AC 2012-4357: PROGRAM OFFERINGS AND CURRICULUM CONVERGENCE BETWEEN THE DUBLIN INSTITUTE OF TECHNOLOGY (DIT) AND THE UNIVERSITY OF MARYLAND, BALTIMORE COUNTY (UMBC)

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Program Offerings and Curriculum Convergence Between the Dublin Institute of Technology (DIT) and The University of Maryland-Baltimore County (UMBC)

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Abstract
Recently the Department of Civil and Environmental Engineering (CEE) at UMBC completed the process of revamping its curriculum and preparing a plan to offer a ABET accredited undergraduate degree in Environment and Water Resources Engineering (EWRE). The process began in a difficult economic period which resulted in an increased emphasis on due diligence as whether the program would succeed. The proposed EWRE program would address several UMBC academic priorities and respond to the anticipated increasing demand for training in this discipline. First, the degree program responded to a growing national and statewide initiatives in climate change and the environment. Environmental engineers, in addition to providing safe water and clean air, address many of the emerging issues associated with climate change, clean sources of energy, and sustainable development. The challenges faced by the EWRE profession today are unique and brought about by a rapidly changing world order with respect to the need for sustainable utilization of energy resources, sustainable use of material resources and production practices, proactive environmental management of emerging technologies (*e.g.* nanomaterials), and sustainable management of shrinking water resources that is increasingly becoming the cause of national and international conflicts. The creation of a new undergraduate engineering degree provides an opportunity to develop a program that embraces new problems and is focused on emerging issues in the field of EWRE. Second, an environmental engineering degree provides an option for UMBC engineering students beyond the available programs (mechanical, chemical/biochemical and computer engineering); this will also likely increase enrollment in UMBC's College of Engineering and Information Technology (COEIT). Third, environmental engineering is the only engineering discipline expected to grow "much faster than the average for all [engineering] occupations" (26% by 2016; http://www.bls.gov/oco/ocos027.htm#outlook).

As part of the degree planning process the following items where addressed:

1. An analysis of potential student enrollments in the program based on market demand, industry needs, and programs at comparably-sized Universities.
2. A description of the additional courses and course sections that would be necessary to offer the program annually.
3. A plan for using a combination of current tenure-track faculty members, the new tenure track faculty member, lecturers and part-time instructors to staff the referenced courses.

4. A description of any specialized laboratories, equipment or any other significant new resources that will be necessary to offer the program.

Currently the Dublin Institute of Technology is facing some of the same issues that catalyzed the UMBC effort. Brian Reed was awarded a Fulbright Scholar Award at DIT and will be part of the effort to address the issues that are facing DIT bringing a perspective that was developed at UMBC. The differences and similarities of the problems and solutions facing the two institutions will be discussed.

1. UMBC Experience

The College of Engineering and Information Technology is comprised of 4 departments with 3 departments offering ABET accredited UG degrees. The Department of Civil and Environmental Engineering (CEE) was formed in 19xx and was approved to offer only graduate degrees. In 2002 the faculty consisted for four tenure-track faculty specializing in the environmental engineering/water resources areas. In 2003-4 MS and Ph.D. degree programs were approved. CEE's research program grew significantly, averaging over $500k,/faculty over the last three years. CEE is closely aligned with the Center for Urban Environment Research and Education (CUERE; http://www.umbc.edu/cuere).

In 2009 planning began on offering an undergraduate ABET accredited degree in environmental and water resources engineering (EWRE) through CEE. This effort addressed several UMBC's College of Engineering and Information technology (COEIT) academic priorities and responded to the anticipated increasing demand for training in EWRE. First, the degree program responded to growing national and statewide initiatives in climate change and the environment. Environmental engineers, in addition to providing safe water and clean air, address many of the emerging issues associated with climate change, clean sources of energy, and sustainable development. The challenges faced by the EWRE profession today are unique and brought about by a rapidly changing world order with respect to the need for sustainable utilization of energy resources, sustainable use of material resources and production practices, proactive environmental management of emerging technologies (*e.g.* nanomaterials), and sustainable management of shrinking water resources that is increasingly becoming the cause of national and international conflicts. The creation of a new undergraduate engineering degree provides an opportunity to develop a program that embraces new problems and is focused on emerging issues in the field of EWRE. Second, a EWRE degree would provide an option for UMBC engineering students beyond the available programs (mechanical, chemical/biochemical and computer engineering); which will increase enrollment in COEIT. Third, environmental engineering is the only engineering discipline expected to grow "much faster than the average for all [engineering] occupations" (26% by 2016; See Figure 1). An undergraduate EWRE degree would also play an important role in complementing UMBC degree programs in the environmental sciences, which are also expected to grow at a 20% rate. Fourth, the UG program would build upon a successful implementation of the graduate degree program in CEE that was initiated in 2003-4. The CEE faculty has been successful in creating a state of the art research infrastructure that has been recognized nationally and internationally, and has been successful in attracting external funding resources. The strong research and graduate degree footprint will catalyze the successful development of the UG degree program by attracting undergraduate students to a department

active in cutting edge EWRE research, and continuing to engage undergraduate students in priority research areas through research assistantships.

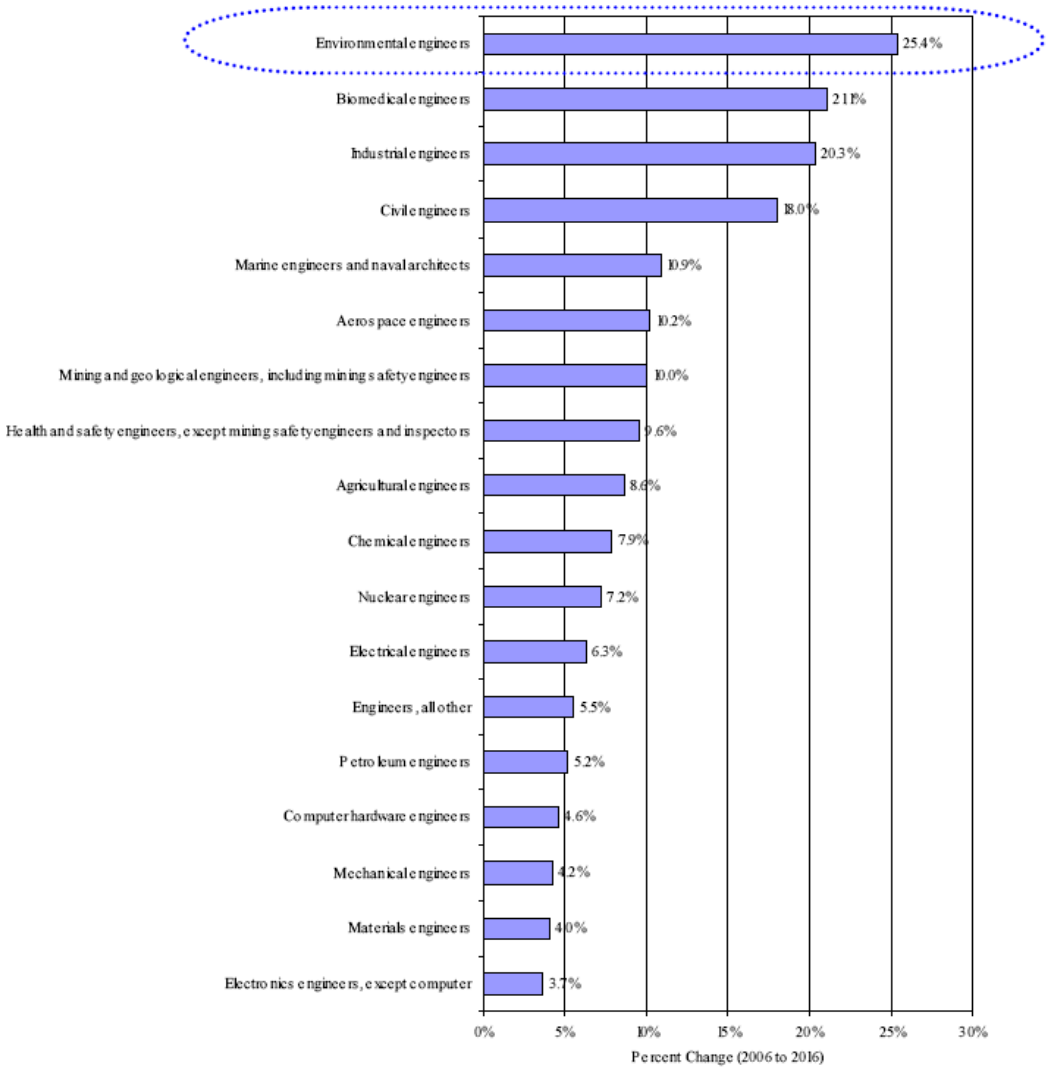

Figure 1. Percent change of engineering occupations from 2006 to 2016 (http://www.bls.gov/oco/ocos027.htm#outlook)

As part of the proposal process the following items were addressed:

1. An analysis of potential student enrollments in the program based on market demand industry needs, and programs at comparably-sized Universities.

2. A description of the additional courses and course sections that would be necessary to offer the program annually.

3. A plan for using a combination of current tenure-track faculty members, new tenure track faculty members, lecturers and part-time instructors to staff the referenced courses.

4. A description of any specialized laboratories, equipment or any other significant new resources that will be necessary to offer the program.

1.1. Assessment and Projected Enrollment Projections

To assess the demand for the proposed degree surveys were conducted of current UMBC freshman engineering students and institutions offering a stand-alone ABET accredited environmental engineering degree. Results are presented and discussed below.

1.1.1 UMBC Freshmen Survey

Students from ENES 101 (a freshmen-level required course for the COEIT's engineering programs, these students would be the entering sophomore class if the degree program was online now). The survey explained what environmental/water resource engineers do and then asked the following question:

> "UMBC is considering starting an undergraduate degree program in Environmental Engineering (EnvEng) that may be available in Fall. If this degree was available would you:"

Choose EngEng as your major?	□
Strongly consider EnvEng as major	□
Consider EnvEng as major	□
No interest in EnvEng	□

The answers to the survey and freshman class enrollment estimates are presented in Table 1. 154 students took the survey with 7.2%, 17.5%, and 37.8% of the students responding that that they would choose environmental engineering as their major, strongly consider Env Eng, or consider Env Eng, respectively. If capture rates of 100%, 25% and 10% are assumed for these three categories, respectively then the freshman-senior class enrollment would be approximately 92 students if one assumes that the students leaving the program in later years is offset by transfer students. These student enrollment projections do not take into account new students that would be brought into COEIT from high school recruitment efforts.

Table 1. UMBC Freshman Engineering Survey Results and Enrollment

Decision	**# of Students**	**% of Total**	**Assumed % of students captured**	**Students Declaring Env Eng as Major**
Choose EnvEng as your major?	11	7.20%	100%	11
Strongly consider EnvEng as major	27	17.50%	25%	6.75
Consider EnvEng as major	52	37.80%	10%	5.2
No interest in EnvEng	64	41.50%	0%	0
TOTAL	**154**			**23**

1.1.2 Recruiting New Students to COEIT

While it was not possible to precisely predict the number of new students entering UMBC's COEIT as a result of the proposed degree, several trends support the assumption that College enrollment would increase. As mentioned previously, the US Department of Labor has predicted that Environmental Engineering is the only engineering discipline that is expected to grow "much faster than the average" (http://www.bls.gov/oco/ocos027.htm#outlook), and thus we believe that there will be increased market demand for the degree which should lead to an increase in students entering the program. Second, there has been a dramatic increase in the number of high school students taking the Maryland Advanced Placement (AP) exam in Environmental Science (10-fold increase since 1998, See Figure 2). While not all students taking this exam will be interested in an environmental engineering major, the results in Figure 2 indicate that CEE would have a strong recruiting pool for the proposed degree. Also note that 57% of the students taking the Maryland AP exam were female; successful recruitment in proportion to this profile has the potential to improve the COEIT's diversity profile.

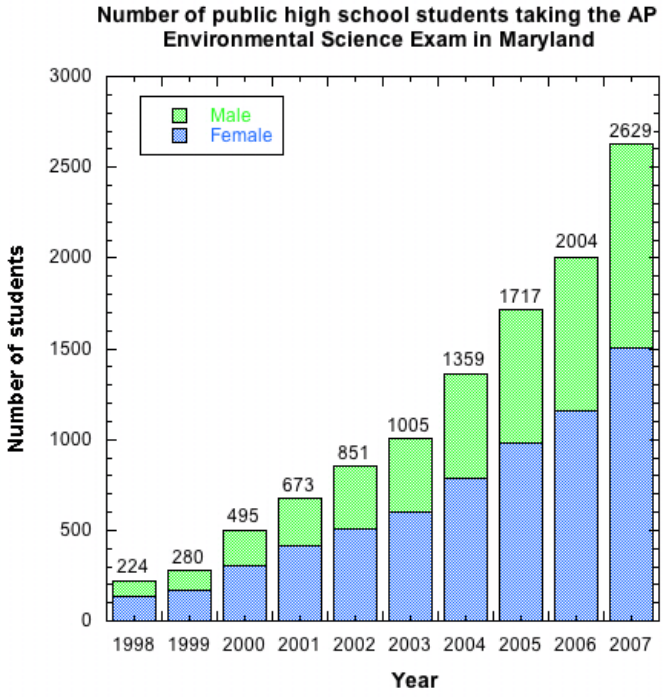

Figure 2. Number of Maryland public high school students taking AP Env. Sci. Exam

An outreach effort to Maryland high schools would be a part of the CEE program so that the enrollment in COEIT would increase rather than just redistributing students from existing departments. The new EWRE degree offering will be incorporated into UMBC's successful

"Project Lead the Way" (PLTW) effort (Newberry, *et al.* 2006). PLTW is partially responsible for the dramatic increase in UMBC's Mechanical Engineering (ME) undergraduate enrollments (nationwide ME enrollments were projected to increase by 5%; UMBC ME's enrollments have doubled). It is believed that additional increases in COEIT enrollments will occur if environmental and water resources engineering is included in PLTW.

1.1.3 Survey of Institutions Offering Environmental Engineering UG Degree

A survey of the institutions (52 total) offering an ABET accredited UG degree in environmental engineering or related subject was conducted by email explicitly to gather information pertinent to this effort. Of the 52 institutions, 46 institutions offer an ABET accredited degree in environmental engineering; one offers a degree in earth and environmental engineering; two offer an environmental engineering option in civil engineering, one offers an environmental engineering science degree, one offers an environmental resources engineering degree, and one offers a degree in environmental systems engineering. The number of programs having an ABET accredited UG environmental engineering degree increased from 16 in 1997 to 46 currently (see Figure 3).

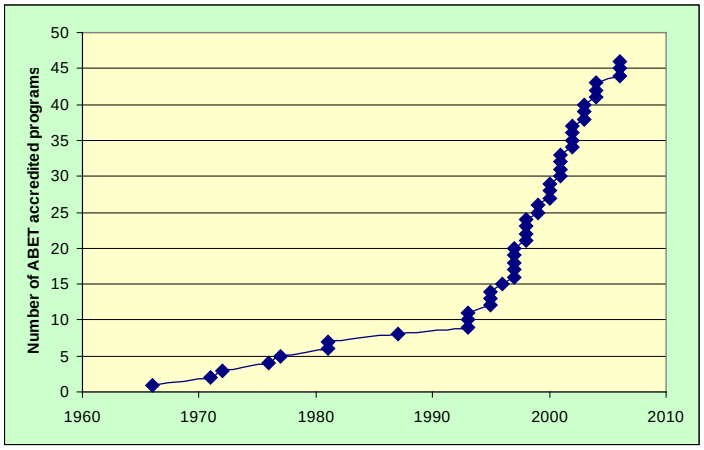

Figure 3. Number of ABET Accredited Environmental. Engineering UG Degree Programs

Representatives from these programs were identified through a web search, and two surveys asking the following questions were distributed to the representatives by e-mail:

1. What are your current enrollments in the Environmental Engineering program?

Freshman	
Sophomore	
Junior	
Senior	

2. Can you send me past enrollments and any projections that you may have developed?
3. Department the degree resides in: _____
4. Number of tenure track faculty that are responsible for teaching the environmental and water resources engineering (EWRE) courses: _____
5. Total number of tenure track faculty in your department: _____

Forty responses were received on questions 1 and 2, and thirty responses were received on questions 3 through 5. Results of the surveys are presented in Table 2. For all but two institutions, the environmental engineering degree resided in a "larger" department, in most cases Civil and Environmental Engineering (only students working towards the environmental engineering degree were counted). The number of faculty teaching EWRE courses and the total number of faculty in the home department were requested because the effort in running a department is distributed over a larger number of faculty when the environmental degree is offered as part of a larger home department. The average freshman through senior student enrollment was 64 $\pm$ 54 students. The average size of the EWRE faculty was about 8 resulting in a student/EWRE faculty ratio of 9.5$\pm$ 7. Note the EWRE faculty size was used to determine this ratio because non-environmental engineering enrollment (*e.g.*, students studying for the more general civil engineering degree) were not included in the enrollment counts. If we assume a class size of 100 students and 4.25 tenure-track faculty, UMBC's CEE student/faculty ratio would be 23.5 (16 if the two lecturers are counted). These numbers are much higher than the national average and the high enrollments could adversely impact CEE's graduate program/research productivity.

Table 2. Results from Institutional Survey

Enrollment (Fresh-Senior)		**# EWRE Faculty**		**Student/EWRE Faculty Ratio**		**# of Faculty in Home Department**	
Mean + Std Dev.	63.8 $\pm$ 53.4	Mean + Std Dev.	7.7 $\pm$ 4	Mean + Std Dev.	9.5$\pm$ 6.8	Mean + Std Dev.	16.4 $\pm$ 6.8
Rang	12 - 261	Rang	3 - 20	Range	1.2 - 29	Range	3-28

1.2. Curriculum and Scheduling

The proposed EWRE curriculum is presented in Table 3. Attention was spent on structuring courses and enrollment caps to maximize enrollments and minimize the number of separate sections offered. A total of fourteen new courses would be offered in the undergraduate engineering curriculum (list in bold type). One section of each course will be offered, with an enrollment goal of 25 students. A six year teaching plan was devised based on hiring two lecturers (one in the second half of year 1, one in second half of year 2) and one tenure-track faculty (hired in year 3). If enrollment goes above 100 into the 125 student range then a fourth tenure track faculty will be required. Lecturers will initially receive a reduced teaching load in exchange for high school and community college recruitment activities; student advisement; and program development efforts. Courses will be added to the program in a staggered fashion: one freshman course beginning in year 1; no additional new courses in year 2; five new junior-level courses beginning in year 3; and eight new senior-level courses (including senior design) beginning in year 4. All courses will be repeated annually after they are first offered. ABET application preparation will begin in year 1 with the ABET submission and visitation occurring after the first undergraduate degree is awarded. High school recruiting will begin in year 1 with most of the effort occurring in years 1 through 3. Recruitment work in the later years is envisioned to be mostly maintenance in scope.

Table 3. Proposed Undergraduate EWRE Curriculum

Freshman Year Fall Semester CHEM 101 Principles of Chemistry I (4) MATH 151 Calculus and Analytic Geometry I (4) ENES 101 Introductory Engineering Science (3) GFR electives (6) 17 Credits	 Spring Semester CHEM 102 Principles of Chemistry II (4) CHEM 102L Introductory Chemistry Lab (2) PHYS 121 Introductory Physics I (4) MATH 152 Calculus and Analytic Geometry II (4) **ENCE 102 Intro to Env Eng and Science (3)** 17 Credits
Sophomore Year Fall Semester CHEM 351 Organic Chemistry I (3) ENES 110 Statics (3) PHYS 122 Introductory Physics II (4) MATH 251 Multivariable Calculus (4) GFR electives (3) 17 Credits	 Spring Semester BIOL 100 Concepts of Biology (4) MATH 225 Introduction to Differential Equations (3) STAT 355 Intro to Prob/Stats for Scientists/Engs (3) EMME 217 Engineering Thermodynamics (3) GFR electives (3) 16 Credits
Junior Year Fall Semester **ENCE 301 Env. Chemistry and Biology (4)** ENGL 393 Technical Writing (3) **ENCE 310 Fluid Mechanics (3)** GFR elective (6) 16 Credits	 Spring Semester **ENCE 312 Hydraulics (3)** **ENCE 302 Physical, Chemical and Biological Processes (4)** **ENCE 304 EWRE Laboratory (4)** CMSC 104 Problem-Solving and Computer Programming [3] GFR elective (3) 17 Credits
Senior Year Fall Semester **ENCE 473 Air Quality and Global Climate Change** **ENCE 471 Green Engineering** **ENCE 411 Physical Hydrology (3)** **Advanced Engineering Elective (3)** GFR elective (3) 16 Credits	 Spring Semester **ENCE 402 Solid/Hazardous Waste (3)** **ENCE 481 Senior Design (3)** **ENCE 412 Applied Numerical Methods in EWRE (3)** **Advanced Engineering Elective (3)** GFR elective (3) 15 Credits

Bold indicates new courses

1.3. Resources and Expenditures

UMBC, as with most universities, is faced with resource issues and starting a new degree program in the current environment is challenging. Also, in the past, UMBC has had a history of starting new programs with overly positive revenue projections, low estimates of required expenditures which led to an underestimation of the true cost of the effort. To address this shortcoming the following economic constraint/conditions were assumed so that a conservative projection of revenues and expenditures could be calculated:

1. A freshman to senior class enrollment of 100 students (25 students/year) was assumed based on the enrollment projection data presented earlier.
2. In-state/out-of-state student ratios, retention rates, etc. were based on Office of Institutional Research data
3. No part-time student enrollment
4. Increase in graduate student enrollment through the BS-MS program and graduate students associated with new tenure track faculty was not counted.
5. A "real" tuition rate of 73% of the published rate was used
6. An in-direct cost of 25% was applied
7. Resources that non-engineering departments would need to accommodate the increase enrollment were included as departmental expenditures.

In Table 4 the budget summary is presented for years 1 through 5. Enrollment scenarios of 75% and 125% of the target value are included. The CEE department contributed approximately $300,000 for startup funds that was accumulated over a several year period using faculty release time and salary savings. For all but the 75% enrollment scenario the cumulative five-year cost of the EWRE degree program is positive. Based on positive budget projections and CEE's commitment to starting the new program a favorable internal response was returned.

The next step in the process was to receive external approval form the University System of Maryland (USM). The proposal was submitted informally for comment and was ultimately rejected for a variety of reasons. Because the underlining merits of proposed degree were compelling it was decided to merge CEE with the Department of Chemical and Biochemical Engineering (CBE) to form the Department of Chemical, Biochemical and Environmental Engineering (CBEE). For a number of years CBE offered two tracks (Chemical Engineering and Biochemical Engineering) as part of their UG degree. After merging the departments a third track, Environmental Engineering/Sustainability, was added. In the USM system approval for tracks in established programs is an internal decision - no external permission is needed. Positions for three faculty (two tenure-track, one lecturer) were approved and in 2011 a tenure track and lecturer were hired. The search for the second tenure track is ongoing. Merging the departments also allowed CEE faculty to become part of a program that is involved in undergraduate teaching. Often funding of public institutions is based heavily on UG enrollment and not having a UG program put CEE in a difficult position given the resource challenged atmosphere. The EE/S track will be accepting students in 2012.

Table 5. Budget Summary for UMBC

	Year 1	Year 2	Year 3	Year 4	Year 5
Target Enrollment: 100 Students					
Total Revenue	$482,121	$438,311	$867,572	$1,009,339	$1,016,346
Net Revenue	$136,271	($30,982)	($204,746)	$14,154	$112,817
Cumulative Net Revenue	$136,271	$105,289	($99,457)	($85,303)	$27,513
125% of projected enrollment					
Total Revenue	$527,713	522,952	$1,012,467	$1,212,014	$1,242,381
Net Revenue	$181,863	$50,534	$(64,538)	$212,141	$334,165
Cumulative Net	$181,863	$232,397	$167,859	$380,000	$714,164
75% of projected enrollment					
Total Revenue	$436,528	$353,671	$722,676	$806,664	$790,311
Net Revenue	$100,053	($103,122)	($335,579)	($174,459)	($99,156)
Cumulative Net	$100,053	($3,069)	($338,648)	($513,107)	($612,263)

2. DIT Experience

The School of Civil and Building Services Engineering is situated within the College of Engineering the Built Environment on the Bolton Street campus of the Dublin Institute of Technology. The School provides programs on the National Qualifications Framework (NQF) leading to awards at Higher Certificate (Level 6), Ordinary Degree (Level 7), Honours Degree (Level 8), Masters Degree (Level 9) and Doctorates (Level 10), covering the spectrum of disciplines associated with the School. Currently the School has progames in Civil/Structural Engineering, Building Services Engineering, and Engineering Computation. These programs have a strong association and affinity with the professional bodies particularly Engineers Ireland. As one of its many functions Engineers Ireland serves as an accreditation body (analogous to ABET). Many of the awards given by the School are the oldest for the particular disciplines in Ireland. The School continues its strong relationship with the professional bodies through the recognition given to our programs and the direct support given particularly by the Institute of Structural Engineers (I.Struct.E.) and the Chartered Institution of Building Services Engineers (CIBSE). DIT continues to strive to develop programs to meet the needs of society and the needs of students.

DIT has some of the same challenges that face UMBC's COEIT: 1) need to increase number of degree options, 2) improving enrollments, and 3) need to improve diversity (especially female students). With this in mind DIT began to investigate implementing a degree in environmental

engineering that has a strong energy engineering component. Descriptions of each component are presented below

> Environmental engineers are the technical professionals who identify and design solutions for environmental problems. Environmental engineers provide safe drinking water, treat and properly dispose of wastes, maintain air quality, control water pollution, and remediate sites contaminated due to spills or improper disposal of hazardous substances. They monitor the quality of the air, water and land. And, they develop new and improved means to protect the environment.
>
> Energy engineering is a growing discipline which touches all aspects of engineering planning, design, construction, operation and decommissioning. All engineers must now be able to assess the impacts of their designs to account for energy use and associated emissions. This program will equip graduates with the tools to incorporate life cycle energy and emissions assessments into a broad range of engineering projects in the fields of infrastructure, renewable energy, built environment and planning.

2.1. Assessment and Projected Enrollment Projections

To assess the demand for the proposed degree surveys were conducted of current DIT first-year engineering students and institutions offering a degree in environmental engineering. Results are presented and discussed below.

2.1.1 DIT First-Year Student Survey

First-year engineering students were asked their interest in an environmental engineering degree using the same wording that was used in the UMBC assessment. 60 students responded and the results are presented in Table 6. Using the same capture rates as were used in the UMBC assessment gives a total of about 11 students who would enter the new degree program.

Table 6. DIT First Year Survey Results

Decision	# of Students	% of Total	Assumed % of students captured	Students Declaring Env Eng as Major
Choose EnvEng as your major?	4	6.7%	100%	4
Strongly consider EnvEng as major	18	30%	25%	4.5
Consider EnvEng as major	22	36.7%	10%	2.2
No interest in EnvEng	16	26.7%	0%	0
TOTAL	**60**			**11**

2.1.2 Recruiting New Students to DIT

Unlike the UMBC assessment there was no readily available data that could be used to gage the interests of second-level (i.e., High School students) in the new degree. As of the writing of this

manuscript we are efforting to contact second level guidance counselors to determine student interest. Data from this effort will be included in the final version of the manuscript.

2.1.3 Irish Institutions Offering Environmental Engineering UG Degree

A search of the Central Application Office (CAO) website (http://www.cao.ie/) for "environmental engineering" programs and returned 16 responses with those keywords but only three are actually environmental engineer program. Two are at Level 8 (University College-Cork and National University of Ireland-Galway) and one at Level 7 (Tallaght Institute of Technology). A summary of these results are presented in Table 7. Data on number of preferences currently made for the two Level 8 programs indicate that environmental engineering at NUIG is not popular (it has 3% of total preferences and 1% of first preferences) while the picture is much better at UCC (21% of all preferences and 14% of first preferences). Data on the Level 7 program was not available

Table 7. Summary of Environmental Engineering Programs in Ireland

Program	Website	CAO Points
Civil and Environmental Engineering - Level 8, University College-Cork	http://www.ucc.ie/en/study/undergrad/what/sefs/civeng/	Required: 405 Dropped from 500 over last 4 years. Average for other 3 Engineering programs is 436
Environmental Engineering - Level 8, National University of Ireland-Galway	http://www.nuigalway.ie/courses/undergraduate-courses/environmental-engineering.html	Required: 470 Average for other 6 Engineering programs is 417
Energy and Environmental Engineering - Level 7	http://www.it-tallaght.ie/index.cfm/page/course?id=33&modeofstudyEntryId=1	Required: 250 250-445 is the current spread of students

2.2. Curriculum and Scheduling

A proposed curriculum for DIT's environmental engineering program is presented in Table 8. Note that this program has not been formally approved. The First Year curriculum is common to all DIT engineering students. In the second year, the curriculum is common for students in the new program and Civil and Structural Engineering students and this was designed to save resources. The design project in year 2 will be problem based and include civil, structural and environmental exercise. The thermodynamics module will be delivered my Mechanical Engineering. In third year students choose to enter the new program or continue on with the existing Civil or Structural Engineering streams (**Figure 4**). In the fourth year Engineering Maths could include applied numerical methods in environmental/energy engineering). The Advanced Environmental Engineering topics course would include topics such as solid/hazardous waste and risk assessment and would be open to Civil Engineering. Two elective subjects from final year will be offered through other engineering disciplines (e.g., coastal engineering, GIS).

Table 8. Proposed DIT Environmental Engineering Curriculum

First Year - Common to all engineering students

Maths (10 ECTS)	Chemistry I (5 ECTS)
Heat, Light & Sound (5 ECTS)	Electrical Circuits & Devices (5 ECTS)
Mechanics (5 ECTS)	Technical Graphics (5 ECTS)
Engineering Design Projects (10 ECTS)	Instrumentation for Engineers (5 ECTS)
Engineering Professional Practice (5 ECTS)	Engineering Computing (5 ECTS)

60 credits/12 classes (11 STEM)

Second Year - Common for all Civil and Structural Engineering/new modules in bold

Engineering Maths III (includes statistics, 5 ECTS)	Engineering Maths IV (5 ECTS)
Fluid Mechanics (plus 3-D flow) (5 ECTS)	Professional Development (5 ECTS)
Engineering analysis (to include statics) (5 ECTS)	Mechanics of Materials (5 ECTS)
Intro to Energy/Environmental Eng. (5 ECTS)	Chemistry II (5 ECTS)
Design Project/Problem (10 ECTS)	Thermodynamics (5 ECTS)
Computing (Mathlab + language TBD) (5 ECTS)	

60 credits/12 classes 11 STEM

Third Year

Engineering Maths (5 ECTS)	Civil Engineering Hydraulics I (5 ECTS)
Civil Engineering Hydraulics II (5 ECTS)	Professional Development (5 ECTS)
Design Project (10 ECTS)	**Env. Biological Processes** (5 ECTS)
Env. Physiochemical Processes (5 ECTS)	**Advanced Env. Chem/Biology** (5 ECTS)
Intro to Renewable Energy Systems (5 ECTS)	**Env. Economics and Policy** (5 ECTS)
Modeling and Simulation (5 ECTS)	

60 credits/12 classes (11 STEM)

Fourth Year

Engineering Maths (5 ECTS)	Advanced Env. Engineering Topics (5 ECTS)
Engineering Practice, Management and Law (5 ECTS)	Project (10 credits)
Scheme Design (5 ECTS)	**Air pollution control** Project (5 ECTS)
Groundwater Hydrology (5 ECTS)	**Surface Water Hydrology** (5 ECTS)
Energy and the Environment (5 ECTS)	Elective 1 (5 ECTS)
Elective 2 (5 ECTS)	

60 credits/12 classes 11 STEM

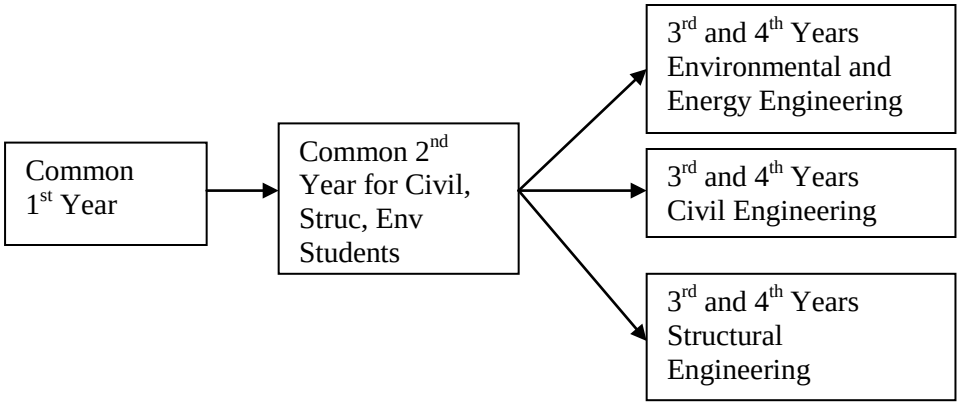

Figure 4. Summary of Streaming for DIT Students

Comparison of UMBC and DIT Curriculums

One interesting outcome of this research was the differences in curriculum between DIT, UMBC. If you compare the number of total courses and the number of STEM related courses that are required to get essentially the same degree (according to the Washington Accord, http://www.ieagreements.org/Washington-Accord/FAQ.cfm) you will see that DIT students take approximately 20% more total contact hours and 37% more STEM contact hours (based on 5 credits at DIT = 3 credit hours at UMBC and 3 credit hours equals approximately 3 contact hrs per week). At the University College-London students receive a degree after 3 years and require no general education courses. Essentially these schools with widely different degree requirements all produce students with degrees that are equal under the Washington Accord. The difference will be even more striking if Ireland moves ahead with the effort to make Level 9 (essentially a MS) the entry point to the process of becoming a Chartered Engineering (Professional Engineer in USA).