AC 2009-1562: THE CHANGING ROLE OF ENGINEERING FACULTY IN THE 21ST CENTURY

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Changing Role of Engineering Faculty in the 21st Century

Abstract

The issue of faculty responsibilities and workload, besides being extremely complex, and multi-faceted issues is a dynamic rather than a static one, as these responsibilities change based on the changing nature of a university, its students, or any of a variety of external factors. This paper discusses some of the efforts made in addressing a sampling of these facets, with examples from two of the largest universities in California, one private and one public. The paper concludes by pointing to ways in which faculty roles can be redesigned or supported so that they can offer students effective education while meeting administrative responsibilities with less stress.

Introduction

Engineering faculty, to be effective in the 21st century, require many of the same characteristics and skills that were needed in the 20th century. However, the traditional services provided by faculty are changing, and this implies that the fundamental role of an engineering faculty is also likely to change. Some of the factors that are bringing about the change are the need to balance the increasing pressures from shrinking budgets, growing costs, the proliferation of online instruction, competition from schools that offer similar programs, the emergence of for-profit institutions, high expectations from students and administration, and other factors. Also, innovation and technological breakthroughs in the 21st century are driving rapid changes in both engineering content and in modes of content delivery, thus requiring engineering faculty to be highly adaptive to constant changes. Besides the need for a growing number of engineers to acquire skills such as communication, collaboration and creativity, there is also an increasing need for faculty to educate students on the ethical implications and environmental consequences of the tasks they perform as future engineers. The faculty has to balance this with other duties such as scholarly development, accreditation, committee assignments, and other service requirements. In short, to be successful it is imperative that the engineering faculty acquire and possess strong management expertise along with varied technical skills.

Typically, all faculty members in universities have certain common responsibilities such as having to commit themselves to their teaching obligations; participate in the development of the programs of their departments and schools and of the university as a whole, engage in scholarly activities; support the university, as appropriate, in its goal to promote and fund programs, and render public service. Besides these, most universities require their engineering faculty to be both imaginative and ambitious intellectually. This becomes difficult especially when the infrastructure to conduct research is limited, particularly in universities that are primarily teaching-oriented. The faculty, in order to meet goals for scholarly contributions, has to work effectively in an environment of increased competition to obtain research funding, heavy teaching loads, and demands necessitated by the need to meet accreditation standards. The administrators are facing similar challenges. Part of the reason is because they require the faculty seeking promotion and tenure to satisfy certain demands but are unable to offer them the same kind of remuneration that such qualified individuals would receive in the private sector. As a result, they are often faced with the problem of not being able to recruit or retain quality faculty.

In fact, the salary gap between academia and industry is one of the primary factors discouraging some capable students from choosing academic careers.

To address these myriad challenges, school and department administrators have to increase faculty productivity without increasing faculty numbers, reduce support staff and/or other operational costs, increase student services (e.g., faculty advisory role in program and career advisement), introduce novel approaches into class room instruction (experiential learning with intensity and focus, iLearning laboratories, small group interaction, multiple delivery modes, etc.), and develop flexible learning methodologies.

Faculty workload is an extremely complex, multi-faceted issue[1]. Milem et al[2] conducted a comprehensive study regarding faculty time allocation over a 20 year period and found that faculty workload has steadily increased over the last 20 years. Fink et al[3] have identified many of the challenges faced by the faculty to meet the demands on the engineering profession in the twenty-first century. This paper discusses some of the efforts made in addressing some of these problems with examples from two of the largest private and public universities in California. The paper concludes by pointing to ways in which faculty roles can be redesigned so that they can offer students effective education while meeting administrative responsibilities with less stress. The authors hope that this paper will stimulate discussion and exploration of these essential challenges.

Description of National University and Its Student Body[4]

Founded in 1971, National University (NU) is a private, nonprofit institution of higher education. Since its establishment the university has dedicated itself to providing educational opportunities to a diverse population of working adult learners. With more than 22,000 full-time students, National University is the second largest private, non-profit California institution of higher education. National University is ranked 7th nationally and 2nd in California for awarding degrees to ethnic minority populations, and is ranked sixteenth out of 3,000 institutions nationwide in awarding graduate degrees to minority students. National University's central purpose is to promote continuous learning by offering diverse instructional approaches, encouraging scholarship, engaging in collaborative community service, and empowering its constituents to become responsible citizens in an interdependent, pluralistic, global community. National University students earn their degrees in a unique one-class-per-month format, and attend classes primarily at night and on weekends so they can continue to move forward in the workplace. The typical student age is 33-35, and most are employed full time while taking their degrees. In NU, each faculty is required to teach eight courses. On a 9 ½ month contract, the faculty's time is roughly allocated 70% for teaching, 20% for service, and 10% for research. National University's faculty model is to have a strong-but-relatively-small core of full time faculty supported by a much larger group of specialized part time (adjunct) faculty who are primarily practicing professionals in their respective fields. While the University administration and the bulk of the faculty are located in San Diego, NU has 28 campus locations around California and some faculty members are located at each location. In recent years the University has experienced a tremendous shift in students moving from on-site classes to internet-based on-line classes. Over half of the students now take at least some classes on-line. NU has been recognized twice with the Eureka ("Baby Baldrige") Award by the California Council for

Excellence and multiple times as one of San Diego's Best Employers among numerous other awards.

Description of San Diego State University and Its Student Body[5]

San Diego State University is part of the California State University System.

Founded on March 13, 1897, San Diego State University began as the San Diego Normal School, a training facility for elementary school teachers. Seven faculty members and 91 students met in temporary quarters over a downtown drugstore before moving to a newly constructed 17-acre campus on Park Boulevard. In 1935, the Legislature authorized expansion of degree programs beyond teacher education, and San Diego State Teachers College became San Diego State College. The college continued to grow over time, reaching an enrollment of more than 25,000 students by 1971. In 1960, San Diego State became part of the newly created San Diego College System, now known as the San Diego university system. In the early 1970s, with legislative approval, San Diego State College became San Diego State University. Beginning its 112th academic year in fall 2008, San Diego State University can take pride in more than a century of achievement in education, research, and service. With an enrollment of approximately 33,000 highly diverse students, San Diego State has grown into the largest institution of higher education in the San Diego region and one of the largest in the California State System. The majority of students are pursuing bachelor's degrees. San Diego State University is a traditional university based on the semester system. Its primary constituents are traditional college going students. And, although traditionally a teaching institution, SDSU is emerging as a prominent research institution as well. For two years in a row, Academic Analytics has ranked SDSU as the #1 most productive research university among schools with 14 or fewer Ph.D. programs based on the Faculty Scholarly Productivity Index. Since 2000 SDSU faculty and staff have been awarded over $1 billion in contracts and grants. The Carnegie Foundation rates the University as a "research/high research" institution, and SDSU anticipates that designation will soon be changed to "doctoral research/extensive"[6].

SDSU's College of Engineering[7]

Established in 1961, the College of Engineering at San Diego State offers a wide range of undergraduate and graduate degrees through its four departments. SDSU's engineering college was ranked #86 among the best undergraduate engineering programs according to US News & World Report's "America Best Colleges 2009" guide. Over one-hundred faculty and staff members work diligently to provide a world-class education to over 2300 students. The 52 full time faculty are assisted by ~25 part time faculty.

Engineering faculty actively participate in the growth of research activity at SDSU. A number of centers, institutes, and laboratories have been established to support engineering research endeavors, including:

- Communication Systems and Signal Processing Institute
- Concrete Materials Research Institute
- Industrial Assessment Center

- Environmental Engineering Research Laboratories
- Facility for Applied Manufacturing Enterprise
- Geo-Innovations Research Laboratory
- Powder Technology Laboratory
- San Diego Center for Materials Research
- Soil Erosion Research Laboratory

Students in engineering at SDSU may participate in any of a number of professional society-related student clubs, including: Association of Information Technology Professionals (AITP), IEEE, National Society of Black Engineers, Pacific Asia Society of Engineers (PASE), and the Society for Women Engineers. One or more faculty advisors support each of these student organizations. The majority of students are not on campus taking classes during the summer.

SDSU actively supports and encourages students in K-12 (primarily high school) to choose engineering as a career through being the regional center for a national program called Project Lead the Way. As a means of enabling student success, SDSU also implements the MESA program, providing extra support for educationally disadvantaged students on their path toward graduation. In both of these endeavors faculty also play crucial roles.

NU's School of Engineering and Technology[8]

The School of Engineering and Technology (SOET) at National University was announced in July 2002, and fully organized under a founding dean in October 2003. In line with NU's model, SOET has 17 full time faculty and ~190 adjunct faculty. Four full time faculty are at locations outside of San Diego (Los Angeles, Costa Mesa, Sacramento and San Jose). Most faculty teach at least a portion of their classes on-line. SOET now offers 17 degree programs in two departments. Each program is under the direction of a program lead faculty, who has the responsibility to ensure to quality of curriculum and instruction. The close correlation between the number of programs and number of full time faculty shows that most everyone will likely have some program lead faculty responsibility. This is a major responsibility, and lead faculty are given extra course workload reductions based on the size of their program.

SOET takes pride in offering curricula that are timely and relevant as well as challenging (e.g., wireless communications, information assurance, sustainability, enterprise architecture, Homeland security and safety engineering, and others). SOET also actively recruits faculty with industry as well as academic experience. Consequently, ~80% of faculty have experience outside academia, including 30% with executive experience at Fortune 500 companies and 40% with entrepreneurial experience in starting their own companies. This experience and related connectedness to the marketplace is prized at NU for ensuring relevance of curricula and for networking with key researchers, innovators and leaders outside academe.

NU's students currently have only one professional society-related student organization in which they can participate, AITP. (Thus, there is only a single club for faculty to advise and support.) This results from the fact that NU is non-residential, that most of the students are working full

time (many with families) and, hence, are not interested in – or just do not have the time for – participation in student organizations. Because of NU's one-course-per-month format, classes are ongoing year-round and there is little difference between student populations in summer versus any other time of year. SOET faculty rarely engage in recruiting activities at K-12 levels (unlike faculty at SDSU with Project Lead the Way) because traditionally few students come to NU directly after high school. SOET faculty are, however, actively engaging counterparts at community colleges to form articulation agreements and transition pathways, particularly since the profile of community college students is moving toward that of NU's traditional students. Finally, SOET faculty are not typically engaged in special programs (a.k.a. MESA) to support educationally disadvantaged students, since NU has traditionally served this population and basic student support structures are normally already in place.

Table 1 provides a summary comparison of National and San Diego State Universities' engineering schools. These two universities are, respectively, the second largest private and public universities in California.

Table 1: Comparison of National University and San Diego State University Engineering Schools[7,8]

Areas	**National University**	**San Diego State University**
Type	Private Non-profit	Public
Year of Establishment	2002	1961
Full time Faculty	17	52
Part Time Faculty	140	27
Total Number of Students	1050	2112
Standard annual teaching load	5~ 8 (quarter units)	4~ 6 (semester units)
Number of departments	2	4
Number of degree programs offered	16	16
Number of Student Professional Organizations Supported	1	5
Carnegie Classification	Master's (larger programs)	Research/high research
Campus locations	multiple	1
Institutes/centers/labs	0/0/4	2/3/4
Work load distribution	Teaching–70% Research – 10% Service- 20%	Full time workload is defined by the union. Overall workload is distributed by the administrators to research, teaching, and service. Typical expectations from research active faculty is: 50% teaching, 40%

		research, and 10% service

Workload Assessment

Faculty members are generally assessed in three areas: (i) teaching, (ii) scholarship, and (iii) service, and faculty members are typically asked to develop a Faculty Development Plan summarizing the planned work for a given academic year. This plan (at NU, for example) is approved by the department chair and the Dean of the school/college as a performance expectation document. The plan, usually, comprises all anticipated activities and workload in a given academic year. A faculty member may be granted a lower academic workload assignment under special or exceptional circumstances such as involvement in a major committee assignment or a major research project, or as a program lead faculty, etc. The Dean is responsible for reviewing the departmental teaching loads and related academic assignments with the departmental chairs, as well as for monitoring compliance. Table 2 provides the typical teaching, research, and service activities of a university faculty member. However, today, the budget constraints and competition haves forced university faculty members not only to perform additional service tasks but also to demonstrate measurable improvements in the following areas:

- Enrollment, retention, and graduation rates
- Development of academic programs and initiatives capable of serving new or changing markets
- Reviewing academic concentrations and majors to develop a more efficient curriculum
- Development of new pedagogies (eg: tablet PC instruction, podcasting, problem based learning, simulation) and delivery formats (eg: online, web-based instruction)
- Recruitment and retention of new faculty members (full time and adjunct), which has now become increasingly difficult because faculty members are expected to perform exceptionally well and receive as compensation for their services less-than-competitive salary and benefits compared to industry counter parts.

Table 2: Typical Teaching, Research and Service Activities of a University Faculty Member

Teaching Duties	**Research Activities**	**Service Activities**
Classroom teaching. Time spent in the classroom, lab, tutorial, seminar, or other formal teaching situations.	**Completing grant applications/proposals**. Completing grant application forms and writing research proposals to granting agencies	**Program/course administration.** Time spent in developing programs, managing/ administering/marketing programs, managing students and offering them advice related to program
Informal, individual teaching. One-to-one or small group teaching outside the classroom/lab environment (e.g., helping	**Preparing/planning/conducting research/scholarly projects**. Preparing for projects such as experiments and field studies. Conducting	**Administrative/ committee work.** Curriculum review, hiring, peer performance appraisals

students prepare a paper for presentation)	projects (e.g. experiments, field studies, literary research)	

Student supervision/Coaching. Supervising students (e.g., reviewing and editing student papers) and counseling/advising these students on academic matters as required	**Analyzing research information/data**. Performing mathematical or statistical analyses, studying/analyzing samples, artifacts, documents, or other research information/data	**Professional development work.** Participating in the field of expertise by supporting professional organizations, writing/peer-reviewing journal articles/reviewing books, and organizing conferences.
Planning lessons, lectures, labs, seminars, teaching aids. Planning teaching points, writing lesson plans, and developing discussion points, preparing presentation power points, and working out solutions to problems.	**Writing research/scholarly articles/manuscripts**. Writing or revising research/scholarly articles or manuscripts based on one's own research	**Externally remunerated professional work**. Work related to field of expertise conducted on a fee-for-service basis. For example, offering consulting services, providing testimony, or making speeches on one's areas of expertise.
Developing tests, assignments, assessments: Developing tests and assignments, grading, and supervising teaching assistants	**Research-related travel**. Travel time to and from off-campus research sites (field studies, other places of learning for the purpose of research).	**Community service**. Participation in activities related to one's field of expertise on a volunteer basis (e. g. , speaking to a local environmental group or serving on the board of a charitable organization)

Faculty members are under increased pressure from students, the university, and the community at large to improve the academic performance of their students[9]. Poor academic performance is a matter of concern for all stake holders (department, school, university, students, parents, alumni, business and industry, and community), and it may require intervention by the faculty so that students can overcome academic and emotional causes of under-performance. Students' performance can soar under the influence of a good teacher, and hence faculty members should play a key role in raising educational standards.

A review of several comparable engineering schools and their workload showed that faculty members tend to work 50.5 hours during an average work week. Faculty members spend a majority of their time on teaching undergraduate students (56 percent), and on institutional service (15 percent), and research/scholarship (12 percent). Forty-seven percent of faculty members describe their primary professional research as program/curriculum design, and more than 50 percent admitted that they are not engaged in funded research. The most common scholarship activity that most of faculty members are engaged in is making presentations at

professional meetings. They spend, significantly, more time than they would like to on teaching students and performing institutional service. Teaching and research are both important. But the relative weight has shifted over time[10]. Since recipients of research grants are highly favored and remunerated, faculty members are under enormous pressure to include research as an important part of their workload. Unfortunately, reduced research budgets at the state and federal level have made it difficult for faculty to obtain funding for their research projects. This is one of the reasons that tenured faculty (typically senior faculty) sometimes opt to increase their income through consulting rather than mentoring junior faculty or supervising graduate student research. This trend tends to be more prevalent in small universities rather than at major universities.

SDSU is rapidly increasing its amount of funded research. Funded researchers can receive lower teaching loads, and the University has increased its support staff to support grants and contracts. The College of Engineering has established a number of institutes, centers and laboratories to facilitate research activities, enhance research productivity, and promote a basis for additional grant applications and funding. Increasing funded research is one of the University's prominent goals.

NU also desires to increase funded research, but is at a significantly different level than SDSU. As described above for many universities, NU faculty research is frequently focused on teaching and instructional methodologies, on curriculum development, and on promoting student achievement. For example, SOET has received two major grants from HP to explore the use of tablet computing in instruction as a means for improving student comprehension of highly complex curricula. In order to support faculty in increasing their scholarly activities NU has taken a number of specific steps, including the following:

- Established professional development funds of $2400 annually for each faculty member, to be used for presenting papers at conferences or similar scholarly pursuits.
- Created Presidential Scholarships and Presidential Awards, which provide reduced teaching loads or research funds, respectively, as 'seed money' to stimulate faculty entering new research areas that hold the promise of receiving external funding in the future.
- Created additional recognition for faculty performing funded research through a "Researcher of the Year" award at the school and the university levels.
- Established a Research Council, an advisory group informing the Provost on methods and initiatives to further enable and support funded research and scholarly activities.

Typically, universities/engineering schools have several competing committees that may have relatively little value. Many of the committees are set up with good intention, but they do not offer any major benefit to faculty. This is because most of the decisions made in the committees are not adopted. It is important to re-align the faculty committees in order to make their existence valid. Appropriate individuals should be assigned to committees whose experience and expertise can be helpful in the outcome. In addition, efforts should be made to ensure that senior members also actively participate in committee work. Typically, junior faculty members are assigned on many committees when they should be given time to establish their teaching and research. Faculty committee responsibilities at SDSU and NU include the following:

Committee responsibilities in Engineering	SDSU	NU

Personnel-tenure (reappointment at NU) and promotion	X	X (also reviews merit increases)
Academic affairs (policy and planning)	X	X
Curriculum	X	(combined with Academic affairs)
Constitution and bylaws		
Honors and awards	X	
Intramural grants committee		
Student learning outcomes assessment committee	X	X
Computer policy committee	X	X
Graduate studies and research programs committee	X	
Computer infrastructure and software committee	X	X
International programs committee	X	(unofficial committee only at this stage)
Student research and scholarship committee	X	

Although NU has fewer fully organized committees in engineering, the much smaller number of full time faculty results in each NU engineering faculty member having significantly more committee responsibilities than counterparts at SDSU. There is no specific resolution of this issue at this time, but potential solutions are being explored as part of a current university project revising faculty policies.

Technology plays a major role in engineering education. Besides the many ways in which it is currently tapped, it can also be used to help reduce the teaching workload. For example faculty members can use podcasting to help students review and understand difficult concepts. Similarly, they can use online simulation tools to help students understand key concepts. Integrating their teaching with such technological tools such as Tablet PC, Blackboard and eCollege, can help them reduce the amount of time they spend in face-to-face interaction with their students. For example, at NU, an 'electronic library' has been set up whereby faculty members can share resources, presentation materials, examples, learning exercises, and other instructional materials. Materials are tagged according to the program and/or course learning outcome(s) they support, so that other faculty searching for ways to assist student learning in specific outcomes can readily find additional ideas and resources. And since many courses have also been developed for on-line presentation (10 of the program in SOET are also available on-line), it is possible for faculty members to also take advantage of the on-line course materials and classroom management tools even when teaching on-site. As a final example, the HP tablet computing research noted above has enabled many faculty to incorporate the use of tablet PCs into their instruction, both on-line and on-site. One engineering faculty member, a recent winner of NU's prized "Teacher of the Year" award exclaimed after using tablets in his classroom for the first time that "… now I can finally teach!"[10]

One other area that has significantly changed faculty responsibilities at NU is related to the role of program lead faculty. Prior to 2002 NU was comprised of three schools: education, business and arts & sciences. The schools of education and business had relatively small numbers of programs with large enrollments (and correspondingly large numbers of faculty) in each

program. So curriculum maintenance, student learning assessment, ensuring program quality, and similar responsibilities were spread among multiple faculty for each program. In the school of arts & sciences some of the programs had smaller numbers of faculty and students, but most were in areas where curriculum changes, textbooks, and other aspects changed more slowly (e.g., history, literature, and so forth). So while fewer faculty were involved with each program, the activities required on an annual basis were fewer. This all began to change as NU added schools of engineering and technology, media and communications, and health and human services. These newer schools had larger numbers of specialized programs, but smaller numbers of students and faculty in each program. And most programs in these fields are based on technologies and materials that change rapidly on an annual basis. This rapid rate of change results in more effort being needed to maintain currency of program curricula, at the same time that this enlarged workload was distributed over fewer faculty per program. So NU is moving actively to support faculty in their lead faculty responsibilities. Some support structures and initiatives include the following:

- Added personnel and functions to the Office of Organizational Research to better assist faculty in collecting and analyzing data needed to assess program quality, student learning, etc.
- Purchased and implemented an electronic tool set (AMS) for faculty to use in organizing and utilizing data for program assessment.
- Created the role of "Assessment Fellows", proving selected faculty having expertise in assessment a full relief of their teaching responsibilities for a year in order that they might be a resource to program lead faculty.
- Increased training opportunities for faculty and staff that may be involved with program or course assessment activities.

These (and other) initiatives are being implemented in order to enable faculty with program lead responsibilities to be effective in their roles while experiencing less stress, time demands, etc.

.**Conclusions and Recommendations**

1. Faculty work must be determined in relation to the mission, objectives, and strategic plans of the university, as well as the mission, goals, and objectives of the department and the school or college.

2. Faculty assignments should embody the principles of consistency and flexibility. Every university expects consistent, high-quality performance from all of its faculty members in the mutually supportive areas of instruction, research, and service. Therefore, faculty assignments should be designed to enable faculty members to contribute to all three areas.

3. Appropriate effort should be extended to achieve flexibility in faculty assignments so that the changing needs of disciplines, departments, and the university are realized.

4. Faculty members' contributions to the university can be maximized by giving them the latitude to explore academic and professional opportunities as they arise,

5. Within a department or school, there should be flexibility in the teaching assignments for individual faculty. Workload assignments should serve the strengths and needs of individual faculty and the department. In a given academic year, some faculty may concentrate more on teaching while others may devote a greater part of their time to research/creative activity and service.

6. Senior faculty should mentor new faculty members to help develop their capabilities for instruction and innovation. They should also guide them in the art of time management so that the new faculty members learn how to make room for educational and scholarship contributions. .

7. A faculty reward system should be in place to encourage faculty to contribute to their fullest potential. This compensation system has to have measurable parameters that can help a committee to objectively determine if a faculty member deserves to receive such an award.

8. The university should encourage faculty members to participate in professional conferences that will enhance their professional growth and further the mission of the university by setting aside internal funds. This will enhance faculty collaboration with other university colleagues to learn about novel methods of teaching, performing research, and service.

9. The university should also review the benefit of every committee established within the university/school to determine if it should continue to exist. The university should also assign more senior faculty members on committees so that junior faculty members can help start their career within the university. Committee should be balanced to include both senior and junior members.

10. The university should also seriously consider the implementation of technology on a regular basis to enhance the effectiveness of teaching.

It would be interesting to survey and collect data on opinions and similar experiences and challenges faced by engineering faculty across the U.S.

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