A UNIFIED ELECTIVE CONCENTRATION IN ENVIRONMENTAL ENGINEERING

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ABSTRACT

Environmental concerns have become so widespread in contemporary society that they require substantive consideration by engineering professionals from areas not traditionally thought to be environmentally-oriented. By focusing professional electives, Clarkson has developed and instituted a program that enables engineering students from a variety of disciplines to substantively increase their technical background in environmental engineering and, at the same time, satisfy accreditation constraints on curricula. Students who have satisfied the requirements of the "Professional Concentration in Environmental Engineering" receive a certificate from the Dean of Engineering upon graduation. The school-wide program is too new to permit assessment, but its forerunner in the Department of Civil and Environmental Engineering has enjoyed excellent success.

INTRODUCTION

The legal and social standing of the environment has undergone enormous changes since the first Earth Day over 25 years ago[1]. Accompanying and reflecting this growth of interest and evolution of concern has been a parallel development of the scope of the discipline called environmental engineering. As Ray[2] noted, "In the not so distant past, engineering students interested in the environment studied 'sanitary engineering'" and their proficiency was likely to be restricted to water and wastewater treatment. The Association of Environmental Engineering Professors, however, has for some time considered environmental engineering to encompass a broader range of disciplines, including: water and wastewater engineering, air pollution control engineering, solid waste engineering, industrial hygiene engineering, radiological health engineering, environmental impact assessment, and environmental management[3]. More recently it has been recognized that the field of environmental engineering now also encompasses hazardous (and toxic) waste management engineering, pollution prevention, and mathematical modeling of complex environmental systems[2]. Adequate solutions to this broad range of problems requires practicing engineers to give substantive consideration to the views and contributions of individuals who represent areas not traditionally thought to be environmentally

oriented. Accordingly, the field of environmental engineering has grown to be truly multidisciplinary and requires direct, productive interaction between professionals from many disciplines of science, economics, and most areas of engineering.

WHITHER ENVIRONMENTAL ENGINEERING?

Finding a “home” for curricula that address environmental engineering - engineering solutions to environmental problems, or environmental systems in the broadest sense - has been a challenge at many universities. Moreover, this challenge may continue because of the extent to which the scope of environmental engineering has changed over recent decades. Based on a historical connection to sanitary engineering, the most common approach taken by universities has been to include the environmental engineering curriculum within a Civil Engineering department. Often, however, chemical, mechanical, and even electrical engineers may find themselves needing some background in environmental engineering. Similarly, the reverse also may be true, and the multidisciplinary threads that now are being woven throughout engineering education, in general, indicate that multidisciplinary interactions will continue to gain in importance into the future.

Providing the opportunity to develop a multidisciplinary environmental background to undergraduate engineering students, unfortunately, is not a simple matter. A multidisciplinary base cannot be constructed easily for engineering students for several reasons. One of the most consequential reasons for this difficulty is the fact that institutions place constraints on engineering curricula in order to meet very restrictive accreditation requirements. The institutions, however, derive substantial benefits from accreditation. Consequently, relevance and suitability are critical issues that will always confront attempts to revise engineering curricula. Curricular constraints, therefore, must be addressed explicitly by new or emerging programmatic directions, such as expanding the availability of environmental engineering course work to students enrolled in other programs.

Institutions could respond in a variety of ways to the needs of engineering students to have better comprehension of environmental issues and, more specifically, how these issues influence each student's respective field of engineering. At Clarkson University, the solutions have evolved with these needs as perceived by both the students and their faculty. Historically, environmental engineering occupied a "sanitary engineering" niche in the Civil Engineering Department (eventually renamed "Civil and Environmental Engineering", or CEE), and all civil engineering majors were required to take a single course that encompassed water and wastewater treatment, water distribution systems, residuals management, and water pollution. The number of electives available to undergraduate CEE majors was decidedly limited. At that time, however, excepting the occasional chemical engineer, very few students other than CEE majors would enroll in environmental engineering courses.

A PROTOTYPE

With the passage of time and the continued growth of environmental concerns in society, engineering students who were interested in establishing a broader base of environmental expertise in their education enrolled in increasing numbers at Clarkson. To meet the growing student numbers as well as interest in environmental engineering, course offerings proliferated within the CEE Department. This proliferation led to consideration of developing a curriculum for an accredited program in environmental engineering (Accreditation Board for Engineering and Technology - ABET). Queries to industry suggested that specialization at the baccalaureate level in environmental engineering could be restrictive for both employers and employees in the long term. Nevertheless, the time seemed appropriate to provide students with a new way to enhance their curricular focus on environmental engineering

In 1992 the environmental engineering faculty opted to establish a special concentration comprised of both required and elective courses pertinent to environmental engineering that would continue to satisfy ABET criteria for the existing baccalaureate program in Civil and Environmental Engineering. In effect, the special concentration was an innovative opportunity to focus elective courses on environmental engineering with similar emphases to those in accredited environmental engineering degree programs. Termed the "Professional Concentration in Environmental Engineering," the popular option consisted of a series of six restricted courses (18 semester hours, see Table I), many of which could be selected by students to fulfill professional elective requirements of the ABET-accredited baccalaureate curriculum. Upon graduation, each student who completed this set of courses was awarded a Dean's Certificate from the Dean of the School of Engineering acknowledging completion of the course work required for the concentration.

The new Professional Concentration in Environmental Engineering was immediately given wide acceptance by the students for whom it was designed, raising enrollments to new highs in the included courses. Soon, the popularity of the program made it attractive to engineering students outside the CEE Department, who recognized their future need for greater familiarity with environmental engineering issues and techniques.

A SCHOOL-WIDE SOLUTION

In response to the growing school-wide interest, the environmental engineering faculty invited the other engineering departments at Clarkson to assist in the development of a Professional Concentration in Environmental Engineering that would be suitable for all engineering disciplines. The new concentration had to be arranged so that the accreditation constraints of each department could be satisfied, yet by appropriate selection of courses, the environmental engineering essence would remain to support the student's original interest and intent. More specifically, the challenge was to devise a means of expanding the list of environmentally relevant courses to permit inclusion of interested students enrolled in Clarkson's Chemical Engineering and Mechanical and Aeronautical Engineering departments. This was accomplished largely by recognizing the extent to which the field of Environmental Engineering had become multidisciplinary and,

accordingly, by broadening the scope of curricular topics that were considered appropriate to such an expanded disciplinary base.

Several constraints were considered in devising an appropriate list of courses that would be applicable to the new environmental concentration. First, the course selection framework had to be developed in a way that would maintain the feasibility of completing requirements for each of the ABET accredited baccalaureate degree programs in 4 years, regardless of department. In addition, to ensure retention of the environmental engineering essence, the course list expansion followed ABET guidelines for a baccalaureate degree in environmental engineering to the extent possible.

The revised and much more flexible Professional Concentration in Environmental Engineering for the School of Engineering now consisted of six courses to be selected from four restricted lists. These lists were designated Advanced Science electives, consisting of non-introductory biology and chemistry courses; Environmental Engineering Design electives; ABET Environmental Engineering electives, consisting of courses from the four areas of environmental engineering recognized by ABET; and Additional Electives, which included courses permitting students to seek more breadth or depth in a specific segment of environmental engineering. The various courses included in the program (Spring Semester 1996) and their distribution among the named categories are listed in Table II. The distribution of the six courses among the groups may be summarized as:

` One course in Cell Biology or Microbiology
` One course in Organic or Physical Chemistry
` One course in Environmental Engineering Design

` Two courses distributed between two of the following four ABET subdisciplines:
  - Air Pollution Engineering
  - Water and Wastewater Engineering
  - Environmental and Occupational Health Engineering
  - Solid and Hazardous Waste Engineering
` An additional course from one of the four ABET subdisciplines or an approved, related course.

The Chair of the Department of Civil and Environmental Engineering oversees the concentration requirements and ensures that each of the engineering departments has current lists of courses that satisfy the requirements for the Dean's Certificate.

ASSESSMENT

It is reasonably clear that the original prototype environmental concentration (Table I) has been highly successful from the standpoint of student interest: 23 students completed program requirements during its first two years, 52 received certificates during the May 1995 commencement, and presently over 100 are enrolled.

It is too early to gauge the success of the newly expanded program, because it was first implemented during the Fall Semester 1995. We will be observing, however, a variety of indicators of success as we evaluate the program in the future, including effects on admissions, retention, and job placement.

REFERENCES

1. Masters, G.M. 1991. Introduction to environmental engineering and science. Prentice-Hall, New Jersey.
2. Ray, B.T. 1995. Environmental engineering. PWS Publishing, New York.
3. Haas, C.N. *no date*. So you want to be an environmental engineer? Association of Environmental Engineering Professors, Department of Civil Engineering, University of Texas, Austin TX.

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Table I: Course work for prototype Professional Concentration in Environmental Engineering - Department of Civil and Environmental Engineering.

Course Number	Course Name
BY 323	Microbiology for Engineering Applications
CM 241	Organic Chemistry I
CE 479	Water and Wastewater Treatment
CE 480	Water Quality Engineering
CE 481	Hazardous Waste Management Engineering
CE 486	Design of Facilities for Water and Wastewater Treatment

Table II. Course work for Professional Concentration in Environmental Engineering - School of Engineering

Course Category	Course Selection
A. Advanced Sciences	(Two required, one from each category)
1. Biology	BY 210 Cell Biology BY 323 Microbiology for Engineering Applications
2. Chemistry	CM 241 Organic Chemistry I CM 371 Physical Chemistry
B. Environmental Engineering Design	(One course required) CE 491 Senior Capstone Design for Water Resources and Environmental Engineering ME 415 Solar Design
C. ABET Environmental Engineering	(Two courses from two different categories required)
1. Air Pollution	CH 434 Air Pollution
2. Water and Wastewater	CH 465 Biochemical Engineering CE 479 Water and Wastewater Engineering CE 480 Environmental Quality Engineering
3. Solid and Hazardous Waste	CE 481 Hazardous Waste Management Engineering
4. Environmental and Occupational Health	IH 416 Principles of Occupational Health
D. Supplemental Electives	(One course, which may be an additional selection from Category C, above, or from a list of approved courses available from the Chair of the Department of Civil and Environmental Engineering)*

* Spring 1996 the listing of Supplemental Electives includes
ES 464 Corrosion Engineering
CE 470 Hydraulic Engineering
CE 474 Hydrology
CE 477/CM 476 Atmospheric Chemistry
CM 409 Receptor Modeling in Environmental Chemistry
CM 430 Colloids and Interfaces
CM 480 Environmental Organic Chemistry
SU 513 Interfacial and Colloidal Problems in Environmental Science
IH 406 Industrial Hygiene Control Methods