more effectively on assignments, projects and presentations.

- Student feedback: Student feedback for the different teaching methods used in these courses was 90% positive. Additionally, 95% of students agreed that course materials were useful and will benefit them in their future professional careers.

The adopted curriculum, multi-course approach, and assessment procedures are providing increased student understanding of professional skills and competencies needed for success in the engineering profession. Teaching methods and student learning are measured and evaluated systematically with results feeding into the CEE Department assessment process for evidence-based objective measures of student performance and attainment of course goals. This multi-faceted organizational structure has allowed faculty to work collectively to help students better develop their skills throughout the four-year curriculum as they prepare to enter the job market and pursue successful engineering careers.

Suggested Steps for Adoption by Other Institutions

Use of this approach to develop, teach, track, integrate, and assess student professional skills and competencies was predicated on a lager adoption of a Department wide assessment process that mapped outcomes and linkages with course goals. Suggested steps for adopting a similar process at other academic institutions is summarized as follows:

1. Adopt Department-wide curricular outcomes, ABET A-K or equivalent, along with appropriate levels of Bloom's Taxonomy.

2. Identify professional skills and leadership outcomes to map within the course curriculum, through linkage with specific course goals.

3. Identify embedded indicator tool and alignment with desired Bloom's Taxonomy level for each specific course goal supporting professional skills and leadership outcomes.

4. Review mapping for appropriate educational scaffolding across all four years in the curriculum to ensure desired coverage and presence of higher Bloom's levels in junior and senior courses.

5. Track performance of embedded indicator results through comparison with an adopted Departmental Standard, and including other measures such as scores from Fundamentals of Engineering Examination, relevant subject areas.

6. In the event Departmental standards are not met, the professor systematically identifies and implements improvements in educational methods, instructional materials, assignments, exercises, and/or measurement of student learning aligned with the course goal of interest and embedded indicator tool used.

7. Solicit and incorporate student feedback and input from industry representatives to refine educational methods and optimally align with outcomes needed to prepared graduates for successful careers in engineering leadership.

8. Document results, implement and track changes as evidence of continuous improvement.

Future Steps

Using a systematic assessment approach to evaluate professional skills has been helpful in identifying a number of steps to further improve and enhance student instruction and evidence of student preparedness. Future steps for improvement include:

- Reevaluation of previously established Bloom's Taxonomy levels, course goals, and mapping across outcomes, especially for Engineering Management, CIVL 411, where assessed student performance should be better aligned with more appropriate higher levels, of Bloom's, namely 3. Application, 4.) Analysis, and 5.) Synthesis.

- Complimenting embedded indicators measures of student performance with additional direct and indirect measures such as results for Fundamentals of Engineering exam for specific topics, (i.e. ethics and business practices), and results from senior exit surveys, employer surveys and faculty surveys on professional skill readiness for career success.

- Integration of current curriculum approaches to student instruction with outside of the classroom, extracurricular activities such as: leadership in student professional societies, service learning projects, mentoring programs, academic competitions, internships, professional meeting forums, and community service.

Future plans are to transition all of the relevant content of these two courses into a two-semester capstone experience that will include major instructional components focusing on professional skills, leadership, ethics and preparation of rigorous structural, environmental and transportation design projects. Once the two-semester capstone course is in place, both of the courses (CIVL 317, CIVL 411) will be sunset having served their purpose in preparing students for professional practice, while at the same time marking useful curriculum milestones along the continuous improvement continuum of the CEE Department's assessment process.

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