Student Perception of Professional Skill Development in the Undergraduate Civil Engineering Curriculum at The Citadel

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Abstract

The ASCE Body of Knowledge (BOK) 2 provides a solid foundation upon which engineering programs should prepare graduates to meet ever increasing societal demands for engineers to serve as leaders, planners and designers of the built environment. Based on this vision for future engineers, The Citadel adopted 22 student outcomes, nine of which are specifically focused on development of student professional skills and competencies. All nine professional skills outcomes are aligned directly with three courses in the engineering program of study including: Engineering Economy, Professional Sustainability, and Engineering Management. Student perceptions of professional skills were surveyed in these courses with regard to the importance of professional skills covered, and degree to which students believe they learned these skills. Survey results provide insight on how the curriculum is preforming across these crucially important professional skills outcomes.

Keywords

Professional skills, curriculum, ethics

Introduction

The Civil and Environmental Engineering (CEE) Department's curriculum has 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 professional skills needed to prepare graduates for successful careers in the engineering profession. Course materials focus on development of professional skills needed to function as a successful practicing engineer.

Outcomes aligning the curriculum along professional skills have been created to link course goals across a step-by-step 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. 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 ASCE published an expanded set of 24 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 known 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 Bloom's 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 Department Outcomes

Twenty-two 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 CEE Department nine professional skills orientated outcomes. Course embedded indicators, assessment tools that specifically measure individual course goals at appropriately assigned levels of Bloom's cognitive performance, which take advantage of test questions, assignments, and projects are used to evaluate CEE Department outcomes. Results from embedded indicators and other measures are systematically evaluated to ensure overall performance standards are met and to formulate solutions in the event problems are identified.

Table 1. Summary of CEE Department Professional Skills Oriented Outcomes

Dept. Program Profession Skills Outcome	Dept. Program Outcome with Professional Skills Linkage
Contemporary Issues	Describe influence of contemporary issues on engineering solutions.
Project Management	Explain what a project is and key elements of project management.
Communication a.) Graphical b.) Verbal c.) Written	Organize and deliver effective graphical, verbal and written communication.
Public Policy	Discuss and explain key concepts involved in Public Policy and Public Administration.
Business	Explain key concepts and processes used in business.
Leadership	Explain the role of a leader and leadership principles and attitudes.
Interdisciplinary Teams	Function effectively as a member of an interdisciplinary team.
Self-Directed Learning	Demonstrate the ability for self-directed learning.
Ethical Responsibility	Apply standard of professional and ethical responsibility to determine an appropriate course of action.

Survey on Student Perception of Professional Skills

Three courses, specifically focusing on development of professional skills were the subject of a student survey to obtain feedback on perception of the importance and understanding of the nine professional skills addressed through courses in the curriculum. These courses include Engineering Economy (CIVL 314), Professional Sustainability (CIVL 317), and Engineering Management (CIVL 411). To provide a collective overview of curriculum covered in these three courses, goals for each course and Bloom's taxonomy levels are summarized in Table 2. Bloom's taxonomy consists of six different levels of understanding: 1) Knowledge; 2) Comprehension; 3) Application; 4) Analysis; 4) Synthesis; and 6) Evaluation [11]. The highest Bloom's level is 6 (Evaluation) and appropriate target Bloom's levels are established by ASCE BOK. Two courses are taken during the junior year and one course is taken during the senior year of the curriculum.

Table 2. Summary of Course Goals and Bloom's Taxonomy Levels

Courses/Course Goals	Outcome	Bloom's Level
Engineering Economy (CIVL 314)		
1. Time value of money	5. Problem Solving	3
2. Nominal and effective interest rates	5. Problem Solving	3
3. Capitalized cost & alternative comparison	11b. Business	3
4. Rate of return analysis	11b. Business	3
5. Benefit cost analysis and ethics	11a. Public Policy	3
6. Cost depreciation methods	5. Problems Solving	3
Professional Sustainability (CIVL 317)		
1. Functioning on multidisciplinary teams	13. Interdisciplinary Teams	2
2. Business concepts and processes	11b. Business	2
3. Project management principles	8. Project Management	2
4. Effective verbal communication	10. Communication	2
5. Public policy and infrastructure design	11a. Public Policy	2
6. Lifelong learning skills	14. Self-Directed Learning	2
7. Attitudes supportive of prof. practice	12. Leadership	2
8. Leadership principles and attitudes	12. Leadership	2
Engineering Management (CIVL 411)		
1. Role of engineering design in society	7. Contemporary Issues	1
2. Engineering management techniques	8. Project Management	1
3. Project management principles	8. Project Management	2
4. Project scheduling & network analysis	8. Project Management	3
5. Business development and marketing	11b. Business	2
6. Ethical and legal aspects of engineering	15. Ethical Responsibility	2
7. Organizational management concepts	11b. Business	2
8. Value engineering & quality management	11b. Business	1

Near the conclusion of each course, a survey was administered to obtain student feedback on perceived importance and achievement of CEE Curriculum outcomes. Surveys were given during the 2014 and 2015 academic years in a manner that reduced the likelihood of students completing a survey more than once. Questionnaire responses were provided on a 1-5 Likert scale and combined results are summarized for all three courses in Table 4 (sample size = 58). Questions, instructions, and response indicators contained on the survey are summarized in Table 4.

Table 3. Summary of Results from Questionnaire (n = 58)

Question	Importance to Student		Learned in CIVL 314/317/411	
	Mean	St. Dev	Mean	St. Dev
1. Contemporary Issues	4.33	0.72	3.68	0.97
2. Project Management	4.63	0.56	3.89	1.07
3. Communication	4.68	0.64	4.11	0.95
4. Public Policy	4.28	0.69	3.60	0.94
5. Business Concepts	4.33	0.81	3.64	1.21
6. Leadership Principles	4.71	0.64	3.99	0.96
7. Lifelong Learning	4.63	0.66	4.29	0.9
8. Multidisciplinary Teams	4.51	0.66	4.16	0.95
9. Supportive Attitudes	4.51	0.66	4.31	0.9
10. Professional & Ethical	4.86	0.35	4.48	0.91

Evaluation of Survey Results

Based on an evaluation of data tabulations, a number of interesting trends and comparisons provide insight into student perceptions for the professional skill outcomes surveyed. Survey questionnaire results include:

1. The importance of an outcome was perceived as higher than the level of student learning for all of the questions posed. This could indicate awareness that there is always more to learn and could also show student reverence for the intellectual challenges associated with fully understanding knowledge affiliated with these professional outcomes.
2. The highest magnitude of importance (4.86) was afforded to professional and ethical responsibility. This outcome also demonstrated at the highest level of perceived student learning (4.48). A graphical distribution of these responses is provided in Figure 1.
3. A lower importance to students for contemporary issues, public policy, and business, ranging from average Likert values of 4.28 to 4.33. Additionally, these same three outcomes, exhibited the lowest levels of student learning ranging from average Likert values of 3.60 to 3.68. Conversely, it is interesting to note students exhibited a higher

value of importance in comparison to their level of learning for each of these outcomes. A graphical distribution of this trend is provided in Figure 2 for public policy. It is possible the nuances of these overarching subjects are difficult to convey to students in an undergraduate curriculum.

4. Additionally, with regard to student understanding of business, a much larger standard deviation (1.21) was noted, as graphically shown in Figure 3.
5. The smallest average standard deviations for importance to students was noted for leadership (0.35) and project management (0.56) indicating that students are in agreement on the significance of these outcomes to their professional skill-set and future success in the engineering profession.
6. Higher levels of importance were noted for leadership (4.71), yet a much lower proportional level of student learning was recorded for this outcome (3.99). See Figure 4 for graphical distribution of these trends. Differences in perception between importance and learned values may be due in part to a large emphasis on leadership of the college through other student life, ROTC courses and other student development activities.
7. Higher levels of importance were noted for project management (4.63), yet a much lower proportional level of student learning was recorded for this outcome (3.89).

Table 4. Professional Skills Questionnaire

Question		Indicate the **importance** of topics to you, as you prepare for a civil engineering career.					Indicate the degree to which you **learned** topics from materials taught in CIVL 314/317/411				
		1 SD	2	3	4	5 SA	1 SD	2	3	4	5 SA
1	**Contemporary Issues**	1	2	3	4	5	1	2	3	4	5
2	**Project Management**.	1	2	3	4	5	1	2	3	4	5
3	**Communication**	1	2	3	4	5	1	2	3	4	5
4	**Public Policy**	1	2	3	4	5	1	2	3	4	5
5	**Business Concepts**	1	2	3	4	5	1	2	3	4	5
6	**Leadership Principles**	1	2	3	4	5	1	2	3	4	5
7	**Lifelong Learning**	1	2	3	4	5	1	2	3	4	5
8	**Multi-Disciplinary Teams**	1	2	3	4	5	1	2	3	4	5
9	**Supportive Attitudes**	1	2	3	4	5	1	2	3	4	5
10	**Professional & Ethical**	1	2	3	4	5	1	2	3	4	5

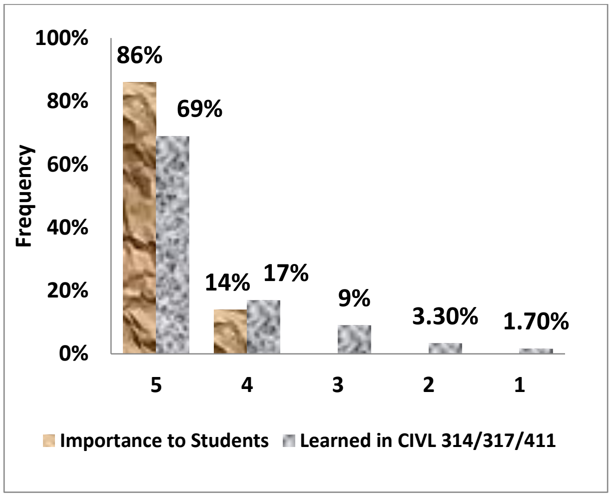

Figure 1. Likert response for professional and ethical responsibility outcome

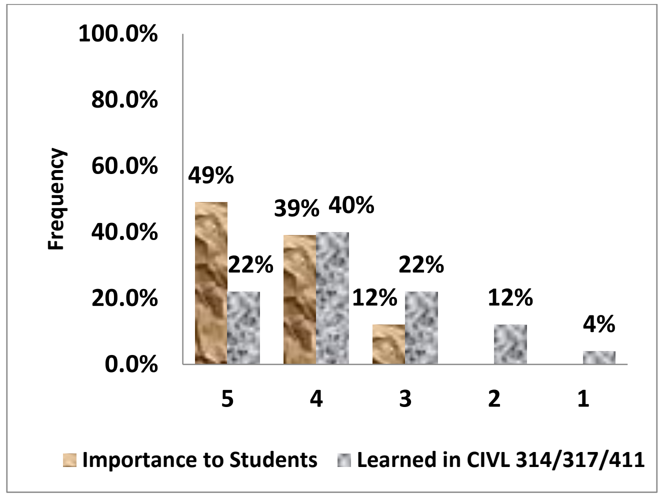

Figure 2. Likert response for public policy outcome

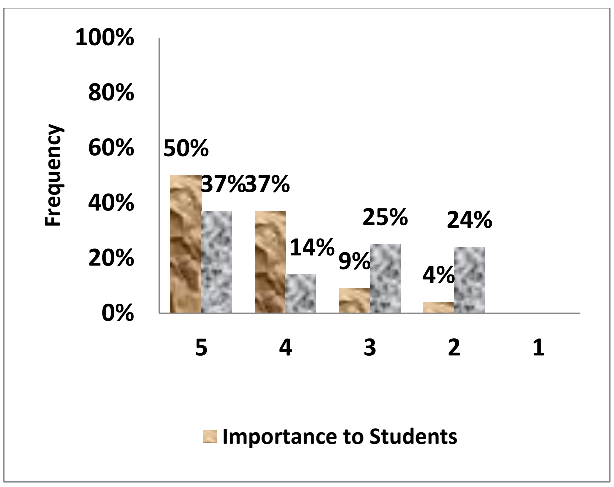

Figure 3. Likert response for business outcome

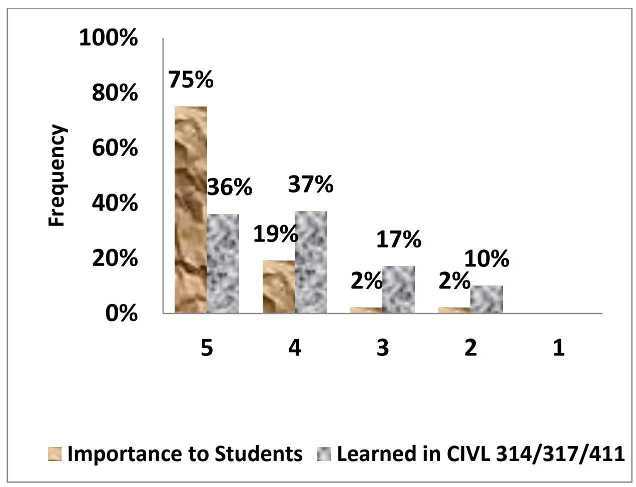

Figure 4. Likert response for leadership outcome

Findings and Conclusions

Although other direct and indirect measures are officially used for assessment of Department outcomes such as embedded indicators, Fundamentals of Engineering examination results and senior exit surveys, this targeted student perception survey questionnaire provides useful insight into how students view the importance and their level of understanding of the professional outcomes. Based on student survey results, the survey findings and conclusions are summarized as follows:

- Likert averages for all outcomes exhibited higher importance than levels of student learning. This could indicate student awareness of the realization there is always more to learn and could also show student reverence for intellectual challenges associated with fully understanding knowledge pertaining to these professional outcomes.

- It was affirming to receive feedback that students place the highest importance on professional and ethical responsibilities. Student Reponses also indicate a belief that they accomplished a high level of learning for this crucially essential outcome to the continued success of the engineering profession. It is important to note that there is no significant ranking of outcome; however, the outcomes may have higher Bloom’s thresholds.

- Student response on understanding of business, exhibited a lower average Likert scale response (3.64) and larger standard deviation (1.21). All three courses include material on business concepts and processes; however a more concentrated emphasis is provided in CIVL 411, Engineering Management. It is possible that students in the junior level courses initially rate their understanding lower, until after they have completed the senior level class, CIVL 411.

- Student response on understanding of project management, exhibited a lower average Likert scale response (3.89) and larger standard deviation (1.07). It is likely these problematic student response values are due to similar factors as described for student understanding of business.

- Although this survey involved multiple courses in the curriculum, the sample size is relatively small and should be expanded to include more students, prior to taking corrective actions to improve the curriculum. An expanded emphasis on professional skills is relatively new and is intended to compliment the long-standing traditional focus on analytical technical skills required to enter the engineering profession.

- As this survey was administered during the junior and senior years while students are still learning more about professional skills, it would be desirable to evaluate responses for these same outcomes through the senior exit survey administered comprehensively to all students. As all students will have completed their senior capstone design projects, this should allow additional experience and perspective, due to the fact that engineering design incorporates essentially all of the professional skills taught in the curriculum.

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