

Development of a BS Environmental Engineering Program in a Civil and Environmental Engineering Department

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Abstract

The Department of Civil and Environmental Engineering at Clarkson University recently initiated a new B.S. degree program in Environmental Engineering. The proposal for this new degree program was recently approved by the departmental faculty following roughly a decade of deliberation. We will discuss our approaches in achieving harmony between the civil and environmental engineering programs within the department. The background and justification for the new environmental engineering degree program are given here, and the process of obtaining the approval and support of the Departmental faculty. The curriculum of the new environmental degree program is also presented, along with how the curricula of the Civil Engineering and Environmental Engineering degree programs complement each other, the benefits and problems associated with this new degree program, its impacts to students on their education and to faculty in both teaching and research.

Background

Clarkson University is a small, independent, technology focused, national university with programs in business, communication, engineering, health sciences, liberal arts, science, and physical therapy. With a total enrollment of just over 3,100, including 385 graduate students, Clarkson is one of the smallest nationally ranked research institutions in the U.S. The small size of the university is said to promote interaction between students and faculty, collaborative research across disciplines, flexibility in programs, and a friendly campus atmosphere. Engineering is the largest discipline (48% of undergraduates), with growing proportions in business (17%), arts and sciences (18%), and interdisciplinary programs (17%).

Clarkson University's Department of Civil and Environmental Engineering has long had strong research components in both civil and environmental engineering. The department has supported graduate programs (Master of Science, Master of Engineering, and Doctor of Philosophy) in each area. But historically the undergraduate program has only offered one degree, that of a Bachelor of Science in Civil Engineering. Environmental Engineering faculty in the department have sought an undergraduate degree in Environmental Engineering since the early 1990s. The Accreditation Board for Engineering and Technology (ABET) requirements for Environmental Engineering in those times were exhaustive and fairly stringent, which meant that any proposal for a new program would rely on procuring significant new resources. Several new courses would have had to be developed to fulfill these requirements, resulting in a need for

new faculty in the area. Though there was continued interest in an Environmental Engineering undergraduate program, proposal after proposal did not meet with department faculty approval.

Changes to the ABET requirements for Environmental Engineering and to the course offerings resulted in a better fit to the existing environmental engineering faculty in the department, and to the courses already offered for an undergraduate concentration in Environmental Engineering. Over the years the requirements of ABET and the interests of the faculty merged. It became possible to offer an Environmental Engineering B.S. with no new faculty and the addition of only one new course.

Efforts then moved to convincing the department faculty of the merits of such a program. Many civil engineering faculty have incorporated environmental concerns into their research foci in the meantime and the environment has become more important in all aspects of engineering. Following the agreement of the faculty, the program quickly moved through the necessary next steps for acceptance. The program was passed by the Dean of Engineering, Faculty Senate, the University's Administrative Council, President, and the Board of Trustees. Finally, though Clarkson University is a private institution, New York State requires approval of the program by the State Department of Education. Once through the department level, the program was accepted by all other levels within a three month period.

Program Goals

The emerging paradigm for environmental sustainability envisions environmental concerns and consequences as integral parts of decision-making in business and government. As such, an approach to environmental problem solving and design that is based on systems engineering principles provides a logical template or theme for structuring a Bachelor of Science program in environmental engineering. In addition, Clarkson University's historic strength in graduate environmental engineering (ranked 23rd in Environmental Engineering/Environmental Health graduate programs by US News and World Report, 2004), and the doctoral level Environmental Manufacturing Management program funded by the National Science Foundation at Clarkson, further define the basis for the program. The theme of a systems approach to environmental engineering is congruent with new environmental policies, which base their regulatory structure holistically as part of the entire decision making process rather than as isolated end-of-pipe, top-of-stack, or bottom-of-landfill problems.

Such a theme has several advantages. First, among the 44 currently accredited B.S. programs in environmental engineering nationwide, only one other (Pennsylvania State University) currently has a systems approach or theme to their program. This provides Clarkson University a basis for a national rather than regional market niche for the program. Second, the grounding of the program in systems engineering can strengthen Clarkson's stated preferences toward team-based open-ended education. Third, the continued development of environmental engineering into a systems approach provides a natural basis for cross-disciplinary courses leading to joint research with other units at Clarkson (e.g. Industrial Hygiene, Environmental Science and Policy, and Chemical Engineering) furthering the goals of the environmental research focus area.

The Curriculum

The curriculum for the proposed program is outlined in Table 1. The program maintains the School of Engineering-wide first year courses (Chemistry, Physics, Calculus, Great Ideas, First Year Seminar and Introduction to the Use of the Computer) for a strong foundation in engineering principles. In the sophomore year, students will begin exploring the basis for the major, obtaining background in earth science, microbiology, fluid mechanics, and physical chemistry as well as continuing mathematics and an introductory course in environmental engineering. This year contains the one new required course that will be developed for the program, CE 240 Earth Science.

The junior and senior years develop the program emphasis on environmental systems engineering. Along with upper division requirements in microeconomics, water resources, thermodynamics and organic chemistry, students will be required to take either CE 479 Water and Wastewater Treatment Processes or CE 480 Environmental Quality Engineering as an environmental engineering foundation course. The core of the program is found in this requirement and the three required Core Professional Courses. The Core Professional Courses must include three of the following: CE 479 Water and Wastewater Treatment Processes or CE 480 Environmental Quality Engineering, (whichever was not taken previously), CE 482/582 Environmental Systems Engineering, CE 486 Industrial Ecology, ES 432 Environmental Risk Analysis, and CE 481 Hazardous Waste Management Engineering. These courses are currently offered in sufficient frequency to allow for students to take advantage of Co-op or Study Abroad opportunities without compromising their ability to graduate in four years. Students will have six professional elective courses to round out their engineering education. These can be any upper division engineering, math, or science course, or chosen from a limited set of courses in technical communications, ethics, business or military science.

The program culminates with a capstone design course in environmental engineering design. This course has been a traditional strength at Clarkson University.

Students who plan carefully will be able to satisfy the requirements for B.S. degrees in both Civil Engineering and Environmental Engineering with 120 credit hours. This is important, at least initially, as students wishing an Accreditation Board of Engineering and Technology (ABET) accredited engineering degree and an environmental engineering degree will need to complete both the Civil and Environmental Engineering degree requirements. This will remain the case until the first B.S. Environmental Engineering student graduates and accreditation is applied for and granted for the Environmental Engineering degree.

Development of the Program

The successful initiation of the program was begun in 2003. A proposal was put forth by the environmental engineering faculty to the Undergraduate Committee of the department. Reaction of the committee was mixed and discussions ensued, primarily concerning the curricular content of the program. There was strong hope of keeping the required credits at 120, a tradition at Clarkson, but many courses were seen as critical to a student's preparation. It was especially

Table 1: ENVIRONMENTAL ENGINEERING CURRICULUM

FRESHMAN - FALL	FRESHMAN – SPRING
CM 131 General Chemistry I (4 cr)	CM 132 General Chemistry II (4 cr)
PH 131 Fundamental Physics I (4 cr)	PH132 Fundamental Physics II (4 cr)
LS 195 Great Ideas I	LS 196 Great Ideas II
MA 131 Calculus I	MA 132 Calculus II
FY/PE 100 First Year Seminar (0 cr)	ES 100 Introduction to the Computer (2 cr)
SOPHOMORE - FALL	SOPHOMORE - SPRING
CE 212 Introduction to Engineering Design	CE 240 Earth Science
ES 220 Statics	BY 323 Microbiology for Engineering Applications
CM 370 or 371 Physical Chemistry	ES 330 Fluid Mechanics
MA 231 Calculus III	MA 232 Differential Equations
CE 340 Introduction to Environmental Engineering	Elective - HUM
JUNIOR AND SENIOR YEARS	
Elective - HUM or SOC	Elective - HUM or SOC
CM 241 Organic Chemistry	EC 350 Principles of Micro and Engineering Economics
CE 330 Water Resources I	ES 340 Thermodynamics I
CE 479 Water & Wastewater Treatment OR CE 480 Water Quality Engineering	MA 383 Applied Statistics
CE 301 Engineering Measurements	CE 491 Senior Design (Environmental/ Water Resources)
Business Elective	Professional Elective
Core Professional Course	Professional Elective
Core Professional Course	Professional Elective
Core Professional Course	Professional Elective
Professional Elective	Professional Elective

All courses are 3 credits unless otherwise noted.
HUM is a Humanities elective; SOC is a Social Science elective.

difficult to change the status of Strength of Materials and Geotechnical Engineering. Both of these courses are required for the B.S. degree in Civil Engineering and are considered by many to be foundations of engineering practice. At the same time, it was felt very important to leave room in the curriculum for upper division courses focused on the many areas of environmental engineering. These issues were the topic of much debate.

The resolution worked for everyone. The desired upper division environmental engineering courses were identified as Core Professional Courses. As laid out in the curriculum above, students need to complete three of these Core Professional Courses out of a selection of six courses. This left room for six Professional Elective courses, only two fewer Professional Electives than available to students pursuing the Civil Engineering degree. Of these Professional Electives, two are identified in the program as Recommended Electives; these are Strength of Materials and Geotechnical Engineering. With this agreement, a curriculum was created that allowed for both important engineering background courses and room to explore upper division electives.

Program Enrollment

It is expected that the proposed program will enroll 10 students per year. This number assumes five students 'new' to Clarkson University, that would have otherwise chosen this major from our competitors, and five 'current' Clarkson University students, that will chose environmental engineering as their major instead of civil engineering or engineering studies. Thus, each year beginning in Fall 2005 a cohort of ten new majors is expected, providing a critical mass of students in the program.

Resources

Current library holdings and electronically accessible journals are sufficient for the major. Laboratory facilities in the William J. Rowley Laboratories are also sufficient to support the expected program enrollment. Expendable laboratory supplies can be purchased through marginal additional departmental funds. Computer facilities available at Clarkson University will also be sufficient to support the program. No major purchases are required specifically to support this program.

Faculty

The program can be completed with the current faculty in the Department of Civil and Environmental Engineering. The department currently employs six faculty, including four registered Professional Engineers, with specialization in environmental engineering and all with the required terminal degrees. In addition, the department has four faculty specialized in Water Resources Engineering, who are also active in environmental research and teaching. All faculty are qualified to teach courses primarily design in content by virtue of education and equivalent experience.

Some required courses in the major will be taught by faculty in the Department of Civil and Environmental Engineering not in the environmental area. These courses are already taught on a

regular basis for the Civil Engineering degree and enrollment in each is not expected to be significantly impacted by the additional students. Some courses in the major will be taught by faculty outside of the department and the necessary agreements to teach these courses were obtained from these departments.

The current faculty can cover the courses required for this major, including the new course in earth science, CE 240. No new faculty positions are required to support the major.

Accreditation

The ABET 2004-2005 Criteria for Accrediting Engineering Programs states the Program Criteria for Environmental and Similarly Named Engineering Programs as:

"The program must demonstrate the graduates have: proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, general chemistry, an earth science, e.g., geology, meteorology, soil science, relevant to the program of study, a biological science, e.g., microbiology aquatic biology, toxicology, relevant to the program of study, and fluid mechanics relevant to the program of study; introductory level knowledge of environmental issues associated with air, land, and water systems and associated environmental health impacts; an ability to conduct laboratory experiments and to critically analyze and interpret data in more than one major environmental engineering focus areas, e.g. air, water, land, environmental health; an ability to perform engineering design by means of design experiences integrated throughout the professional component of the curriculum; proficiency in advanced principles and practice relevant to the program objectives; understanding of concepts of professional practice and the roles and responsibilities of public institutions and private organizations pertaining to environmental engineering."

Table 2 briefly illustrates the courses and methods by which these program specific requirements are met. In addition to these requirements ABET requires General Education requirements be met. These are met through Clarkson's Foundation Curriculum (or it's potential replacement, the Clarkson Common Experience). Full demonstration of the student capabilities will be made in a report to ABET during the application process for accreditation.

Timetable

Students will begin the program in Fall 2005. Some civil engineering students of the Class of 2008 may elect to double major in Civil Engineering and Environmental Engineering. Thus there is the potential for the first graduates in the program to complete the requirements for the degree in this manner as early as Spring 2008. Accreditation for the degree will be sought following the graduation of the first graduating class, as early as 2009. Following this timetable, the first time the new course, CE 240 Earth Science, will need to be taught is Spring of 2006. All other courses can continue their current schedules.

Table 2: Program Response to ABET Requirements

REQUIREMENT (IN BRIEF)	PROGRAM RESPONSE
Proficiency in math through differential equations	MA131, MA 132, MA231, and MA232 required
Probability and statistics	MA 383 required
Calculus-based physics	PH 131 and PH 132 required
General chemistry	CM 131 and CM132 required
Earth science	CE 240 (new course) required
Biological science	BY 323 required
Fluid Mechanics	ES 330 required
Introductory level air, land, water, health issues	CE 340 required
Laboratory experiments	CM 131, CM 132, PH 131, PH 132, CE 212, CE 340, CE 330, CE 479, CE 480 have laboratory components, leading to experiences in several areas
Engineering design	CE 212, CE 340, CE 479, CE 480, CE 301, CE 491, CE 482/582, CE 486, CE 481 and electives contain design aspects. (The program requires 18 design credits)
Advanced principles and practice	CE 479, CE 480, CE 482/582, CE 486, ES 432, CE 481 and electives address advanced principles
Professional practice and roles	CE 340, CE 491, EC 350, BUS elective, and professional electives address professional practice issues

Conclusion

The Department of Civil and Environmental Engineering at Clarkson University has successfully established a new degree program in Environmental Engineering to exist side-by-side with the Civil Engineering program. The program is maintained by the same structure the department has utilized for years. The Chair, Associate Chair and Undergraduate Committee administer both programs in the department, without need for a new or additional governance structure. Faculty interaction is expected to increase within the department as all faculty will become more conversant in environmental engineering and environmental aspects of civil engineering, as well as interaction with faculty in other departments in the university. Though the path was long, the result is a stronger department, with two interacting degree programs at the undergraduate level.

Biographies

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