

## **AC 2009-1661: OFFERING A SUCCESSFUL ENGINEERING TECHNOLOGY PROGRAM AT A LARGE RESEARCH UNIVERSITY: CHALLENGES AND UNUSUAL CIRCUMSTANCES**

### **Carmine Balascio, University of Delaware**

Carmine C. Balascio, Ph.D., P.E. is an Associate Professor in the Department of Bioresources Engineering at the University of Delaware. He earned bachelor's degrees in Agricultural Engineering Technology and Mathematics from U.D. He earned an M.S. in Agricultural Engineering and a Ph.D. double major in Agricultural Engineering and Engineering Mechanics from Iowa State University. He teaches courses in surveying, soil mechanics, and storm-water management and has research interests in urban hydrology, water resources engineering, and assessment of student learning. In August 2008, he concluded eight years as a member of Delaware's Engineering Licensing board, the DAPE Council, but continues to be active on DAPE and NCEES committees.

# Offering a Successful Engineering Technology Program at a Large Research University: Challenges and Unusual Circumstances

## Abstract:

This paper examines the challenges facing the Department of Bioresources Engineering in offering its 4-year general Engineering Technology (ET) Program at the University of Delaware (UD). UD is a large land-grant university classified by the Carnegie Foundation<sup>(1)</sup> as a Research University (very high research activity) – RU/VH. The RU/VH designation indicates the highest level of research activity as rated by the Carnegie Foundation. The department and its ET program are subject to unusual circumstances because neither is formally associated with the university's College of Engineering, but instead are administered through the College of Agriculture and Natural Resources. The challenges examined in this paper include:

- Recruitment of ET students for a program and department located physically and administratively in the university's College of Agriculture and Natural Resources.
- Coping with limited departmental laboratory space for teaching laboratory-rich ET subject matter.
- Recruitment of faculty who can contribute to a general ET program when hiring decisions are based primarily on the ability of a potential tenure-track faculty member to support the *research* mission of the College of Agriculture and Natural Resources – a mission that does not specifically include research related to ET.
- Recruitment of faculty in a department with no doctoral program and only a fledgling master's program.

The role of adjunct faculty, future evolution of the ET program at UD, and implications for programs in more conventional settings are also discussed.

## Introduction:

The history of the general ET program at the University of Delaware (UD) goes back to the 1960s when the then Department of Agricultural Engineering began an unaccredited 4-year program in Agricultural Engineering Technology (AET). At that time, the department offered no graduate degrees and the university was not in the upper tier of research institutions. From the program's inception through the 1980s, 20 to 30 students typically graduated each year. In the early 1980s, the AET program obtained TAC of ABET accreditation and became the only accredited AET program in the country at that time. To serve an indentified need in the state, a 4-year general ET program was added about 1983 that was intended to serve mainly transfers holding 2-year ET associate degrees from regional community colleges. The 4-year general ET degree obtained TAC of ABET accreditation by around 1987.

Because of demographic shifts in the state, the AET program was attracting only a few students per year and was no longer sustainable by the mid to late 1990s. By this time, also, the university had evolved into a top-tier research institution. In 1997, the name of the department was changed to Bioresources Engineering (BREG) to reflect a wider research emphasis beyond agriculture. The AET program was discontinued and the general ET program was modified to accept incoming freshmen. In 2002 the ET program was revised further to increase its rigor and to include two concentrations: (1) Applied Electronics and Controls and (2) Construction Technology and Technical Management.

At the time of these changes, the faculty in the department were well-suited to the two concentrations. Construction-related topics such as surveying, CAD, statics, strength of materials, cost estimating, project economic analysis, project management, fluid mechanics, thermodynamics, soil mechanics, wood and steel structure design, concrete and masonry structure design, and HVAC were offered in addition to courses generally in support of the electronics and controls concentration: electrical power, instrumentation, analog circuits, PLCs, and applied controls. Additional related courses such as utilities, welding and metals, storm-water management, wastewater treatment systems, manufacturing, safety and health in the workplace, plant layout and materials handling, and machine design rounded out the offerings.

Most of these courses were taught and/or developed by the department's regular tenure-track faculty, but part-time contingent faculty were utilized regularly for some of the more specialized offerings such as welding and metals, PLCs, and safety and health in the workplace.

### **Current Conditions**

The ET program has had healthy enrollment; we regularly graduate 20 to 25 students per year. We get relatively few students who start the program as freshmen, however. A typical incoming freshman class will have only 4 or 5 members. The program does attract non-traditional part-time students who transfer credits from a 2-year ET degree and who are often working full time in support of a family. We also get a considerable number of internal transfers from other divisions in the university. The low number of freshman who begin in the ET program is undoubtedly a result of its low visibility by virtue of its lack of affiliation or association with the College of Engineering. Prospective students simply don't think to look for an ET program housed within the College of Agriculture and Natural Resources.

Most students either choose the Construction Technology and Technical Management concentration or specify no concentration, which is an option. Two-year ET programs often have students taking courses in subject areas that would normally be taught in upper division courses within a 4-year ET program. Because of accreditation considerations, junior college courses cannot transfer directly as upper division university courses, which present the material at a higher level. As a result, associate degree holders usually transfer significant numbers of unusable credits. Usually, transfer students who have 2-year ET degrees are better off not specifying a concentration in the 4-year ET program because it's possible to make more efficient use of their transfer credits. Most students who do not specify a concentration often end up

taking courses associated with the Construction Technology and Technical Management concentration, however. There has been relatively little demand for the Applied Electronics and Controls concentration; we have taken steps to eliminate it.

Since the early 1990s UD has emphasized faculty research, and it is now classified by the Carnegie Foundation<sup>(1)</sup> as a Research University (very high research activity) – RU/VH. The RU/VH designation indicates the highest level of research activity as rated by the Carnegie Foundation. With the university's increasing emphasis on research and the prospect of upcoming faculty retirements in the BREG department, the likelihood of finding future faculty members – who will be hired on the basis of their ability to support the research priorities of the College of Agriculture and Natural Resources – who can also support the current ET program, with its emphasis on construction, looks remote. The department has evolved with a strength in the area of water resources engineering, and future faculty hires will undoubtedly have expertise in water resources or related environmental areas.

### **Recruitment of Students**

Since the ET programs in BREG have never been affiliated with the UD's College of Engineering, student recruitment has been largely by word-of-mouth throughout the department's history. We have pursued several strategies to maintain student numbers, but the most important is to provide a quality degree that serves potential student and employer needs. That nearly all students have offers of employment, often in entry-level engineering positions, before they graduate, and that many pass the FE exam helps the reputation of the program.

We have designed the ET program to be attractive to part time non-traditional students who may be employed full time by offering our courses, on a rotating basis, during late afternoon and evening hours. Existing UD undergraduate engineering programs do not cater to this part-time non-traditional student clientele. As a result, the average age for our students has been a very non-traditional 24 to 25 years.

We have developed relationships with faculty at regional community colleges offering two-year ET degree programs. To facilitate opportunities for students from community colleges, articulation agreements between the various community college ET programs and the ET program at UD have been initiated. Community college faculty advisors will frequently refer their students to our ET program. When confronted with the choice between the ET degree and a traditional engineering degree at UD, many of transfer students will choose the ET program because:

- Late afternoon and evening classes allow full-time employment,
- Transfer credits from ET degrees earned at a community college can be used more efficiently in the ET program as opposed to an engineering program, and
- ET courses are focused on engineering practice as opposed to theory, which is usually emphasized in engineering courses.

Though we have no official affiliation with the College of Engineering, we have developed contacts over the years with engineering advisors. Faculty advisors in the College of Engineering will frequently refer students to our ET program who may be struggling with the theoretical level of presentation often employed in engineering courses. Internal transfer students from the College of Engineering are usually very capable students, but their learning styles may be more compatible with the more visual, active learning, or hands on instruction commonly used in ET programs. Broberg et al. <sup>(2)</sup> found that ET students generally have more visual learning styles as opposed to engineering students who tend to prefer verbal learning.

Many students who apply for admission to an engineering program at UD are not accepted and are instead admitted to the university as “undeclared”. These students are usually quite capable, and they often find our ET program through word of mouth. Such students frequently commit to ET when they realize that traditional engineering career paths, including licensure (in Delaware, its surrounding states, and a total of approximately 35 states nationally), are open to ET graduates.

We have run advertisements in the student newspaper to attract internal transfers in the past, but we can undoubtedly do more to improve our marketing in this area. We have also begun discussions with the College of Engineering about developing a visual presence on the College of Engineering web site for the ET program. In the past, the College of Engineering has not been receptive to such a move, but recent changes in administration may have left them more amenable.

As might be expected, the ET program at UD has math and science requirements that are mostly less rigorous than those of UD engineering programs. The ET program, for example, only requires two semesters of sophomore-level (200-level) non-engineering calculus and a total of 12 credits of mathematics at the 200-level or above. Often, the additional credits beyond calculus include statistics and finite math. Two semesters of physics are required, but the course sequence can be algebra-based rather than the engineering calculus-based physics. Interestingly, the ET chemistry requirement is actually more rigorous than that of most engineering programs. The majority of engineering programs only specify one semester of chemistry, while ET students take the same introductory chemistry course as do the engineers but are additionally required to take the second course in the sequence.

When we get students who are capable of successfully taking engineering math and physics, we encourage them to do so. With the higher level math and physics, students are eligible to complete one of several engineering minors available at the university such as Civil Engineering, Environmental Engineering, or Biomedical Engineering. Students with engineering minors can directly substitute required engineering courses taken for the minor in place of similar ET courses. ET graduates who earn engineering minors have particularly attractive employment prospects; they often obtain licensure and some have gone on to complete graduate degrees in engineering.

## **Coping with Limited Lab Space and Facilities**

Before 1998, the department had ample space in the College of Agriculture and Natural Resources for fully equipped laboratories in electricity, utilities, welding and metals, hydraulics, and machinery. With increasing emphasis on research around that time, teaching space was converted to faculty offices and research laboratories in a building renovation; and a substantial portion was lost.

Fortunately we have developed relationships with our College of Engineering colleagues, and several of our faculty have joint appointments in College of Engineering Departments. Some engineering programs have specified selected ET courses as required or as technical electives. Some departmental faculty teach engineering science courses such as statics and strength of materials for Civil and Environmental Engineering students.

In return, we've gained access to College of Engineering teaching labs and facilities. Our ET courses for statics & strength of materials, machinery design, fluid mechanics, hydrology, and soil mechanics routinely utilize College of Engineering facilities for laboratory sections. There is no teaching lab left on the UD campus that can still be used for welding and metals instruction. In that case, we've made arrangements with a local technical high school to use its facilities.

## **Recruitment of Faculty**

At one time, TAC of ABET minimum criteria for faculty qualifications included three years of industrial experience. Our ET program was cited in a TAC-ABET 2004 visit for not adhering to that requirement with our most recent faculty hire at the time. With an increasing emphasis on research, the position was advertised as 70% research and 30% teaching. We had no applicants out of a pool of about 40 for the position who had the combination of industrial experience and academic qualifications who would have been suitable. We were able to hire a candidate with strong research capabilities who could still contribute to the teaching program by taking on courses in computer programming, electricity, and controls. He had no industrial experience, however. We considered the industrial experience requirement a very real threat to the continued accreditation of our ET program.

Fortunately, the latest version of the TAC-ABET criteria for program accreditation does not specify a rigid requirement for faculty industrial experience<sup>(3)</sup>. Under Criterion 6 for faculty, the passage states<sup>(3)</sup>:

*Overall competence of the faculty will be evaluated through such factors as formal education, balance of academic experience and professional practice, industrial experience, professional certification, teaching experience, teaching effectiveness, technical currency, scholarly activity, professional society participation, communication skills, extracurricular support for student activities, and similar attributes appropriate to the program educational objectives.*

*Individual faculty members must have educational backgrounds, industrial experience, professional practice, communication skills, and technologically current knowledge that support the field of instruction and program educational objectives. Collectively, the faculty must be capable of providing students an appropriate breadth of perspective and effective instruction in the use of modern technical and non-technical methodologies in careers appropriate to the program educational objectives.*

Our most recent faculty opening was again advertised with a 70% research component and 30% teaching. Out of about 80 applicants for the position, there were few who had industrial experience and none of those had the research credentials necessary to succeed in the position. We eventually hired a person with a very strong water resources research background who was adept at working on and building interdisciplinary teams. We judged those abilities to be crucial for success of the individual in the position because at the time of his hire the department had no graduate program. He quickly established relationships with and eventually obtained joint appointments in departments that did have graduate programs as a means of acquiring access to graduate students.

At the time we hired for this most recent faculty position, we had been working on establishing a master's degree program in BREG, and it has recently gone on the books. The master's program is important for attracting good researchers, but to attract top-notch researchers a doctoral program would be better. We have no prospects for developing a doctoral program in BREG in the near future, so we continue to work on nurturing our relationships with departments in the College of Engineering so our present and future faculty might have access to doctoral students.

The precedent for recent faculty hires in BREG has been for a high research component in the appointment. A person hired on a 70% research appointment will teach only one or two courses per year. To compensate, some tenured faculty have voluntarily taken a higher teaching load, but that approach may not work in the long run. The research focus of new faculty hires must support the research mission of the College of Agriculture and Natural Resources, but that mission does not include ET research specifically. Externally funded research in the BREG Department has historically been of an applied nature, and that emphasis has attracted faculty who are capable of teaching courses in an ET program. Funding pressures and the superior status of basic research for faculty career advancement may influence that direction in the future, however.

The department's developing emphasis on water and natural resources engineering fits the research mission of the College of Agriculture and Natural Resources, but the resulting backgrounds of current faculty members are not broad enough to offer the wide range of courses that is optimal for a general ET program. Out of necessity, we use adjunct faculty to fill the gaps. We generally use adjunct faculty to teach upper division courses in areas outside the expertise of regular faculty: PLCs, Cost Estimating, Project Management, Safety and Health in

the Workplace, and Manufacturing are examples. Selected lower division skills courses are also sometimes taught by adjunct faculty: welding and metals and CAD are prime examples.

### **Future evolution of the ET program**

Through a combination of regular faculty and adjunct faculty, we hope to continue offering the Construction Technology and Technical Management Concentration, but we recognize a need to have other options. To address the issue of incompatibility between research focus and ability of faculty to teach in an ET program, we had investigated the possibility of revising the general ET program to become a General Engineering program, but department faculty were willing to do so only with the cooperation of the College of Engineering, who discouraged the idea. Without some affiliation with the College of Engineering, department faculty were not convinced we could attract enough students to sustain a general engineering program. The College of Engineering did encourage us to develop an environmental engineering technology concentration for the ET major, however. With the department's research emphasis on water resources, the future prospects of our being able to support an environmental engineering technology concentration are very good and potential student demand for such a major is reasonably high.

The master's program in BREG that we have initiated currently requires a thesis; we are now in the process of adding a non-thesis option. We perceive an opportunity to serve a part-time student clientele composed of people possessing BS degrees in engineering or ET who are working full-time. Again, this is a student population segment that has not been served well by existing engineering master's programs at the university because graduate classes are often not scheduled with working people in mind. Courses for the BREG master's degree will be offered in the late afternoon and early evening so people employed full time can enroll. Besides catering to an underserved clientele with the non-thesis option, we believe the non-thesis master's will bolster the thesis-option master's degree by increasing enrollment in our graduate-level courses, thus making the overall program more viable.

We are also exploring the possibility of obtaining EAC-ABET accreditation of the master's degree. Such a program would leave open the possibility of developing a five-year course of study based on the ET degree in combination with an engineering minor and graduate engineering courses. The program would lead to an EAC-ABET-accredited NCEES model law master's degree that would be available to highly capable ET students. Practicing engineers-in-training who do not have model law undergraduate degrees may be particularly interested in pursuing such a degree because it would enhance their licensing prospects and mobility.

### **Wider Implications**

The circumstances affecting the ET program at UD are unusual, but there may be wider implications for ET programs at other institutions. The NSF<sup>(4)</sup> and others (e.g., Ted I. K. Youn<sup>(5)</sup> in *The Academic Job Market Is Bad for All of Us* ) have identified a trend toward more research interest and activity among faculty at institutions not classified by the Carnegie Foundation as having high or very high research levels. Perusal of advertisements for academic



positions posted in professional journals and other academic periodicals finds job descriptions for ET and similar positions that often specify a need for the incumbent to develop an externally funded research program – even at institutions that have not had an historical focus on research. The NSF<sup>(4)</sup> notes that:

*The historical concentration of academic R&D funds among the top research universities diminished somewhat between the early 1980s and mid-1990s but has remained relatively steady since then. Academic R&D activity is also occurring in a wider set of institutions.*

- *The set of institutions in the group below the top 100 academic R&D institutions in funding increased their share of total academic R&D expenditures from 17% to 20% between 1983 and 2003. This was offset by a decline in the top 10 institutions' share from 20% to 17%.*
- *The change in the number of institutions supported occurred almost exclusively among higher education institutions classified as Carnegie comprehensive; liberal arts; 2-year community, junior, and technical; or professional and other specialized schools.*

This growing emphasis on research over teaching at institutions aspiring to higher research status will require ET departments at such institutions to hire faculty who can thrive in a research environment. They will be faced with many of the same challenges that confront BREG at UD in offering its general ET undergraduate program, that is:

- Finding research-focused faculty who have the ability to teach and interest in teaching ET subject matter.
- Supporting the research efforts of research-oriented faculty in ET departments that often do not have master's programs and almost never have doctoral programs.

At some institutions an approach like that taken by BREG at UD may work: Form relationships with departments that have graduate programs so that through joint appointments, department faculty can gain access to graduate students. It may be necessary to institute graduate programs as was done by BREG at UD, especially at institutions where no such links with engineering graduate programs in other departments are available.

Since most departments that offer ET programs are not traditional engineering departments, the graduate programs developed and associated research performed will most likely be very much applied in nature. A further problem that may be encountered is the scarcity of funds for *applied* research – especially from federal government grant programs.

## **Conclusions**

The challenges of maintaining a successful ET program at the UD were examined. The program is subject to unusual circumstances in that neither its department nor the program itself has any association with the College of Engineering and are instead housed in the College of Agriculture and Natural Resources. A challenge exists in recruiting students to an ET program housed in a nontraditional ET college because of low program visibility. A large percentage of students are internal or external transfers and/or non-traditional students most of whom find the program by

word-of-mouth. In the future, the department needs to expand its recruiting efforts using a variety of media outlets; and it also needs to develop some program association with the College of Engineering.

The biggest challenge is the difficulty of supporting a general ET program with faculty who are recruited for positions emphasizing research and who are hired almost solely based on their ability to support the research mission of the College of Agriculture and Natural Resources in which the ET program's department is housed. For successful faculty recruitment, we will need to build and strengthen the recently initiated master's degree program in BREG and attempt to hire faculty members who are good at working in and developing interdisciplinary research teams to increase their prospects for research achievement. The department is taking steps to make the ET program more compatible with faculty whose strengths are in water resources engineering by developing a concentration in environmental engineering technology. To keep supporting the construction technology and technical management ET concentration in the future, it will be necessary to continue utilizing adjunct faculty.

Finally, the wider implications of the BREG department's experience at UD were examined. Since growing emphasis on research is occurring at a variety of formerly teaching-focused institutions, it may be expected that many of the challenges encountered by the ET program at UD will be replicated elsewhere.

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