AC 2007-1456: FACULTY HIRING TRENDS AT SMALL- TO MEDIUM-SIZED RESEARCH-INTENSIVE CEE DEPARTMENTS AND BALANCING THE NEEDS OF RESEARCH AND PRACTICE

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Faculty Hiring Trends at Small- to Medium-Sized Research Intensive CEE Departments and Balancing the Needs of Research and Practice

Abstract

Civil and environmental engineering (CEE) departments are embracing the use and development of new technological breakthroughs that are constantly taking place to address social problems in an increasingly complex, globally connected, and congested world. The development of new solutions requires a strong focus on fundamental and applied research, often in emerging areas that are only tangentially related to traditional civil and environmental engineering areas. To remain competitive, research-oriented departments are hiring faculty in these cutting-edge engineering science-oriented research areas who may not have strong training in traditional CEE areas, and especially in design. In smaller departments, this type of hiring practice has the potential to cause the undergraduate curriculum to favor engineering science-oriented topics over engineering practice-oriented topics. This paper examines recent faculty hiring practices in 14 small- to medium-sized research-oriented CEE departments in the U.S., and discusses potential impacts on the profession. The importance of maintaining flexibility in ABET CE program criteria, and in the second edition of the Civil Engineering Body of Knowledge document, is also stressed.

Faculty Hiring Practices

I investigated faculty hiring practices at 14 small- to medium-sized research-oriented CEE departments (typically having between 10 and 40 faculty members) by searching department Web pages and identifying assistant professors. I ignored faculty members hired recently as associate or full professors. I then contacted current or former chairs at these departments and posed the following questions to them:

1. Does your department tend to hire faculty in engineering science areas?
2. Has the number of faculty able to teach design courses declined in recent years? If so, how does the department teach design courses to meet ABET needs?
3. Your recent hires (assistant professors) are listed below. For each person, please indicate:
   (a) The person's potential to secure a P.E. license soon after tenure
   (b) The ability of the person to teach design courses in their discipline

In general, department chairs indicated that there has been a change over time with respect to faculty hiring practices and that the number of faculty with the ability to teach traditional design in on the decline. Nevertheless, the department chairs tended to be optimistic with respect to the ability of their faculty to teach design courses and obtain the P.E. license. I paraphrased the response from them, reviewed degrees received (CE or non-CE BS and MS), research interests, courses taught, and design work experience to assess: (a) the ability of the assistant professors to teach traditional civil engineering design courses (e.g., design of structures, foundations, hydraulic and hydrological systems, pavements, transportation systems, and wastewater treatment systems); and (b) their likelihood of obtaining P.E. licenses. It is of course possible that faculty members having a low likelihood of teaching design at present could learn to teach traditional design courses, and those having a low likelihood of obtaining the P.E. license could eventually obtain one as long as they have ABET-accredited engineering degrees. However, such transformations are rare for research active faculty members in research-intensive schools. It is more likely that these faculty members could become involved in teaching non-traditional design concepts (e.g., the design of: new and more durable material systems to withstand extreme loads; sensor networks to monitor civil infrastructure systems; control systems to mitigate traffic congestion; biomechanical devices, bioremediation systems for cleaning up toxic sites, etc.).

I have summarized the information on assistant professors in Table 1. The 14 departments in the table include those at private and state universities that have a long tradition of excellence in research, as well as those at state institutions that have become much more research-oriented in the last decade. The table lists the number of faculty in each department with non-engineering BS or MS degrees, as well as those with both BS and MS degrees from outside engineering. Faculty with non-engineering BS or MS degrees usually had them in the sciences (biology, chemistry, environmental science, mathematics, microbiology, physics, or statistics). The faculty members were hired because their PhD research was in an area related to civil engineering, so the specific discipline of the PhD degree is not particularly relevant to this study and is not included in Table 1. The following observations are made from this review:

- Most research-intensive CEE departments hire faculty members to extend the frontiers of new knowledge through research. The ability of new hires to teach practice-oriented design courses is a consideration in faculty searches, but is often not a binding condition. Some department chairs acknowledged the difficulty in recruiting faculty members with the ability to perform research in emerging areas while at the same time being able to teach traditional design, since such people are in short supply.
- Eleven of the 66 faculty members (17%) in the departments listed in Table 1 do not have a BS degree in engineering. Five of these earned MS degrees in engineering. Nine of the faculty members (14%) do not have a BS or MS degree in engineering. The distribution varies widely from department to department. Since MS degrees are not accredited, they may not necessarily provide training in design.
- Almost all of the departments listed in Table 1 have hired one or more faculty members whose expertise is in engineering science. These include not only those faculty members who have BS or MS degrees in the sciences, but also those with engineering degrees who perform research on science-oriented topics. Commonly, such faculty are members of the environmental engineering groups within their departments, but more and more people are performing engineering science-oriented research in other areas such as global climate change, hydrology and water resources, and materials.
- The ability of faculty members to teach traditional practice-oriented CEE design courses depends not only on whether they have engineering BS or MS degrees, but also on their PhD research and the time elapsed since they were last involved in traditional design. Some are more capable of modeling and understanding natural phenomena than engineered systems. I have categorized the ability of faculty members to teach traditional design and their likelihood of obtaining a P.E. as “High”, “Medium,” or “Low.” Most faculty members with a BS or an MS in engineering should be able to teach design and obtain their P.E. license, but some are unlikely to do so. Current or former department chairs provided feedback on the ability of their faculty members to teach traditional design courses, and their likelihood to obtain the P.E. license shortly after tenure. Some de-

partments have broadened the definition of design beyond the traditional technical content to include issues such as sustainability, economics, policy, and risk. Sixteen of the 66 faculty (24%) have a low likelihood of teaching traditional design courses. Most departments are able to sustain their ability to teach design: some departments have sufficient balance amongst their junior faculty; some hire adjunct faculty from practice; some have junior faculty members be mentored by senior ones by co-teaching; and some assign design courses primarily to more senior faculty. As senior faculty approach retirement, some departments, especially those that are not in metropolitan areas, face challenges in their ability to teach traditional design.

- Fifteen of the 66 faculty members (23%) in the departments listed in Table 1 have a low likelihood of obtaining their P.E. licenses. Other than perhaps for gentle cajoling, none of the departments require their faculty to obtain a P.E. license. Research funding, scholarship, and guidance of PhD students are the primary expectations for promotion to associate professor with tenure, although good teaching is typically also required.

Impact on the Profession

The baccalaureate programs in research-intensive CEE departments do not always align with the expectations of employers. The constraints imposed by the hiring trends discussed above diminish the ability of some research-intensive CEE departments to provide curricula that are rich in traditional practice-oriented design courses, and hence their graduates may have somewhat of a "theoretical bent." Bright students are attracted to research-intensive CEE programs due to their reputations, and employers vie for the graduates from these programs. These students tend to be well-educated, creative thinkers, and effective problem solvers, but may need additional training and development in traditional practice-oriented design. Lawson[1] eloquently argues that: "…theory promotes understanding, and understanding enables engineers to develop the practical expression of judgment and intuition vital to the engineering profession." However, employers often desire to hire graduates who will be fully productive from the first day on the job. Harichandran discussed this risk of dichotomy between research and practice.[2]

The civil engineering profession must realize that research-intensive CEE departments must hire faculty capable of performing research in emerging areas that often have a strong engineering science focus in order to survive in a highly competitive funding environment. Further, this research can lead to innovative solutions to civil engineering problems, especially when effective bridging mechanisms between research and practice are established.[3] While it is possible to find faculty with expertise in science-based research who are able to teach practice-oriented design classes, such people are in short supply. Hence, many departments have a significant number of faculty who have a low likelihood of teaching traditional civil engineering design or obtaining a P.E. license. The problem is likely to become more acute as time passes and senior faculty retire. Hiring adjunct faculty members from practice to teach design courses is perhaps the easiest solution. However, only a select number of practitioners tend to be good instructors of entire courses. This can cause difficulties, especially for departments in non-metropolitan areas where practitioners capable of teaching are in short supply.

In this environment, it is clear that CEE employers must take more responsibility than in the past for strengthening the practical design abilities of new graduates. The continued growth of the profession is a shared responsibility between universities and employers. The emerging second edition of the *Civil Engineering Body of Knowledge for the 21st Century* (BOK) document recognizes this shared responsibility.[4,5] University curricula are expected to lay the core foundations for all outcomes in the BOK, but employers are expected to provide avenues for further professional growth of their employees. In the current draft document, achievement of learning outcome levels in the post-baccalaureate but pre-licensure phase of a civil engineer's professional life is called for in outcomes related to contemporary issues, risk/uncertainty, sustainability, project management, communication, ethics, public policy, business and public administration, teamwork, leadership, lifelong learning, and attitudes. The current thinking is that state licensing boards will validate the learning that occurs during the pre-licensure experiential phase of a civil engineer's career.[6,7] In November 2006, the ASCE Committee on Academic Prerequisites for Professional Practice (CAP[3]) charged its Experience Committee to propose in more detail the validation of learning outcomes achieved through experience. This committee's work should become available in the next year.

ABET Accreditation and the BOK

ABET accreditation of civil engineering programs plays a strong role in defining minimum standards for BS programs. Overly prescriptive requirements can shackle the ability of CEE departments to respond to a rapidly changing research environment and remain competitive in research compared to other engineering disciplines. This must be recognized as ABET CE criteria continue to evolve.

Within the civil engineering context, design is often interpreted by ABET evaluators in the traditional practice-oriented sense (e.g., design of structures, foundations, hydraulic and hydrological systems, pavements, transportation systems, and wastewater treatment systems). However, engineering design is more broadly the creative process of conceiving and developing a solution to an engineering problem. It is possible, even within the civil engineering context, to define design more broadly and include activities such as the design of: new and more durable material systems to withstand extreme loads; sensor networks to monitor civil infrastructure systems; control systems to mitigate traffic congestion; biomechanical devices, bioremediation systems for cleaning up toxic sites, etc. The training of ABET evaluators to view design in this broader context would afford greater flexibility to research-intensive CEE departments and could alleviate the risk of dichotomy between research and practice.

Another issue related to the qualifications of faculty members to teach traditional design courses is professional registration. The ABET civil engineering program criteria include:[8]

> *The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.*

Of a total of 23 other engineering program criteria, similar statements exist for 6 (agricultural, architectural, biological, construction, environmental, and surveying). A nationwide survey of 180 engineering deans performed in 1999-2002 indicated that only 31% of full-time engineering faculty members across all disciplines, and as low as 10% in some states, had secured professional licensure.[9] Unfortunately, no breakdown is provided for civil engineering faculty. As mentioned earlier, none of the 14 civil engineering programs reviewed in this study require faculty members to obtain a P.E. license. As time passes, it would appear that these programs might strive to demonstrate the qualifications of more and more of their faculty to teach design courses by virtue of education, as opposed to professional licensure or design experience. The big question is whether civil engineering ABET evaluators will "buy" this argument.

The possibility of lifting the ABET prohibition on dual-level accreditation (i.e., accreditation of identically named BS and MS programs) that is currently being debated is also relevant. Maintaining flexibility and reducing work requirements for dual-level accreditation will promote the acceptance of dual level accreditation.

Development of the *Civil Engineering Body of Knowledge for the 21st Century*[6] was a major accomplishment of the profession. The BOK strongly influences ABET CE criteria as evidenced by the similarities between the new criteria recently adopted and the first edition of the BOK. Through a process of consultation and debate, highly prescriptive language in early drafts of the new ABET CE criteria was revised. Currently, the BOK2 Committee is working on a second edition of the BOK. The BOK2 Committee has stayed away from using highly prescriptive language in order to maintain flexibility.

Conclusions

Research-intensive CEE departments are hiring more and more non-traditional faculty members in order to remain competitive in research and extend frontiers in the discovery of new knowledge. A significant number of these new faculty members have BS and MS degrees in science areas, and are not well qualified to teach traditional civil engineering design courses. While the use of practitioners as adjunct faculty members is an easy way to remedy this imbalance, small- to medium-sized CEE departments in non-metropolitan regions are facing challenges in maintaining their ability to teach traditional design in their curricula, especially as senior faculty approach retirement. It is likely that in the future the undergraduate curriculum in these departments will tip more toward engineering science topics. In this environment, it is important for CEE employers to assume a greater responsibility in strengthening the practical design capabilities of new graduates.

For CEE to remain a forward thinking innovative profession, it must embrace the seeking of new knowledge in emerging areas. The profession must therefore afford CEE departments the flexibility to perform cutting-edge research to explore the frontiers of knowledge and develop effective solutions to societal problems. ABET CE program criteria and the CE Body of Knowledge must similarly maintain flexibility so as not to shackle research-oriented CE departments.

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Table 1. Data on Assistant Professors in CEE Departments at Selected Universities

University	# Asst. Profs.	# with Non-Engr. BS	# with Non-Engr. MS	# with Non-Engr. BS & MS	# Likely to Teach Traditional Design			# With or Likely to Obtain P.E.		
					High	Med.	Low	High	Med.	Low
Arizona State Univ.	5	1	1	1	5	-	-	4	1	-
Carnegie Mellon Univ	4	0	1	0	4	-	-	-	4	-
Colorado State Univ.	6	1	2	1	3	1	2	4	1	1
Columbia Univ.	2	0	0	0	1	-	1	1	-	1
Cornell Univ.	5	0	0	0	3	-	2	2	-	3
MIT	4	1	1	1	-	-	4	-	1	3
Michigan State Univ.	9	1	3	1	4	2	3	3	4	2
Princeton Univ.	2	0	0	0	2	-	-	2	-	-
Rice Univ.	3	1	1	1	2	-	1	2	-	1
Stanford	6	4*	2*	2	1	4	1	2*	2	2
Univ. of Colorado	6	0	0	0	5	1	-	4	2	-
Univ. of Maryland	3	0	0	0	2	1	-	2	1	-
Univ. of Michigan	7	0	0	0	5	2	-	5	2	-
Univ. of Wisconsin	4	2	3	2	1	1	2	1	1	2
TOTALS	66	11	14	9	38	12	16	32	19	15

* 1 non-engineering BS and MS is in architecture. One registered architect is counted as a P.E.