An Alumni Survey as an Assessment Tool for New Mexico Tech's B.S. Environmental Engineering Curriculum

Randal S. Martin and Clinton P. Richardson
Dept. of Mineral & Environmental Engineering
New Mexico Tech
Socorro, NM 87801

INTRODUCTION

According to the 1996 report by the Engineering Workforce Commission (EWC) of the American Association of Engineering Societies, Inc.[1], there are 3376 full-time and 319 part-time undergraduate students enrolled in environmental engineering-related curriculums throughout the United States. Of these, 1911 and 235, respectively, are enrolled in an environmental engineering program at one of 14 colleges and universities accredited by the Accreditation Board for Engineering and Technology (ABET)[1,2]. As can be seen in Table 1, these schools represent a wide geographic area and contain a varying number of students enrolled in environmental engineering curriculums. Additionally, Table 1 shows other schools which offer similar or related programs accredited under ABET's Environmental Engineering Group (e.g. Civil & Environmental Engineering).

The Department of Mineral and Environmental Engineering at the New Mexico Institute of Mining and Technology (New Mexico Tech) in Socorro, New Mexico has awarded Bachelor of Science degrees in Environmental Engineering since 1970 and became officially ABET-accredited in 1993. As a part of the periodic reviews mandated by ABET, as well as by the North Central Association of Colleges and Schools, the Environmental Engineering Program at New Mexico Tech developed an assessment survey to evaluate alumni's opinions concerning the program's curriculum and its preparation for their subsequent careers, whether professional employment or graduate school.

BACKGROUND AND SURVEY INFORMATION

The required course work leading to a Bachelor of Science degree in Environmental Engineering at New Mexico Tech (NMT) includes 59 credits of college-wide basic requirements, 55 credits of supporting engineering and science classes, and 24 credits of core environmental engineering classes. A total of 138 credits is divided over 52 classes, inclusive of laboratory classes. Figure 1 shows NMT's most recent (1997-1998) undergraduate environmental engineering curriculum[3]. Although the environmental engineering curriculum at New Mexico Tech has continued to evolve over the past decade, the emphasis and the core courses have remained essentially the same. The most significant deletions within the last few years have been the removal of *Fluid and Thermal Systems*, *Transport Processes*, *Finite Element Analysis*, and *Case Studies in Industrial Environmental Problems*. Recent additions to the environmental engineering curriculum have included *Elementary Fluid Mechanics*, *Heat and Mass Transfer*, *Organic Chemistry I*, and *Environmental Law and Regulations*.

The survey was separated into two main sections: (1) Employment Information and (2) Curriculum Survey. Additionally, although the forms were intended to be anonymous, information was also solicited on gender and year of graduation. The Employment Information section of the survey consisted of questions regarding years of employment within an environmentally-related field, sector of employment (regulatory, industry, consulting, etc.), salary range, job titles and promotions, responsibilities, supervisory duties, and so on. The Curriculum Survey portion of the questionnaire asked for information on which of NMT's courses were most and least useful, any additional courses which should be added to the program, pursuit of graduate degrees, and departmental, as well as college-wide, faculty competence and availability. Figure 2 shows the actual questions included on the survey form.

The survey was E-mailed or sent via surface mail, including a self-addressed, stamped envelope, to all locatable alumni who had graduated since the 1987-1988 school year. Although the program has been in existence since 1970, it was felt this time period most adequately represented the current curriculum, and would, therefore, elicit the most relevant responses. During this period 108 Bachelor of Science degree in Environmental Engineering were awarded, with a gender split of 70.4% male and 29.6% female. The survey and an introductory form letter were sent to the 96 alumni for whom addresses (street or E-mail) could be established through personal contacts, known employers, or NMT's alumni office.

RESULTS AND DISCUSSION

The surveys were mailed out in late September, and responses came in over the following several months. Four of the surveys were returned as undeliverable. In total, 40 responses (42%) were received, with 73% being received from male alumni and 27% being received from female alumni. These percentages are very similar to the overall graduation percentages previously discussed.

Employment Information

Several interesting issues were noted from the compiled Employment Information portion of the survey. Eighty percent of the responding graduates found initial employment within the environmental engineering field, and 78% of the original respondents remain employed within the field. Sixty-four percent (64.1%) of the total responding graduates have sought or obtained some type of professional certification. A slightly higher percentage (72.4%) of those within the environmental engineering field sought or obtained certification. The bulk of the registrations consisted of Fundamentals of Engineering (FE, formerly EIT) or Professional Engineering (PE) certifications.

Figure 3 shows the division of the environmentally-employed graduates among the regulatory, industrial, consulting, and other (e.g. civilian military employees, graduate school) employment sectors. As can be seen, consultant companies employ the largest portion (33%) of the graduates, industrial and regulatory sectors account for approximately equal percentages (27% and 23%, respectively), and the "other" category accounts for the remaining 17%. Figure 3 also shows the divisions among the employment sectors as a function of gender. It is interesting to note the consulting and regulatory sectors were the strongest employers (43% each) for the female

graduates. The industrial sector hired only 14% of the responding female graduates and the "other" sector hired none. In contrast, the industrial and consulting sectors were the dominant employers (30% each) for the male graduates, with only marginally smaller percentages in the remaining two categories.

The starting salaries, corrected to 1997 dollars, for all of the B.S. Environmental Engineering graduates averaged approximately $32,300. An apparent gender basis was noted, with female graduates receiving average starting salaries of $30,600 and male graduates receiving average starting salaries of $32,800. However, it should also be noted that the starting salary ranges for each of the sexes were dramatically different. Starting salaries for females and males ranged from $27,000 to $35,600 and $17,300 to $59,500, respectively. According to the collected data, the largest gender inequity occurred within the industrial employment sector. However, these data must be interpreted with caution as no information was collected on the number of job offers or graduate preferences for particular employment sectors. As shown in Figure 4, the average starting salary within the industrial sector was $30,000 for females and $38,300 for males. The regulatory sector showed a smaller, positive female basis ($31,400 vs. $28,600). The consulting sector hired females and males at essentially the same rate ($30,000 vs. 30,400). Insufficient data exist to comment on inequities within the "other" sector.

Curriculum Survey

Table 2 shows the compiled data indicating the classes which the responding alumni found most and least useful as applied to their career paths. Additionally, suggested course additions are also shown. Data were included in Table 2 only when at least two responses were recorded for a given class. It should further be noted that individual responses were not limited to one class per category, and, in fact, most respondents listed several courses in each.
As perhaps may be expected, the required core environmental engineering classes, with the exception *Soil Mechanics* and *Senior Design Thesis*, led the list of most useful courses. *Groundwater Hydrology*, taught through NMT's Earth and Environmental Science Department, and *Wastewater Treatment Process Design* equally received favorable responses from 20% of the alumni, second only to *Air Pollution Engineering I & II* (32.5%). *Environmental Law and Regulations, Solid & Hazardous Waste Engineering*, and *Water Treatment Process Design* were all deemed about equally useful. This seemingly indicates that NMT's undergraduate program adequately addresses the wide range of job assignments encountered under the environmental engineering umbrella. Interestingly, several supporting classes appeared among the most useful including *Technical Writing, Chemistry, Transport Processes, Fluid Mechanics, Environmental Microbiology*, and *General Biology*.

Instrumentation, Measurement, and Process Control topped the list (17.5%) as the class found to be least useful be the responding graduates (see Table 2). This course was originally taught under the Department of Electrical Engineering, and gradually evolved into a course dealing with time and frequency domains. In 1994 and 1996, the class was modified under the guidance of the Environmental Engineering Program and the Engineering Science Group to be a practical survey course covering the basic components of instrumentation, measurement, and process control systems common to the field of engineering. At present, approximately 1.2 credit hours of the

course are designed to deal with the theory of process control, 0.8 credit hours are designated for coverage of common measurements and instrumentation, and 1.0 hour is assigned to practical laboratory exercises. The unfavorable responses include time periods covering both the previous and the current version of the class. The surveyed data suggest a revisitation of the course content should be implemented.

Cell Biology and *Physical Chemistry*, although they were also near the top of the least useful list (see Table 2), are not likely to be modified as they are both prerequisites for subsequently required classes. *Finite Element Analysis*, which was also viewed as unfavorable by a number of graduates, has been dropped as a requirement from the Environmental Engineering curriculum as of the 1996-1997 school year and replaced with *Organic Chemistry I*.

Suggestions for additional courses were led by requests for a separate class dealing with environmental law. All of these responses were from 1995 and earlier alumni, who graduated before NMT's addition of *Environmental Law and Regulations* as a required class. Other suggestions included course work in general areas of civil engineering, computer design/modeling, and business and management, and more discipline-specific areas such as site assessment, HAZWOPER training, and geology.

Approximately 33% of the respondents have obtained or are in the process of obtaining graduate degrees. Most of the advanced degrees are Masters of Science in Environmental Engineering, but some graduates have pursued advanced degrees in other disciplines such as mechanical engineering, chemical engineering, nuclear engineering, environmental management, etc. With one exception, the continuing graduates felt the undergraduate curriculum at NMT prepared them well for graduate school. Responses included comments such as "good study skills", "everything (in graduate school) is rehash", "feel ahead of the rest of the students", "NMT harder -- learned more", and "prepared for workload/challenges". The single response which indicated NMT did not prepare the student well enough for graduate school gave no supporting comments. Overall, the alumni were pleased with their experience at New Mexico Tech. On a scale of one to five, with one being very poor and five being excellent, the responding graduates rated their overall educational experience as an average of 4.28±0.72 (the uncertainty represents one standard deviation). Departmental faculty competence and availability were rated at 4.38±0.88 and 4.49±0.72, respectively. College-wide faculty competence averaged 4.03±0.71.

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REFERENCES

[1] Engineering Workforce Commission (1997), *Engineering and Technology Enrollments: Fall 1996*, American Association of Engineering Societies, Inc., Washington, D.C.

[2] Accreditation Board for Engineering and Technology (1996), *1996 Accreditation Yearbook: For Accreditation Cycle Ended July 1996*, Engineering Accreditation Commission, Technology Accreditation Commission, Related Accreditation Commission.

[3] New Mexico Tech (1997), *Science and Engineering 1997-1998 Catalog*, New Mexico Institute of Mining and Technology, Socorro, NM 87801

BIOGRAPHICAL INFORMATION

RANDAL S. MARTIN, Associate Professor of Environmental Engineering
Dr. Martin received his Ph.D. in Civil Engineering from Washington State University in 1992. At New Mexico Tech, he has had prime responsibility for air pollution-related courses at both the undergraduate and graduate level. Dr. Martin's research interests include biogenic non-methane and oxygenated hydrocarbons, atmospheric modeling and photochemistry, and catalytic air pollutant control.

CLINTON P. RICHARDSON, Department Chair, Associate Professor of Environmental Engineering.
Dr. Richardson received his Ph.D. in Civil Engineering from the University of Kansas in 1987. Dr. Richardson's teaching interests include water and wastewater treatment, solid & hazardous waste engineering, geotechnical waste containment, and a wide variety of general engineering courses. His research interests include biological wastewater treatment, groundwater remediation, and geotechnical waste containment.

Table 1. ABET-accredited environmental engineering schools and undergraduate enrollments[1,2].

Environmental Engineering	**Enrollment (Fall 1996)**
California Polytechnic State University	279
University of California - Riverside	45
University of Central Florida	246
University of Florida	343
Michigan Technical University	331
Montana Tech of the University of Montana	244
New Mexico Institute of Mining and Technology	131
North Carolina State University - Raleigh	148
Northern Arizona University	115
Northwestern University	80
Rensselaer Polytechnic Institute	70
Stevens Institute of Technology	39
Syracuse University	62
Utah State University	136
Civil and Environmental Engineering	
University of Michigan	255
University of Pittsburgh	unavailable
Tufts University	93
Youngstown State University	98
Civil Eng. with Environmental Eng. Option	
Ohio State University	unavailable
Environmental Engineering Science	
Massachusetts Institute of Technology	72
Environmental Resources Engineering	
Humbolt State University	375

Table 2. Alumni survey results for which there was more than one response of the most useful, least useful, and suggested additional courses concerning NMT's environmental engineering undergraduate curriculum.

Most Useful Courses	% of Responses	Least Useful Courses	% of Responses	Suggested Additions	% of Responses
Air Pollution Engineering	32.5	Instr. & Process Control	17.5	Law	20.0
Groundwater Hydrology	20.0	Cell Biology	10.0	Management	7.5
Wastewater Treatment	20.0	Physical Chemistry	10.0	Civil Engineering Classes	5.0
Environmental Law	15.0	Finite Element Analysis	7.5	Business	5.0
Hazardous & Solid Waste	15.0	Humanities	5.0	Site Assessment	5.0
Water Treatment	12.5	Groundwater Hydrology	5.0	HAZWOPER Short Course	5.0
All Env. Eng. Classes	12.5	Electrical Engineering	5.0	Geology	5.0
General Engineering	10.0	History	5.0	Computer Design/Modeling	5.0
Technical Writing	10.0	Quantitative Analysis	5.0		
Chemistry	10.0	Engineering Economics	5.0		
Air Pollution Sampling Lab	10.0				
Transport Process	7.5				
Water & Wastewater Lab	7.5				
Env. Microbiology	5.0				
Fluid Mechanics	5.0				
Biology	5.0				

Figure 1. New Mexico Tech's 1997-1998 environmental engineering curriculum[3].

Total Degree Requirements = 138 credits

Basic Degree Requirements (59)

- Calculus I (4)
- Calculus II (4)
- Physics I and lab (5)
- Physics II and lab (5)
- Chemistry I and lab (4)
- Chemistry II and lab (4)
- Biology I and lab (4)
- Intro to Engr I (2)
- Intro to Engr II (3)
- English I (3)
- English II (3)
- Humanities (6)
- Social Sciences (9)
- Hum./S.S. elect (3)

Required Supporting Courses (55)

- Technical Writing (3)
- Calculus III (4)
- Diff. Equations (3)
- Applied Statistics (3)
- Cell Biology (3)
- Env. Microbiology (3)
- Groundwater Hyd. (3)
- Quant. Analysis (3)
- Physical Chemistry (3)
- Organic Chemistry I (3)
- Fluid Mechanics (3)
- Statics (3)
- Mech. of Materials (3)
- Eng. Economics (3)
- Electrical Eng. (3)
- Thermodynamics (3)
- Heat & Mass (3)
- Process Control & Meas. with lab (3)

Environmental Engineering Core Courses (24)

- Introduction to Env. Eng. (3)
- Env. Laws & Regulations (2)
- Water Treatment Process Design (2)
- Wastewater Treatment Process Design (2)
- Water & Wastewater Laboratory (1)
- Senior Design Thesis (3)
- Air Pollution Eng. I (2)
- Air Pollution Eng. II (2)
- Air Pollution Sampling (1)
- Soil Mechanics and lab (2)
- Solid & Haz. Waste Eng. (4)

Figure 2. Employment information and curriculum survey questions.

General Information

Year of Graduation?
Gender (male or female)?

Employment Information

Are you currently employed in the environmental field (yes or no)?
Approximately how long have you been employed within the field?
How many employers within the field have you worked for?
What is your current salary range?
What was your starting salary, and in what year?
Would you describe your employer as Regulatory, Industry, Consulting, or other?
Please list your current title and responsibilities.
What were your previous job titles, if any?
Have you obtained any professional registration (EIT, FE, PE, QEP, etc.)? If so, what, when, and where?
Please comment on your current supervisory responsibilities (e.g. how many people, what category of employees, etc.).

Curriculum Survey

Which courses at NMT were most useful?
Which courses at NMT were least useful?
Are there any additional types of courses which you feel would be beneficial to the students currently enrolled in the environmental engineering program?
Since graduation have you pursued or obtained an advanced degree?
- If so, what, where, and when?
- Did NMT adequately prepare you for graduate school? Why or why not?

Following a 1 to 5 scale (1 = very poor, 5 = excellent), rate the following items:
- Departmental faculty availability
- Departmental faculty competence
- College-wide faculty competence
- Overall educational experience at NMT

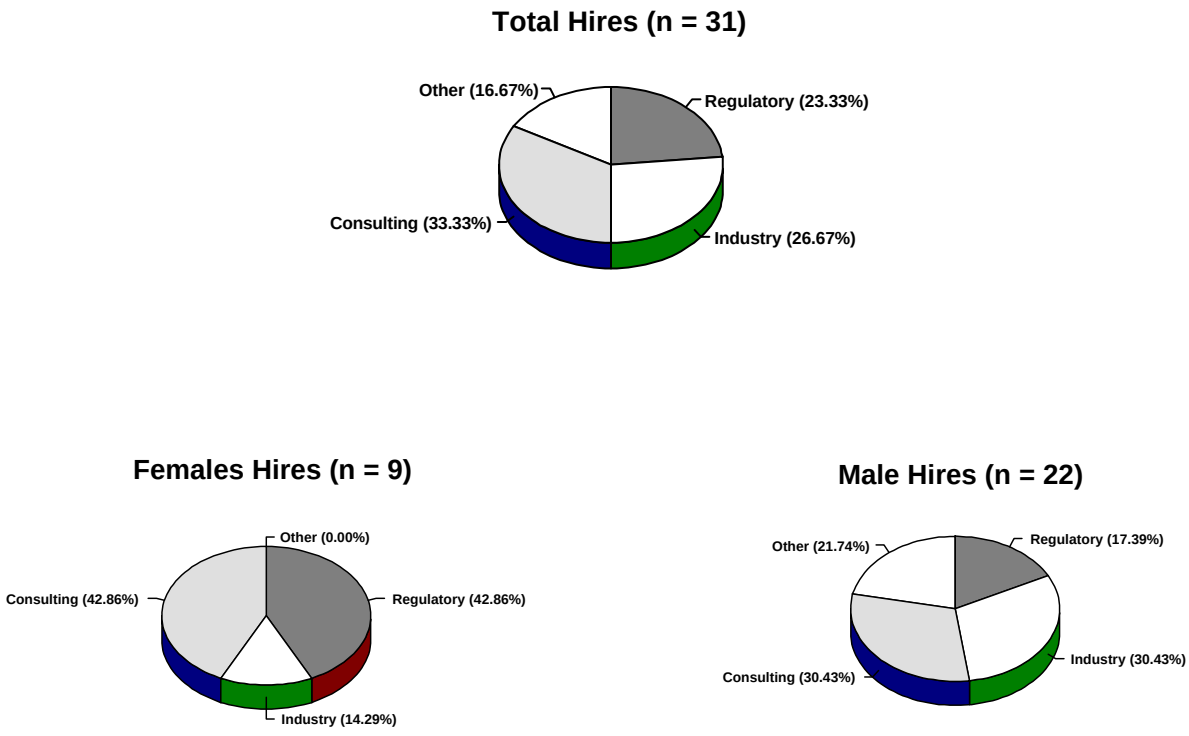

Figure 3. Employment sector and gender distributions of starting positions obtained by NMT's B.S. Environmental Engineers.

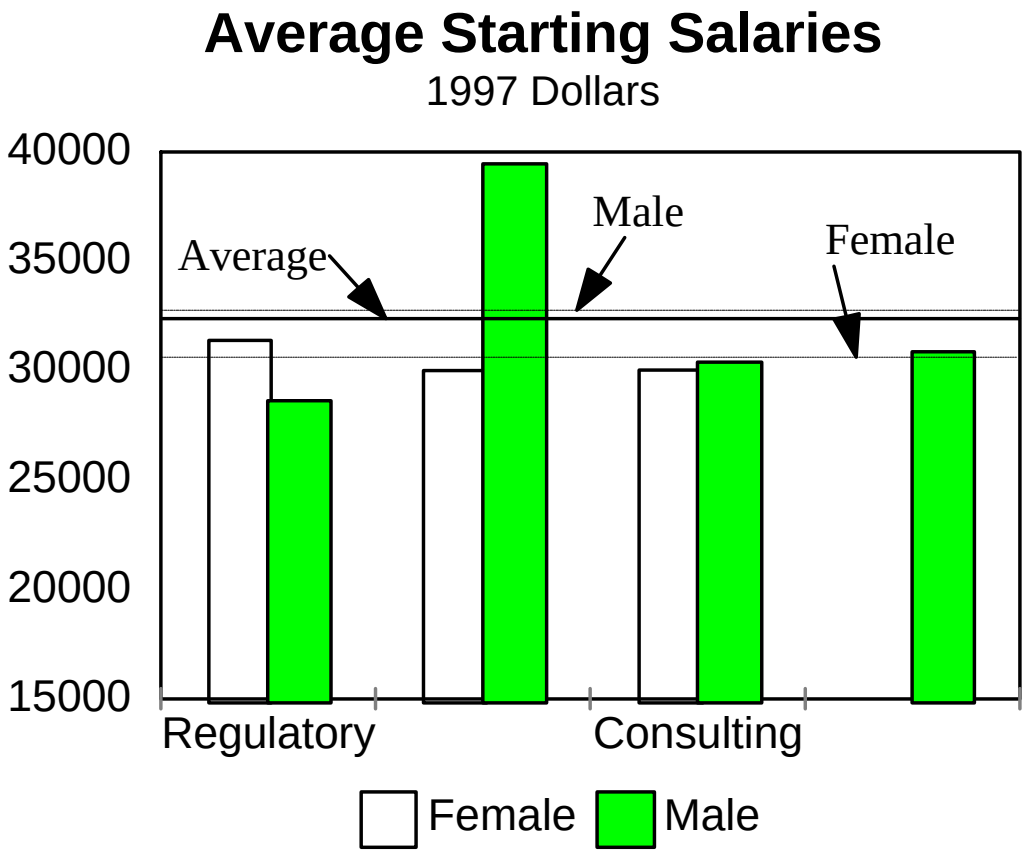

Figure 4. Gender and employment distributions of starting salaries obtained by NMT's B.S. Environmental Engineers.