A Civil Engineering Program Developed in the "Age" of ABET 2000

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INTRODUCTION

The engineering program at Rowan University was started in 1996, the result of a $100M gift to Rowan University in 1992. This allowed the Civil and Environmental Engineering (CEE) curriculum to be developed with ABET 2000 in mind. A committee of nationally renowned experts provided the starting point, which was further developed by faculty and outside consultants. Consequently, the Rowan University Civil Engineering curriculum includes some of the most successful innovations in engineering education. The focus is on technical excellence, communication skills, and a well-rounded general education. The engineering curricula provide for a hands-on, team-oriented approach to a highly interdisciplinary education. The purpose of this paper is to describe the ABET 2000-oriented curriculum, along with the assessment system used to ensure continual improvement.

Many of the curriculum innovations are incorporated in the Engineering Clinic classes, which students enroll in every semester. Students from all disciplines work together on projects beginning in the Freshman Clinic, which is devoted to engineering measurements and reverse engineering. This continues in the Sophomore, Junior and Senior Engineering Clinics. In Sophomore Clinic, students work on multidisciplinary design projects. This course is also tied to the students' communication courses, allowing faculty from engineering and communications to work together. In Junior and Senior Clinic, students work in small teams on industry or government sponsored projects. Other innovations include a seminar course on practice issues and a two semester senior design course.

Preparation for our first ABET accreditation visit began in earnest in Fall 1999. As our first graduating class was in May 2000, our first ABET visit was in Fall 2000. A number of assessments are used to ensure continual improvement, including evaluation of select course assignments, surveys, exit interviews, faculty reflection, etc. Many assessments have numerical results that are related to green, yellow, and red flags. Green flags indicate that expectations are being met, while yellow flags indicate that correction may be needed. Red flags indicate that an immediate corrective action is needed. Other assessments are qualitative in nature. For example, the faculty meets at the end of each semester to discuss courses just completed. The resulting reflection can lead to improvement in individual courses or in a series of related courses.

In this paper, we describe our curriculum (and its development) and our ABET assessment system.

THE CURRICULUM

Curriculum Development

Founded in 1923, Rowan University has evolved into a comprehensive regional state university with six colleges, including a new College of Engineering initiated as a result of a major donation in 1992 from the Rowan Foundation (Rowan and Smith 1995).

The College developed the Rowan University engineering curricula and the initial framework for the College with the assistance of a National Advisory Council. The National Advisory Council for the Development of the College of Engineering first met in June of 1993. It was charged with developing the framework for a new and innovative College of Engineering and was composed of internationally renowned leaders in engineering education and industry.

The National Advisory Council was composed of two separate committees. The Education Committee was chaired by Dr. Simon Ostrach, Wilbert J. Austin Distinguished Professor of Mechanical and Aerospace Engineering at Case Western University and Home Secretary of the National Academy of Engineering. The Corporate Committee was chaired by E. Douglas Huggard, the Chairman of the Board of Atlantic Energy/Atlantic Electric. A Subcommittee of the Education Committee assisted in the development of the preliminary engineering curriculum for each program. This Subcommittee was chaired by Dr. B. Samuel Tannenbaum, Professor of Engineering and former Dean of Faculty at Harvey Mudd College.

The National Advisory Council was created so that the Rowan Engineering Programs would incorporate the most successful innovations in engineering education and facilities, and meet all of the accreditation criteria of the Accreditation Board for Engineering and Technology (ABET). Within CEE, two separate options were developed – general civil engineering and environmental engineering. After the engineering faculty began to arrive at Rowan University in the Fall of 1995, changes in the original curricula were made based on the input of the new faculty. These changes were carefully considered and much of the original curricula developed by the National Advisory Council still remains. For example, while the two options in CEE were retained, the names of these options were changed to the infrastructure emphasis and the environmental emphasis, respectively. However, CEE is seeking ABET accreditation in civil engineering; each option meets the ABET criteria for civil engineering.

One major change that was made in CEE was the requirement for students to take a minimum of two courses each in four of the five areas of civil engineering specialization that are offered at Rowan. Other changes included the addition of required courses including an introductory course in environmental engineering, a two-semester capstone design course, a course in civil engineering systems, and a course in civil engineering practice. In addition, the sequences of courses within each area of civil engineering specialization were also examined carefully and some were redesigned.

For example, as originally designed by the National Advisory Council, the structural engineering courses included a traditional three-course sequence of structural analysis followed by concrete design and then steel design. The CE faculty changed this traditional sequence so that analysis and design would be included in each course of a three-course sequence – Structural Engineering

I, II, and III. Structural Engineering I is focused on the analysis and design of reinforced concrete beams and columns. Structural Engineering II focuses on the analysis and design of structural steel trusses including compression and tension member design, the analysis and design of bolted and welded connections, and the classical and modern methods of truss analysis. Finally, Structural Engineering III focuses on the analysis and design of frames, both concrete and steel. Figures 1 and 2 are the current infrastructure and environmental curriculums.

Civil Engineering Hallmarks

CEE strives to give civil engineering students the ability to understand and apply the core science, mathematics, and engineering principles that form the basis of civil engineering. Students work individually and in multidisciplinary teams to identify and solve engineering problems using their accumulated knowledge and experience along with advanced technology such as computers and laboratory equipment.

Every CEE course can be characterized as a problem-solving course. Engineering design issues and experiences are integrated throughout the undergraduate CEE Program, beginning with two sophomore courses in the curriculum sequence, Introduction to Environmental Engineering and Structural Engineering I. Issues related to safety, economics, ethics and social and global impact are discussed and considered in virtually every course. Students are also exposed to a wide range of hands-on, standards-based, civil engineering laboratory experiences integrated throughout the curriculum. Communication skills (both written and oral) are integrated throughout the curriculum to give students the ability to communicate effectively in preparation for both engineering practice and for graduate studies. The sequence of courses is arranged such that every student in CEE has a proficiency (two or more courses) in at least four of the five areas of civil engineering that are covered (structural, water resources, geotechnical, transportation, and environmental).

The junior and senior courses provide ever-increasing opportunities for CEE students to work on CEE design problems. This culminates in the capstone design sequence (Civil Engineering Design Project I and II) where the seniors in the CEE Program work in teams on an open-ended, real-world, civil engineering design problem. The capstone design sequence allows students to draw upon various aspects of their undergraduate coursework to develop a comprehensive, engineered solution to an open-ended civil engineering problem. This two-semester capstone sequence addresses a real-world problem and is coordinated with practicing engineers. Faculty coordinators serve in an advisory capacity and coordinate class meetings and presentations. Because of the required prerequisites, students have already been adequately trained in the fundamental principles of engineering analysis and in the concepts of engineering design. This is an opportunity for these skills to be applied without the formal direction found in typical engineering courses. Students are organized into design teams and are led by a student who acts as a project manager. Because of the variable nature of the proposed activities (i.e., field work, computer graphics, technical writing, oral presentations, etc.), the design teams identify the relative strengths of each team member. In addition to a final report, students prepare interim reports, attend business meetings, and give formal presentations. One or two faculty members are assigned as the Senior Design Project Coordinator(s). However, all faculty members

CIVIL ENGINEERING PROGRAM - INFRASTRUCTURE EMPHASIS - 128 SH

FIRST YEAR:

Freshman Engineering Clinic I	2	Freshman Engineering Clinic II	2
Calculus I	4	Calculus II	4
Advanced College Chemistry I	4	Physics I	4
Composition I	3	Computer Science and Programming	4
General Education Course	3	General Education Course	3
Total	16	Total	17

SECOND YEAR:

Sophomore Engineering Clinic I	4	Sophomore Engineering Clinic II	4
Math for Engineering Analysis I	4	Math for Engineering Analysis II	4
Advanced College Chemistry II	4	Intro. to Environmental Engineering	2
Statics	2	Surveying	2
Solid Mechanics	2	Structural Engineering I	3
Total	16	Total	15

THIRD YEAR:

Junior Engineering Clinic I	2	Junior Engineering Clinic II	2
Structural Engineering II	3	Structural Engineering III	3
Fluid Mechanics I	2	Water Resources Engineering	3
Civil Engineering Systems	2	Organic Chemistry I*	4
Material Science	2	Geotechnical Engineering	3
Civil Engineering Materials	2	Total	15
Introduction to Microeconomics	3		
Total	16		

FOURTH YEAR:

Senior Engineering Clinic I	2	Senior Engineering Clinic II	2
Civil Engineering Design Project I	2	Civil Engineering Design Project I 2	
Geotechnical Engineering Elective	3	Water Resources Engineering Elective	3
Transportation Engineering	3	Transportation Engineering Elective	3
Civil Engineering Practice	1	General Education Course	3
Technical Elective	3	Structural Engineering Elective	3
General Education Course	3	Total	16
Total	17		

Total = 128 SH

* infrastructure students may choose Physics II or Geology I in place of Organic Chemistry I

Figure 1: Infrastructure Curriculum

CIVIL ENGINEERING PROGRAM - INFRASTRUCTURE EMPHASIS - 128 SH

FIRST YEAR:

Freshman Engineering Clinic I	2	Freshman Engineering Clinic II	2
Calculus I	4	Calculus II	4
Advanced College Chemistry I	4	Physics I	4
Composition I	3	Computer Science and Programming	4
General Education Course	3	General Education Course	3
Total	16	Total	17

SECOND YEAR:

Sophomore Engineering Clinic I	4	Sophomore Engineering Clinic II	4
Math for Engineering Analysis I	4	Math for Engineering Analysis II	4
Advanced College Chemistry II	4	Intro. to Environmental Engineering	2
Statics	2	Surveying	2
Solid Mechanics	2	Structural Engineering I	3
Total	16	Total	15

THIRD YEAR:

Junior Engineering Clinic I	2	Junior Engineering Clinic II	2
Structural Engineering II	3	Structural Engineering III	3
Fluid Mechanics I	2	Water Resources Engineering	3
Civil Engineering Systems	2	Organic Chemistry I*	4
Material Science	2	Geotechnical Engineering	3
Civil Engineering Materials	2	Total	15
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Senior Engineering Clinic I	2	Senior Engineering Clinic II	2
Civil Engineering Design Project I	2	Civil Engineering Design Project I	2
Geotechnical Engineering Elective	3	Water Resources Engineering Elective	3
Transportation Engineering	3	Transportation Engineering Elective	3
Civil Engineering Practice	1	General Education Course	3
Technical Elective	3	Structural Engineering Elective	3
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* infrastructure students may choose Physics II or Geology I in place of Organic Chemistry I

Figure 2: Environmental Curriculum

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participate in the course by acting as consultants. The high level of faculty participation and commitment shows students the emphasis we place on the design component of the curriculum and the importance of being exposed to realistic civil engineering practice. Faculty participation also continually reinforces faculty awareness of the importance of incorporating design throughout the curriculum and the responsibility they all have in the success of the design experience of the students.

A separate one-credit course - Civil Engineering Practice - also exposes CE students to important topics related to the practice of civil engineering such as: contracts and finance, job site safety, and marketing. Guest speakers engaged in professional practice present most of these topics.

The Engineering Clinic

The Engineering College is committed to innovative methods of learning to better prepare students for entry into a rapidly changing and highly competitive marketplace. Key objectives of Rowan University's Engineering Curriculum include:

- Creating multidisciplinary experiences through collaborative laboratories and coursework;
- Stressing total quality management for solving complex problems;
- Incorporating state-of-the-art technologies throughout the curricula;
- Creating continuous opportunities for technical writing and communication, and
- Emphasizing hands-on, open-ended problem solving, including undergraduate research.

To best meet these curriculum objectives, the four engineering programs of Chemical, Civil and Environmental, Electrical and Computer, and Mechanical Engineering have common Engineering *Clinic* classes (Clinics) throughout their programs of study (Table 1).

Table 1: Overview of Civil Engineering Clinic Content

Year	Engineering Clinic Theme (Fall)	Engineering Clinic Theme (Spring)
Freshman	Engineering Measurements	Competitive Assessment
Sophomore	Discipline Specific Design	Interdisciplinary Design
Junior	Open-ended problem solving in small teams	
Senior	Open-ended problem solving in small teams	

It is important to note that clinic classes mix students of different engineering disciplines. Furthermore, upper level clinics often mix juniors and seniors.

In the Freshman Clinic, students work in multidisciplinary teams of 4 - 5 students with one professor working with 4 or 5 groups at a time. The Fall semester of the Freshman Engineering Clinic has laboratory components from all major engineering disciplines and focuses on basic engineering measurements. In the Spring semester, students work on a semester-long reverse engineering or process evaluation project. For example, students have reverse engineered coffee makers, hair dryers, remote-control cars, electric toothbrushes, and portable water filters.

Some institutions have used traditional discipline specific laboratory experiments at the freshman level (Perna and Hanesian 1996), while others engage students in discipline specific freshmen engineering design projects (McConica 1996). Rowan's engineering program seeks to unify these topics and provide an innovative multidisciplinary laboratory experience for teams of engineering freshman. In addition, a major focus of this clinic is on problem solving skills, written and oral communication skills, safety and professional ethics.

The Sophomore Clinic is focused on engineering design. Students are exposed to discipline-specific and multi-discipline design projects. For perhaps the first time, students are exposed to realistic design problems best solved by multidisciplinary engineering teams. Thus, this class truly addresses the needs of current and future employers who require engineers to be constructive, functioning parts of a multidisciplinary team. Students in Sophomore Clinic quickly realize that they must "self-acquire" knowledge to solve the given problem within the time constraints. This course has significant communication components, both writing and speaking and is taught with engineering and communication faculty. Past projects include the design of landfills and baseball parks, and the design and construction of guitar effect pedals and small bridges.

In Junior and Senior Clinics, students work on an open-ended project in a multidisciplinary team of 3 - 5 students under the supervision of one or more professor. Each team works on a unique project, which can be multiple semesters in length. A typical sequence includes information search and review, development of a clear and concise problem statement, research and/or design and testing activities, and presentation of results via written report and presentation. Projects have included product design, process modification, process development, and applied and fundamental research. Most projects are funded by industry or governmental agencies.

ABET – ASSESSMENT OVERVIEW

ABET objectives A - P are grouped under the Rowan CEE Program goals, that Rowan CEE graduates will be:

- Knowledgeable engineers, who are able to remain current during their professional careers;
- Problem-solvers, who are able to obtain needed information and identify, formulate, and solve problems;
- Well-rounded engineers, who understand professional, ethical, and global issues and are able to work in multidisciplinary and diverse groups; and
- Communicators, who are able to disseminate information to professional and lay audiences.

In some cases, two similar ABET objectives were combined in our assessment system. For this reason, we use a numbering system to describe CEE objectives (ABET objects are identified by a letter). A summarized list of the ABET Objectives is given below, for the readers convenience.

A. knowledge of mathematics, science, and engineering.
B. design and conduct experiments as well as analyze and interpret data.
C. design system, component, or process to meet desired needs.

D. function on multidisciplinary and diverse teams.
E. identify, formulate, and solve engineering problems.
F. understand professional and ethical responsibilities.
G. effective communication skills.
H. broad education necessary to understand the impact of engineering solutions in a global/societal context.
I. recognize need for and the ability to engage in lifelong learning.
J. understand contemporary issues.
K. use techniques, skills, and modern engineering tools necessary for engineering practice.
L. proficient in mathematics through differential equations; probability and statistics; calculus-based physics; and general chemistry.
M. proficient in a minimum of four (4) recognized major civil engineering areas.
N. able to conduct experiments, as well as to analyze and interpret data, in at least two recognized major civil engineering areas.
O. able to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum.
P. understand professional practice issues such as: procurement of work; bidding versus quality based selection processes; how the design professions and the construction professions interact to construct a project; the importance of professional licensure and continuing education; and/or other professional practice issues.

To ensure continual improvement with regard to these goals and the ABET objectives; Rowan CEE documents describe outcomes, indicators, practices, assessment methods, assessment criteria, and evaluation results for each goal and objective. Outcomes are general descriptions of what students will be able to do if they have successfully met an objective. Multiple outcomes are assessed for some objectives. Indicators are more specific examples. Practices describe the courses and activities which afford students opportunities to obtain the required knowledge and skills. Assessment methods describe the specific instruments that will be used to assess how well students are meeting an objective. Assessment criteria are the measures used for evaluation. Assessment evaluations are year-by-year records of assessment results. An example is given in Figure 3, without evaluation results. Each year's evaluation results are added below the assessment criteria; this then becomes part of the written record for that year. Each Goal and Objective has a unique set of outcomes, indicators, practices, etc. Some have as few as two assessment methods; others have as many as five.

A "flag" system is used to represent assessment results. Green flags indicate that expectations are being met, while yellow flags indicate that correction may be needed. Red flags indicate that an immediate corrective action is needed. For most assessment methods, the associated assessment criteria are numeric. For example, a green flag might indicate that 85 - 100% of students have achieved a desired score on an assignment; a yellow flag that only 70 - 85 % scored adequately; and a red flag that less than 70% achieved the desired score. Specific examples of assessment criteria are given in the next section.

Goal 3 - Objective 3: The Civil Engineering Program at Rowan University will produce graduates who have the broad education necessary to appreciate contemporary issues (ABET J) and understand the impact of engineering solutions in a global/societal context (ABET H).

Outcome 1 **-** Students will develop an awareness of how the practice of Engineering impacts, and is impacted by, other disciplines, societal factors, and contemporary issues.

Indicators:
1. Complete a meaningful and effective general education program to obtain a broad education.
2. Ability to identify and discuss human factors, natural resources, the environment, business and economics, government, and other global and societal issues related to engineering.
3. Consider the natural resource and environmental impact of engineering projects
4. Apply their broad education to the solution of engineering problems.

Practices:
1. Engineering Courses: Surveying, Civil Engineering Materials, Structural Engineering I, II, & III, Introduction to Environmental Engineering, Water Treatment, Wastewater Treatment, Geotechnical Engineering, Transportation Engineering, Civil Engineering Systems, Water Resources Engineering, Electives in Structural, Environmental, Water Resources, Geotechnical, and Transportation Engineering, Civil Engineering Practice, and Senior Design.
2. Courses outside of engineering
3. Lower level clinic
4. Upper level clinic
5. Internship
6. Professional organization activity

Assessment Methods:
1. Report in Introduction to Environmental Engineering
2. Design Project(s) in Advanced Water Resources Engineering.
3. Exit Interviews
4. Attendance at Professional Organization activities
5. Faculty Biannual Review

Assessment Criteria:
1. Goal – 85 to 100% of students score: at least 15/20 on Societal Context part of Report, at least 11/15 on Political Context part of Report, and at least 11/15 on Ethics part of Report; Yellow Flag **-** <85%; Red Flag **-** <70%. See Assessment Criteria Appendix.
2. Goal **-** 85 to 100% of students will pass open-ended design project(s) in Advanced Water Resources Engineering; Yellow Flag **-** <85% of students; Red Flag **-** <70% of students. “Pass” is defined as receiving a score of 7/10 (70%) on each of the following sections: understanding contemporary issues/problem identification; and understanding of societal and/or environmental impact of design solution. See Assessment Criteria Appendix.
3. Engineering has positively or negatively impacted society or the world. Can you list some engineering-related global or societal issues? Goal – 85 to 100% of students will be able to discuss at least one issue during their exit interview. Yellow Flag **-** <85%; Red Flag **-** <70%. See Assessment Criteria Appendix.
4. Goal **-** 85 to 100% of students attend at least three meetings per year; Yellow Flag **-** <85%; Red Flag **-** <70%.
5. Goal – Review of course content indicates that curriculum supports this Goal and Objective; Red Flag **-** Review of course content indicates that curriculum does not support this Goal and Objective. See Assessment Criteria Appendix.

Figure 3: Example of Assessment documentation

ABET - ASSESSMENT PROCESS

The ABET assessment process is a cycle. At CEE, we are interested in ‘closing the loop’. First, we must identify problems early. We do this through assessment procedures. Second, we must develop improvement strategies in response to perceived problems. We do this at our assessment marathons and, if necessary, at regular faculty meetings. Finally, we implement improvements.

A number of different assessments are used to ensure the continual improvement of the CEE program. Examples of most types of assessment are described in this section, and include course assignments, the EIT, surveys, exit interviews, and assessment marathons. Some courses are so important to the assessment process that separate sub-sections are devoted to their description, including CE Practice, Civil Engineering Design Project, and the Clinics. A complete list of assessments is given below with corresponding ABET objectives shown in parentheses.

- Final Report and Presentation in Senior Design (C, E, G, K, O)
- Take home final exam in Civil Engineering Practice (P)
- Report from Introduction to Environmental Engineering (H, I, J)
- Laboratory experiments / report in Geotech Engineering (B, N)
- Experimental Design Exercise & Laboratory Report - Wat Res Eng (B, N)
- Design Project in Advanced Water Resources Engineering (H, J)
- Design Project in Water Resources (E)
- Exit Interviews (H, I, J, P)
- Alumni Feedback (E, F, I, P)
- Internship Employer Feedback (G)
- Employer Feedback (G)
- Course Survey in Sophomore Clinic (D)
- Peer Reviews / Instructor Assessment in Senior Design (D)
- Peer Review in Junior and Senior Clinics (D)
- Completion of at least two classes in four of the five areas offered (M).
- Successful completion-Calc I/II, Phys I, Math for EA I/II, & Chem I/II (A, L)
- EIT enrollment, Practice EIT (F)
- Attendance at Professional Organization activities (F, H, I, J)
- Assessment Marathon (A – P)

Course Assignments

Some courses in the Civil and Environmental Engineering curriculum at Rowan have assignments specifically used as assessment tools for ABET purposes and for our program of ‘closing the loop.’ In this sub-section, course assignments from two courses are described, Water Resources Engineering and Introduction to Environmental Engineering.

One of our ABET goals is to ensure that students can "identify, formulate, and solve engineering problems." Indicators of student success in this area include:

- Essential information is distinguished from extraneous data
- The problem is approached in a logical and technically correct fashion
- The absence of necessary information is recognized and reasonable approximations are made
- The problem solution is correct and always reasonable

One assessment tool for this goal is a set of engineering design reports from our junior-level course in Water Resources Engineering.

In Water Resources Engineering, students complete a variety of homework assignments, including text-based problems, laboratory exercises and brief reports, and open-ended design problems. The text-based problems primarily relate to assigned readings and lecture material. The laboratory exercises and reports allow students to investigate various flow phenomena, make observations, draw conclusions, and convey their findings to others in a written fashion. The open-ended design problems are larger assignments in which students must integrate material covered in class, from prior classes, and from experiences outside the class.

The open-ended design problems are set up so that the students act as design engineers for a consulting company. Projects are presented to the students in the form of a letter, from one of the firm's clients, which states the problem and provides some (but not all) of the information required to develop an engineering solution. Students work in teams of two or three to solve the client's problem, but each student is required to turn in a separate solution. The solution is in the form of a one- or two-page letter report from the student to the client, backed up with detailed engineering calculations so that a knowledgeable peer can verify the design approach and procedures used. The basic format of the "design labs" follows those used at institutions such as The University of Minnesota and Valparaiso University (Weiss and Gulliver, 2000).

The number and nature of the open-ended design projects varies from year to year depending on course direction and student interests. Past projects have included design of water distribution systems, reservoir and pumping systems, and open channels, and economic analysis of an engineering project.

For ABET assessment purposes, each assignment is evaluated for:

- Proper identification of the problem (25%);
- The solution approach (25%); and
- The technical solution itself (*i.e.*, getting the right answer) (25%).

The remaining 25% of the students' grade is based upon the "mechanics" of the submittal, including the cover letter, sample calculations, and references.

For each of the three assessment areas (problem identification, solution approach, technical solution), our criteria for measuring "success" at achieving our ABET goal is that 85-100% of the students in the class score at least 18/25 (70%) on each of the assessment areas for each assignment. If 70% - 85% of the students achieve this, then we consider this to be a "yellow flag" indicator. If fewer than 70% of the students score at least 18/25 on each portion, this is considered a "red flag".

Introduction to Environmental Engineering is a required course for all civil engineering students in their sophomore year. This course is designed as an introduction to environmental engineering and covers basic aspects of water, soil, and air environments including principles, applications, and design concepts pertinent to water/wastewater/air quality, pollution and treatment. Students, in addition to traditional assignments, are required to work on a team project designed to meet three ABET goals, listed below:

- To broaden education necessary to understand the impact of engineering solutions in a global/societal context;
- To recognize need for and the ability to engage in lifelong learning;
- To understand contemporary issues.

The following indicators are used:

- Students are able to identify and discuss human factors, natural resources, the environment, business and economics, government, and other global and societal issues related to engineering
- Students consider the natural resource and environmental impact of engineering projects
- Students apply their broad education to the solution of engineering problems.
- Complete a meaningful and effective general education program to obtain a broad education
- The student uses archival journals and/or the internet to obtain information

The project assigned to the students is based on a real environmental pollution problem. The students research the social, political and ethical impacts of the pollution and its engineered solution. The class of Spring 2000 researched the Arsenic crisis in Bangladesh. The class, in teams of three/four, researched social, political and geographical issues related to the arsenic contamination as well as the chemistry of arsenic, health impacts and engineered solutions for arsenic removal. For ABET assessment purposes the team report is evaluated for societal, political and ethical context. Students are also required to include at least six references related to the project. The criteria for measuring success in achieving the ABET goals is that 85-100% students will score 75% or more in each of the above mentioned assessment areas (societal, political, ethical and references). If 70% - 85% of the students achieve this, the condition is "yellow flag". If fewer than 70% of the students score at least 75% on each portion, this is considered a "red flag".

CE Practice

The CE Practice Seminar is designed to introduce students to the issues that they will face in professional practice. Many of these issues are difficult to incorporate directly into regular engineering courses. Experts from civil engineering and related industries, and government agencies are invited to present each topic. Topics covered in the Fall of 2000 were:

- Personality Styles
- Transition to Work and Graduate School
- Contract and Finances
- Specifications
- Regulatory Agencies and Context Sensitive Design (CSD)

- Cost Estimating
- Job Site Safety
- Professional Licensing and the EIT Examination
- Ethics
- Marketing
- Administration and Project Management
- Law

Some of the notable speakers include a member of the state board on professional engineer licensing, members of the state contractor's association, contractors, attorneys, owners of engineering firms, and a member of the state environmental regulatory agency.

This course is taught concurrently with the senior design course and is used to present a number of important concepts needed in performing the senior design project. Of special importance were the sessions on contract and finances, specifications, regulatory agencies, cost estimating, and administration and project management.

This course was particularly valued by the ABET reviewers. We also obtained very positive feedback from our industry partners concerning this course. In addition to the presentation of knowledge, we believe that these seminars also provide a venue where students can interact with the engineers, contractors, regulators, and lawyers which they will work with in the future. CE Practice is used to evaluate ABET Objective P (professional practice).

Civil Engineering Design Project

The Civil Engineering Design Project is the culminating design experience for the graduating seniors. The Design Project is a sequence of two 2-credit hour courses during the senior year. The senior civil and environmental engineering students work in teams of 4 or 5 students to solve an open-ended design project. Local engineering firms provide the projects and representatives from these firms participate in the evaluation process. The projects are either projects the firms are currently working on or are projects they have already completed. Students must prepare engineering plans, specifications, cost estimates, and written and oral project reports. Because the course extends over two semesters, an attempt is made to place issues such as information collection, planning and preliminary or concept design during the first semester with more detailed design during the second term.

The Design Project course was designed with the ABET 2000 criteria (ABET, 1999) and the concerns of industry in mind. Some of these concerns include lack of team skills, poor written and oral communication, lack of ability to consider alternatives, inability to synthesize components into a system, and weakness in economic analysis (Black, 1994; National Research Council, 1985; National Research Council, 1991; Katz, 1993; Knox, et. al., 1995).

Civil Engineering Design Project plays a prominent assessment role in CEE ABET assessments. The final written report is used to assess ABET C, E, G, K, and O; the oral presentations are also used to assess ABET G; and peer evaluations are used to assess ABET D. The most complex aspect of the assessment is the use of the written reports for several different criteria. This is accomplished by developing a standardized grading form for the reports that has several components. The written report grade includes a component for written communication quality and a technical merit component. Each of these is subdivided further to allow direct assessment of individual criteria. For instance, the technical merit score includes subcategories related to a) problem definition, b) approach to solving the problem, c) data collection and analysis, d) assumptions made, e) alternative evaluation, f) use of analysis, simulation or other tools, g) ability of the solution to address the problem, h) the use of sound engineering principles, and i) the use of sound economic principles. Combinations of these evaluation points are used to assess specific ABET criteria.

Clinics

One of the hallmarks of the program is the truly multidisciplinary curriculum in which laboratory/design courses are offered simultaneously to engineering students in all four disciplines. Indeed, a hallmark of the engineering program at Rowan University is the multidisciplinary, project-oriented, Engineering Clinic sequence. The Engineering Clinic is a course that is taken each semester by every engineering students at Rowan University. In the Engineering Clinic, students and faculty from all four engineering departments work side-by-side on laboratory experiments, design projects, and research. The solution of these real-world problems requires not only a proficiency in the technical principles, but, as importantly, requires a mastery of written and oral communication skills and the ability to work as part of a multidisciplinary team. The clinics are described in greater detail in the section of this document titled "The Engineering Clinic" (above).

The engineering clinics are used in assessment of ABET objective D (ability to function on multidisciplinary and diverse teams). This is an appropriate venue to assess Objective D as the students' function on truly multidisciplinary and diverse teams. In sophomore clinics, the course survey is used to identify the extent to which the clinic promoted group work. In junior/senior clinics the peer evaluation forms are used to assess ability to function on diverse and multidisciplinary teams. For the assessment, our criteria for measuring "success" at achieving our ABET goal is that 85-100% of the students in the class score at least a satisfactory or higher on the peer evaluation form. If 75% - 85% of the students achieve this, then we consider this to be a "yellow flag" indicator. If fewer than 75% of the students achieve a satisfactory or better score, this is considered a "red flag".

This course was particularly valued by the ABET reviewers. Though used to directly assess only ABET objective D, it obviously helps CEE to achieve objectives A, B, C, E, F, G, H, I, J, K, N, O, and P. However, direct assessment is difficult, as each student's clinic experience is unique, depending on the specific projects they worked on. Therefore, feedback into the improvement process is primarily through the assessment marathon. We have also obtained very positive feedback from local industries and agencies. As a result of the junior/senior clinics, the students have also shown increased interest in graduate studies and research. Several students have presented and published their research findings at local and national conferences and journals.

Exit Interviews

During April 2000, the department chair conducted exit interviews with the 18 graduating seniors in the CE Program. Each senior was asked a series of 36 questions dealing with the CE

Program, the College of Engineering, and Rowan University. These answers were compiled and some of the results are presented below. Exit Interview results are used to assess ABET objectives H, I, J, and P (global/social context, lifelong learning, contemporary issues, and professional practice, respectively)

When asked if their expectations of the Rowan Engineering program were fulfilled, 72% of the seniors answer yes, 22% answered mostly, and only 6% answered no. Similarly, when seniors were asked if they would make the same decision over again, 78% said yes, 17% said maybe, and only 6% said no.

When the seniors were asked if they had been treated fairly and with respect by the engineering faculty at Rowan, 94% answered yes and only 6% answered mostly. Similarly, when asked if they were satisfied with the quality of teaching that they received within the College of Engineering, 94% of the seniors said yes and only 6% said mostly.

When asked if they were satisfied with the advising that they received, 89% of the seniors answered yes and only 11% answered mostly. When the seniors were asked if their experience at Rowan University made them better aware of the professional-practice issues facing an engineering today, 83% said yes, 6% said somewhat, 6% said unsure, and 6% said no.

When seniors were asked if they would recommend Rowan Engineering to other students, 89% answered yes and only 11% answered maybe. Similarly, when asked if they would recommend the CE Program to other students, 89% said yes and only 11% said maybe.

The most startling response to the exit interview was the question, “Do you plan to attend graduate school now or in the future.” All of the graduating seniors answered this question yes with 33% saying immediately and 67% saying in the future.

Surveys

A number of surveys are used as part of the CEE ABET assessment. Course surveys are collected for each course and the results used in the assessment marathon, as described in a subsequent section. Other surveys used include an Internship employer survey, Employer survey, Alumni survey, and Junior/Senior Engineering Clinic peer survey.

The internship employer survey and employer survey are used in assessing ABET objective G (communication). This provides an external evaluation of this important skill. The alumni survey is used in assessing ABET objectives E, F, I, and P (problem-solving, professionalism and ethics, lifelong learning, and professional practice, respectively). Students can best evaluate themselves on these issues after they have practical experience. The Junior/Senior Engineering Clinic peer survey is used to assess ABET objective D (multidisciplinary and diverse teams). An excellent opportunity to assess this is after a student team has worked together for an entire semester on an open-ended project.

EIT

Although there is not an explicit course for training students for the Engineer-In-Training (EIT) examination, there is a systematic effort in the department to prepare students for this examination. This effort has included a full-length mock examination, the sale of review materials through the student chapters of ASCE and ASME, and topical review sessions conducted by muti-disciplinary faculty. The success of preparatory efforts is shown in student pass rates. The civil engineering students at Rowan University have a pass rate of 83.33%. This is a general indication of the success of the program.

The Practice EIT administered to seniors in the Spring semester is used to evaluate ABET Objective F (professional and ethical responsibilities). The Practice EIT has a section on ethics. Students are evaluated according to the fraction of correct answers they give in this section of the practice exam.

Assessment Marathon and 'Closing the Loop'

The assessment marathon is a half-day meeting of all CEE faculty that occurs at the end of each semester. The purpose of the assessment marathon is to:

- Review the assessment results collected during that semester (e.g., course assignments, surveys, etc.);
- Review general policies of the department, as appropriate (e.g., advising and transfer policies);
- Review every undergraduate course taught during the semester; and
- Identify and plan for any needed improvements identified at the marathon.

A number of things must be done in order for this meeting to proceed efficiently and smoothly. The division of labor must be relatively even. Each faculty must have clear responsibilities for data collection and assessment and for facilitation at the meeting. For example, faculty member X may be responsible for the course assignment in water resources, the EIT, and the alumni survey. Faculty member Y might be responsible for the advising policy, the course assignment in introduction to environmental engineering, and the CE practices course. Each professor is responsible for his or her course(s). Professors are expected present their own perception of how the course ran, as well student perceptions recorded in course surveys. Before the marathon, each faculty member completes a table summarizing how each of his or her course(s) contributed to student learning as related to the ABET Objectives (of course, each course does not meet all ABET objectives). An example is provided in Table 2. This brief table directs discussion of the course at the marathon. It can be modified at the marathon, based on faculty discussion, and becomes part of the permanent ABET record.

Once the assessment results, general policies, and courses have been reviewed, the meeting concludes with a discussion of needed improvements. In particular, any yellow or red flags are discussed; however, all improvement needs identified during the meeting are discussed. If necessary, additional faculty meetings are scheduled for further discussion. These discussion are expected to 'close the loop', from problem identification to improvement implementation.

Table 2: Example Course Summary

COURSE NAME	**Water Treatment**
Summary of S'00 activities	Used Powerpoint for lectures, worked problems on board. Heavy work load, with assigned readings (tested with RATs), homework, and laboratory memos. Laboratory went well, students created bench scale treatment system for Rowan Pond Water. Performance on exams lower than expected.
Suggested course improvements	Incorporate more pictures into Powerpoint slides. Work more problems in class. Assign more problems in homework. Hold two semester exams instead of one. Assign semester long water treatment plant design project.
Suggested curriculum improvements related to this course	None
A. knowledge of mathematics, science, and engineering.	Students introduced to topics in aquatic chemistry.
B. design and conduct experiments as well as analyze and interpret data.	Student conducted numerous experiments, including coagulation, sedimentation, adsorption, and disinfection. Student designed and tested a bench scale apparatus to treat Rowan Pond Water.
C. design system, component, or process to meet desired needs.	Students designed sedimentation, precipitation, filtration, disinfection, and adsorption processes.
D. function on multidisciplinary and diverse teams.	Students worked in a team with a structural, environmental, and mechanical engineering. Team was also gender diverse.
E. identify, formulate, and solve engineering problems.	Students solved problems related to sedimentation, precipitation, filtration, disinfection, and adsorption processes.
F. understand professional and ethical responsibilities.	Discussed importance of proper design.
G. effective communication skills.	Students wrote numerous laboratory reports.
H. broad education necessary to understand impact of engineering solutions in global/societal context.	Students studied importance of engineering processes to quality of life.
I. recognize need for and the ability to engage in lifelong learning.	Not emphasized. Next semester, emphasize continuous development of new treatment processes.
J. understand contemporary issues.	Importance of water quality and quantity emphasized.
K. use techniques, skills, and modern engineering tools necessary for engineering practice.	Students used calculators and spreadsheets to solve problems.
L. proficient in mathematics through differential equations; probability and statistics; calculus-based physics; and general chemistry.	Students used calculus to derive equations, used statistics to evaluate and analyze results, and used general chemistry to understand processes.
M. proficient in a minimum of four (4) recognized major civil engineering areas.	Second Course in Environmental Engineering sequence.
N. able to conduct experiments, as well as to analyze and interpret data, in at least two recognized major civil engineering areas.	Student conducted numerous experiments, including coagulation, sedimentation, adsorption, and disinfection. Student designed and tested a bench scale apparatus to treat Rowan Pond Water.
O. able to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum.	Students designed sedimentation, precipitation, filtration, disinfection, and adsorption processes.
P. understand professional practice issues.	Not emphasized, emphasize case study next year.

PRELIMINARY RESULTS OF OUR ABET VISIT

While the final ABET results are not yet known, the ABET review team commended several areas of the CE Program including the engineering clinic courses, the civil engineering practice course, and the civil engineering capstone design sequence. The civil engineering practice course was especially well-received by the ABET review team. The ABET review team raised questions regarding the traditional problem of excessive faculty workloads within the CE Program; the assessment-related problem of acquiring and maintaining adequate input and buy-in from all stakeholders including students, alumni, and industry; and the proficiency of CE students in the use of statistical tools. The ABET objective that requires a proficiency in probability and statistics does not clearly indicate how this is to be met. CEE currently achieves this by devoting 1-hour of a 2-hour course to probability and statistics, with reinforcement occurring in subsequent courses.

BIBLIOGRAPHY

ABET, "EAC Criteria for 1999 – Criteria for Accrediting Engineering Programs," Accreditation Board for Engineering and Technology, Inc., 111 Market Place, Suite 1050, Baltimore, MD, 1999.

Black, K. M. An Industry View of Engineering Education. Journal of Engineering Education, ASEE, v 83, n 1, 1994, pp. 26-28.

Katz, S. M., "The Entry-Level Engineer: Problems in Transition from Student to Professional," *Journal of Engineering Education*, vol. 82, no. 3, ASEE, July 1993, pp. 171-174.

Knox, Robert C., David A. Sabatini, Ronald L. Sack, Robert D. Haskins, Larry W. Roach and Scott W. Fairbairn, "A Practitioner-Educator Partnership for Teaching Engineering Design," *Journal of Engineering Education*, vol. 84, no. 1, ASEE, January, 1995, pp. 5 – 11.

National Research Council, *Engineering Education and Practice in the United States: Foundations of Our Techno-Economic Future*, Washington, DC, National Academy Press, 1985.

National Research Council, *Improving Engineering Design*, Washington, DC, National Academy Press, 1991.

Weiss, P.T., and Gulliver, J.S., (2000) What do students need in hydraulic design projects? *Proceedings, 1999 International Water Resources Engineering Conference*, edited by R. Walton and R. Nece, ASCE.

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