AC 2008-1406: PROFESSIONAL PRACTICES IN CIVIL ENGINEERING: MEETING AND EXCEEDING THE NEW CIVIL ENGINEERING PROGRAM CRITERIA

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Professional Practices in Civil Engineering: Meeting and Exceeding the New Civil Engineering Program Criteria

Introduction

The emerging global nature of the worldwide marketplace for products and services coupled with the exponential rise in technological advancement in the industrialized world has led to the near-term, long-term, and critical need for holistic engineering education which includes and stresses a broad range of leadership and management skills in addition to a concentrated traditional technical curriculum. Emerging young engineers will, in many instances, be required to lead teams of diverse professionals and manage budgets and schedules for domestic and/or international projects only a few years beyond completing their formal undergraduate education.

The new program criteria developed by the American Society of Civil Engineers (ASCE)[1], and used by ABET during the accreditation process, recognizes this change and is more closely aligned with the Body of Knowledge[2]. One major change is that the new criteria now include a statement requiring that students "can explain basic concepts in management, business, public policy, and leadership."

This paper describes a course entitled "CEE Professional Practice" that can serve as a model for other universities striving to meet and exceed the requirements of the new program criteria. The course focuses on 11 areas of professional practice such as how management and leadership differ, management of self and others, and how organizational structure can influence success. These areas are interrelated through a semester-long keystone project. The project selected for this course must meet certain criteria; the project must be current, large in scope, and controversial with unknown solutions.

At the conclusion of this course, students have had the opportunity to lead, manage, create, and structure groups, interact with project sponsors, develop and evaluate many solutions, and view a major engineering project from a holistic perspective. This course is designed to help students find their initial place in the world of engineering and to offer a much broader perspective of the profession of civil engineering. This will enable them to intelligently and effectively map out the initial stages of their professional careers.

This course was originally developed under the previous ASCE criteria; consequently, only our assessment of the course changed with the new criteria. The assignments and rubrics used to assess this course will be discussed, as well as its placement within our curriculum.

Course Content

CEE Professional Practice (CEE 4601) is a senior-level holistically-oriented course designed to expose mature undergraduate students to a wide range of practical aspects in the profession of engineering, including the following:

- An examination of self-abilities and interests
- Leadership and management

- Organizational structure and theory
- Management of self
- Management of others
- Communications (verbal and written)
- Teams, groups, and group thinking
- Project management
- Ethics in engineering
- Marketing professional technical services
- A global view of the emerging engineering marketplace

An Examination of Self-abilities and Interests

For individuals to be successful in their profession, they must 'fit' well within the framework of their chosen organizations. Such a fit requires an *analysis of self*. This course opens with such an analysis. Students are first introduced to the concept that their view of themselves is not, necessarily, the same as the view of others toward them. There are always three distinct, but possibly differing views: *who we are, who we think we are, and who others think we are.* After considerable discussion, students are asked to categorize themselves as Changers, Doers, Floaters, or Non-Doers as members of the global society that they plan to serve. These categories are not prioritized and are discussed in a forum related to the overall needs of society and are not restricted to the engineering profession only. The goal here is to raise the concept of self-awareness within each student such that he/she understands that their service to society, through a career in engineering, will be valuable and successful if they truly focus on the proper fit for themselves within the profession.

Leadership and Management

Based on input from leaders in the engineering industry (design, consulting, and construction management) invited to speak as guest lecturers in this course, we can conclude that some engineers will find themselves in junior leadership and management positions not long after completion of their undergraduate studies. Leadership and management, although related, are not the same.

Students are introduced to the concept that leadership is *people* driven and that management is *process* driven. For a leader to be successful, that individual must create an environment among all of the people of the organization such that every person feels secure and is willing to share thoughts, ideas, and concepts without the fear of reprisal or humiliation. In essence, the leader must be personally and professionally committed to the long-term growth of each and every individual within the organization. Only through such personal and professional commitment to people, can a leader galvanize efforts and create an organization where every individual shares 'from the heart' and, as a result, helps make the organization more successful than the success that each individual could ever generate on his or her own. Leaders should not be focused on the 'bottom line' but, rather, on the people within their organizations.

Managers, as the students are instructed, are process driven. Managers should be focused on schedules, specific assignments, and budgets. The essential goal of the manager is to insure that

projects are completed with a high degree of quality, on time, and within budget. Although managers are, indeed, managing individuals to insure project success, their primary focus is project and process oriented. If the leader has been successful in creating the environment described above, managers will be more successful in achieving their individual project and process goals.

An organization with a high turn-over rate (the rate at which individuals are joining and leaving the organization) is one that is the victim of poor leadership. Almost all organizational problems can be traced back to poor leadership. Because the engineering profession is highly people oriented, leadership, within the profession, must be people oriented to achieve organizational success. If an organization is led properly (focus on people), its reward will be a strong bottom line.

Organizational Structure and Theory

Students are exposed to various types of organizational structures including pyramids, rakes, matrixes, and relational structures. The concept of 'line positions' and 'staff positions' is also introduced. In addition to introducing these types of structures, each is discussed and examined for positive and negative aspects. Various forms of organizational structures are also related to various types of organizations in the private and public sectors. Following this aspect of the course, students, previously assigned to groups for semester projects, are instructed to develop Organization Charts for their groups, assigning each individual a specific project responsibility and clearly showing the reporting structure within their organizations. Groups are encouraged to assign individuals to both line and staff positions.

Management of Self

Throughout the semester, the course strives to emphasize the importance of self management as a key stepping stone toward management of others and toward effective leadership. This is stressed by focusing on three specific and related aspects: self driven responsibility, time management, and career planning.

Self-driven responsibility is founded on results-oriented daily work, on commitment to others, on the project team, on elimination of self praise, and on working in an environment not based on partial credit. Time management is presented, stressing the over arching goal to *Do it Now* and to eliminate procrastination. Students are instructed to keep a clean desk, apply the 80/20 rule[3], act on what they have, not on what they do not have and to hold meetings only when necessary. Career planning is stressed and presented as a fluid and changing effort to be conducted annually. Students are encouraged to think through their emerging careers, to try to choose a career path in concert with who they are and to plan for the future. But, they are strongly encouraged not to tie themselves to a plan which becomes obsolete with the passage of time and the occurrence of unpredicted events. Career planning is essential but not rigid, valid but not stationary, and occasional but not permanent.

Management of Others

Interpersonal skills are taught as the 'keys to success'. The key concept of this topic is that *effective management of others places their needs above and beyond the manager's needs.* If engineers have the technical ability to conceptualize, design, build, and operate without the ability to communicate effectively, their opportunities to move forward into management and leadership positions may be significantly reduced. It is important to understand, at this point, that all engineers do not wish to move into management and leadership positions and prefer career advancement along purely technical paths. This aspect is discussed in the course and fully embraced as a fulfilling, essential, and valuable career path within the profession. Well-structured, technically-based organizations understand and embrace this difference among engineering professionals and provide for various paths to accommodate varying career interests and goals.

Interpersonal-skills training is directed toward a conscious effort to remove self focus, to establish a good personal relationship with all organizational personnel including the *most junior individuals* in the organization, to not push down blame, to praise in public and reprimand in private, to stress positive motivation and to avoid negative motivation, to make subordinates feel valuable to the overall goal of the group and, as the manager or leader, to accept blame when problems arise and give praise to subordinates when the project team is positively recognized.

Students are exposed to types of people to manage including fellow professionals in engineering, professionals in other fields, clerical, administrative, vocationally-trained personnel, vendors, subcontractors, as well as blue-collar personnel (union and nonunion). Each group is discussed from the standpoint of proper, respectful, and effective interaction with the goal of group-oriented success.

The issue of age differential is addressed. Young engineers, perhaps assigned to a construction site, may find themselves in a position where they are managing experienced construction workers twice their age or more. Emphasis is clearly placed on the importance of mutually-driven respect and the concept that an individual's experience is valuable and valued on the team regardless of educational levels achieved. Students are encouraged to strive to learn from individuals older than them and to respect individuals without regard to age, education, or experience.

In considering the management of others, Maslow's[4] 'Hierarchy of Needs' is used to explain the importance of effective delegation and the role of coaching as another word for leading. Here again, a well-coached sports team, regardless of level, is one where all members of the team are convinced, in their hearts, that their coach believes in each one of them personally and that he/she depends on them, through delegation, to devote their talents to the overall goal of the team.

Communication (Verbal and Written)

In many instances, program and/or project failure is linked to poor communication. Although numerous means of instant communication are currently ever present, this problem still persists.

Students are directed toward this problem and are provided with solid suggestions to solve it. There are five forms of communication in the engineering profession which are (in order of precedent): listening, speaking, writing, visual aids, and calculations.

Regarding verbal communications, students are taught to develop skills in the "you" based conversation, not the "I" based conversation. They are instructed to become good listeners and to be empathetic and attentive rather than selective, pretentious, and ignorant. They are instructed to develop skills in 'questioning' rather than in 'telling'. We learn from others when we ask for their input. In the holistic approach to management and leadership, listening is the most important skill to develop. Verbal communication, when question based, is bi-directional and, therefore, more effective than written communication, which is uni-directional. The purpose of written communication is, quite often, to get to the point of verbal communication. Usually, only through verbal communication, is anything really accomplished.

Regarding written communication, students are instructed to focus on the following: always summarize in the beginning, place broad findings and some detail in the body of the document with fine details in the appendix, ask questions in the text as a literary tool, select graphs and tables wisely, focus on conclusions, choose words carefully, and have trusted colleagues review your work before submission.

Regarding verbal presentations, the following is offered as guidance:

- know your audience
- prepare your presentation yourself
- keep the presentation focused on results
- practice with colleagues
- stay within the allotted duration
- check out the presentation room before the event and have a back up visual aids plan in the eventuality of equipment failure
- allow about 1 minute for each slide or visual aid
- talk to the audience, not the visual aids
- encourage questions and interaction
- have a brief, concise, and strong conclusive statement and do not back off from it.

Students use these techniques twice during the semester when giving both functional and final project presentations.

Teams, Groups, and Group Thinking

Based on input from numerous professionals in the engineering field asked to offer insight regarding these issues, we can conclude that, to a substantial degree, the current and emerging engineering culture throughout the industry is team-oriented. Teams, or groups, of professionals from diverse professional backgrounds are tasked with achieving project or program goals. A clear and direct focus of teams and groups is emphasized in this course. This is the third course in which students explicitly address the inner-workings of teams[5]. The team, or group, is defined as a small number of individuals (usually six or less) with a common goal. The team has a leader and a manager. The leader is encouraged to create an environment where all participants can feel free to offer suggestions, concepts and input without the fear of reprisal or humiliation. The

manager is encouraged to schedule tasks and control time budgets. *The successful team achieves more, collectively than any one member of the team can achieve individually. In a successful team, the whole of the effort becomes, indeed, greater than the sum of its parts.*

Group thinking[6] is a negative outcome which results from poor leadership - leadership not focused on people. Group thinking emerges when group members discern a predestined outcome driven by an authoritarian leader controlled by external input rather than the good of the team and the ultimate success of the project. There have been numerous monumental failures resulting from group thinking including the Challenger space shuttle disaster of 1986[7] and the U.S. response to the attack on Pearl Harbor in 1941[6]. Students are exposed to group thinking and are made aware of the presence of group thinking when it begins to occur. Hopefully, through this awareness, they will understand the inherent dangers of group thinking and try to eliminate it as much as possible in their careers.

Project Management

Although project management is not at the heart of this course (there is a separate elective available in this area), it is stressed in the semester-long project. Leaders and managers, as defined above and as identified in the group organization charts, are responsible for defining project tasks, assigning individual responsibilities along with task durations, and completion dates. Groups are also required to complete and submit time sheets along with their functional and final presentations. Bar-chart and critical-path scheduling are discussed. Students are required to submit bar-chart schedules for their semester-long project. The interaction among the leader, the manager, and the producers is emphasized. Various degrees of success in this regard are evident in the functional and final semester presentations.

The concept of billability or utilization is introduced. Students are exposed to the concept of a cost-multiplier contract where the multiplier is a factor which is multiplied by direct salary and includes aspects such as burden, overhead, and profit. This multiplier is examined in detail and discussed as a function of the various types of engineering services offered. The concept is discussed later as well in the topic of *Marketing Professional Technical Services* where competition is introduced and overall project cost becomes a variable in eventual selection of an organization for a specific program or project.

Ethics in Engineering

Although ethical behavior seems to be inherent in all of the courses offered within the curriculum, it is emphasized here. The concept of ethical behavior is introduced by discussing two general approaches to ethics: utilitarianism and rights-based ethics. Here the students are exposed to the concept that the common good should govern society and ethical behavior (utilitarianism) or that the rights of the individual should govern (rights-based ethics). Each approach is examined in detail without bias toward either. Students are requested to consider which they personally believe in. The most important aspect in this part of the course is the emphasis on the National Society of Professional Engineers (NSPE) Code of Ethics[8] and/or the American Society of Civil Engineers (ASCE) Code of Ethics[9], which both stress the paramount

importance of upholding the safety of the public as the primary guiding principal for all engineers.

Marketing Professional Technical Services

In general, undergraduate degrees in engineering do not include course work regarding professional services marketing. However, in the ever-changing business environment, engineers may be involved with proposal preparation, conceptual presentations, and the marketing of their organizations to procure future projects. Therefore, professional services marketing is introduced during this course.

A historical perspective of marketing professional technical services is offered. The difference between sales and marketing is discussed. Approaches to professional services marketing are taught including the doer-seller concept, the senior leadership concept, and the dedicated marketing staff concept. All of these approaches have both positive and negative aspects. As young professionals, engineers, regardless of the market sectors chosen for their career paths, will, more than likely, be involved in some aspects of professional services marketing. Given that observation, their responsibilities in this regard may include the following: attendance at client meetings, attendance at technical conferences, participation in proposal preparation efforts, development of cost estimates and participation in market strategy formation sessions.

In addition, ethical behavior in marketing professional technical services is also covered with a focus on the total elimination of professional indebtedness. Also covered are the following: proposal shopping, price-based negotiations, truth in negotiations, and arms-length client relationships. Students are also instructed about the primary aspects of the development of marketing plans which will, if executed methodically, result in success as measured by new projects and/or markets for their organizations. The cost of such marketing plans and marketing programs is also discussed. Such cost must be controlled and managed because it usually is considered overhead and comes off of the bottom line.

A Global View of the Engineering Marketplace

This course is designed to broaden thinking, not narrow it. Therefore, the emerging global nature of the engineering marketplace is stressed as the future environment in which young engineers will find themselves. The internet and the ease through which verbal and written communication can take place has allowed for engineers to consider employment opportunities worldwide. Such opportunities will expose young engineers to others societies, other cultures and other ways of accomplishing goals. Not only geographically, but functionally as well, emerging engineers may find themselves in a wide range of initial positions in which they must strive to function successfully. This course is designed to offer this global focus to allow these emerging engineers to see the substantial impact they can have on their world.

Semester-Long Project

Project Selection

All of the aspects of professionalism in engineering discussed above are addressed and reinforced by the completion of a semester-long project. The selected project is technical in nature with the potential for major, sweeping societal, and/or cultural changes. The students are involved holistically in the project and are not narrowly focused only on its technical aspects. Therefore, each semester, the selection of this semester-long project is critical to the success of the course.

At the outset of the semester, students are divided into 'Functional Groups'. Each group is assigned a specific functional area of the project to investigate. Examples of these functional areas may include:

- technical design
- environmental impact
- economic impact
- legal issues
- financial considerations
- political impediments and roadblocks
- federal, state, and local regulations
- future demographic predictions
- future industrial, commercial, and residential development.

There are usually about six to eight students in each group. They are required to select a leader and a manager, to develop an organization chart of their group, and to assign specific tasks to each individual in the group. At about midterm, each group is required to give a 'Functional Presentation' to the class regarding their particular area of study. All members of the class are required to participate in these Functional Presentations. Information shared by each group will be utilized by all groups at the conclusion of the course for their final presentations. Through this approach, students are taught the value of interdependence and the need for a wide range of professional interaction as a means to project-wide success.

For their final presentations, which are given at the conclusion of the course, the groups are required to quickly summarize the entire project and then to offer innovative and creative solutions to problems that arose during the semester and credible paths forward. Grades for these final presentations are given, to a substantial degree, based on the groups' abilities to find new and creative solutions through interaction among themselves, with classmates in other groups, and with external individuals involved in the project. Personnel from all external agencies and organizations involved along with other faculty are invited to both the Functional and Final Presentations.

The semester projects selected over the past 3 years were:

2005	Bank Erosion along the eastern shore of the Chesapeake Bay, MD endangering home owners, personal property, and tiger beetles which are listed on the National Endangered Species Act.
2006	Expansion of an existing rapid transit system in southern NJ to Philadelphia, PA.
2007	Deepening of the Delaware River from the ports of Camden, NJ and Philadelphia, PA to its intersection with the Atlantic Ocean.

Project Type - Major and Current

The selected project must be substantially large in scope with the potential to have a real and measureable long term affect on people, property, and the environment. It must be current and on-going such that no clear answers are evident. Through this approach, students can not simply hunt for the 'right answers' and report them back to the class. Because the project is current, students must consult with project sources, and then search themselves for their answers, opinions, and suggestions.

Project Location and Local Interaction

The selected project must be regional and local, state, and federal agencies located in the region are notified of the project and are asked to participate. Other recognized non-governmental organizations involved with the project may also be asked to participate. A 'lead' organization or agency is identified and, in conjunction with their support, an early semester field trip is undertaken to stimulate interest among the students and to provide a forum through which students and agency personnel meet and begin to formulate opinions, ideas, and project suggestions.

Following this field trip, students are assigned a project mentor from the participating agency. This project mentor is an individual willing to share project information with the group with respect to their specific functional areas. Students are not restricted from interacting with other agencies and/or individuals involved with the project. Throughout the semester, professionals involved with the project from a wide range of perspectives are invited to the course to offer opinions and ideas and to help students develop their overall approach to project solutions.

Controversial Project Aspects

The selected semester-long project must have some current and unresolved controversial aspects associated with it. These aspects may be environmental, economic, societal, technical, legal, demographic, cultural, and/or political in nature. The reason for this requirement is to allow students to realize that most projects in which they will be involved during their professional careers will probably be controversial to varying degrees. Students are expected to evaluate the nature of the controversies associated with the semester project, take firm positions, and defend

these positions with facts and details. Their positions are expected to lead to recommended solutions during their final presentations.

Placement in Our Curriculum

This course is a 4th year required course for all civil engineering majors which is offered during the fall semester. There are a series of technical prerequisites so that students are capable of addressing a wide range of technical issues that may arise during the completion of the project.

In addition to the project-related reports, students are also required to complete approximately 10 written assignments during the semester on a wide range of topics associated with the course content as described above. Through this effort, they develop and improve their writing skills which are essential to becoming full and comprehensive engineering professionals.

Assessment Process

The CEE Department at Villanova University has seven educational outcomes. These outcomes are that our graduates will be able to:

1. explain and apply selected principles from basic and applied sciences to solve common engineering problems
2. explain and apply principles and practices from five civil engineering disciplines to solve common civil engineering problems, and, in addition, be able to analyze and design solutions for more complex problems in at least three civil engineering disciplines
3. demonstrate relevant skills associated with contemporary civil engineering practice including written and oral communication, computer proficiency, appropriate engineering laboratory techniques, and teamwork
4. explain by way of several examples the societal context of civil engineering practice including the importance of civil engineering works to society and contemporary issues from at least three civil engineering disciplines
5. explain basic concepts in management, business, and public policy
6. explain the professional and ethical responsibilities of engineering practice including the significance of licensure and the need for life-long learning
7. demonstrate an interest in liberal arts and the Judaeo-Christian humanistic tradition.

CEE Professional Practice is the most heavily assessed course in our curriculum. The following ABET criteria are assessed in this course:
d. an ability to function on multidisciplinary teams
f. an understanding of professional and ethical responsibility
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues

In addition, a portion of the ASCE program criteria is assessed as well. Specifically, the requirement that students can explain basic concepts in management, business, public policy, and

leadership (ASCE 5 in Table 1) and can explain the importance of professional licensure (ASCE 6 in Table 1) are assessed in this course.

A rubric was developed to aid in the assessment process. An example is shown as Figure 1. The instructor(s) teaching the course are provided with the rubric at the start of the semester and it is their responsibility to create and evaluate the assignments. All assignments are evaluated and the instructor saves one example of student work from each category for archival purposes.

In addition to performing assessment on individual outcomes, the instructor(s) also qualitatively assess the course at the end of the semester. This form is shown as Figure 2. This form is then placed in the course binder so that the instructor (if the same) is reminded of the suggested improvements when teaching the class again and can document improvements to the course.

Results of Assessment

At the time of writing, we have one year of assessment data. Our goal is to have 80% of the work at or above satisfactory. If only 65% of the work is at or above satisfactory, then the matter is investigated by a committee of faculty members. The results of the assessment from 2007 are summarized in Table 1.

Table 1. Summary of assessment results

ABET/ASCE criteria	Brief description of assignment	% at or above satisfactory
d	Students are required to prepare functional and final presentations along with associated time sheets clearly detailing the number of hours devoted to preparing these documents.	100%
f	Students were required to prepare a one page summary of and comment upon a presentation given by representatives from industry in which presenters stressed the importance of ethical behavior, lifelong learning, and professional licensure.	100%
h	The final report for the semester-long project was used to assess this outcome.	100%
i	Students attended a presentation given by stakeholders regarding the semester-long project. The speakers addressed the importance of lifelong learning, professional licensure, and ethical responsibility. Students were required to submit a one page summary of and comment upon this presentation.	100%
j	The final report for the semester-long project was used to assess this outcome.	100%
5	In-class assignment requiring students to describe the differences between management and leadership, organizations in business, and other related issues.	100%
6	Students were required to write two one-page summaries of and comment upon presentations given by various industry speakers. Their presentations stressed life long learning and the importance of professional engineering licensure.	100%

Conclusions

CEE Professional Practice was developed to provide a real and tangible link to societal problems which can be addressed by civil engineers, while meeting the requirements of accreditation. Based on student feedback, the assessment described above, and informal input from regional organizations involved in providing guest lectures and participating in semester-long projects, we can conclude that this course helps emerging engineers find their initial paths in the profession while adhering to the basic principles of ethical behavior, effective teamwork, creative analysis, and lifelong learning. Through significant interaction with regionally-based professionals from outside of the university, students develop a sense of their personal worth as professionals and begin to understand that their lives and their careers can affect change in both a local and global sense. The goals of this class are to prepare technically-trained graduating engineers for the marketplaces which they will face after graduation, help them choose the right initial career path, and provide lifelong tools for success in the engineering profession.

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Figure 1. Example rubric

CEE Outcome:	3. demonstrate relevant skills associated with contemporary civil engineering practice including written and oral communication, computer proficiency, appropriate engineering laboratory techniques, and teamwork
ABET:	-
ASCE:	5. can explain basic concepts of leadership
Date:	
Name of evaluator:	
Class:	
Brief description of assignment:	

Tally the number of students falling into each category. Save one example of student work from each category. Place completed rubric and samples of student work into the CEE Outcome 3 binder in Tolentine 143.

	Complete mastery of the concept with no errors	Mastery of the concept with minor errors	Satisfactory attainment of the concept with some errors	Limited attainment of the concept – multiple errors	Unsatisfactory attainment of the concept – many grave errors	Total number of students
Percentages in each category						

Comments on the assignment:

Comments on the results:

Figure 2. End of course evaluation form

Villanova University - CEE Department

Assessment Report/Improvement Recommendations for CEE xxxx
Performed by:
Date:

If this course is part of the assessment process fill in the following, otherwise delete:

Program Sub-outcome(s) Assessed with Coursework from this Class
Insert program sub-outcomes here.

Assignments used to Perform Assessment
Describe type of assignment (test, homework, laboratory, report, etc.) used in the assessment process.

Results from Rubric
Quantitatively report the results for each sub-outcome separately providing composite values if appropriate.

Success of Implemented Recommendations from Previous Year
Describe how previous recommendations were implemented and how successful those changes were.

Course Recommendations
Describe any recommendations.

Basis for Recommendations
Describe how the recommendations for improvement were developed (rubrics, instructor observations, etc).