Report of Academic Program Review of the Mechanical Engineering Department at the University of New Mexico.

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Overview

We were supplied the Department self-study report well in advance of the visit. We met with faculty, students and administrators over the 2-1/2 day period, Feb 15-17. It is regrettable that the Dean of Engineering was not available to answer questions that were critical to our work and to our understanding of the issues, policies and strategic plans of the School of Engineering. Our report is organized by summarizing our findings by constituency. We then address the questions posed by the Deans and the Department, giving both our findings and recommendations in our responses.

The overarching goal of achieving Top 50 US News & World Report ranking.

We embrace and endorse the Department's short term and long term goals, as expressed in the self-study and drawn out over the course of our visit. In particular, we find the department's overarching goal of achieving Top 50 US News & World Report ranking to be a reasonable one. Investing in the Mechanical Engineering department to make it a top 50 department (using aggregate measures of scholarship, productivity, and visibility) is also an investment in the School of Engineering. For example, a survey of the USNWR rankings reveals all top engineering schools also have top Mechanical Engineering departments. The Department's desire to reach its goals for both the undergraduate and graduate programs was therefore the focal point of many of our discussions. In our opinion, the keys to top 50 ranking are (i) a viable ABET-accredited UG program, (ii) a viable PhD program (as distinct from a graduate program with a preponderance of MS students), (iii) a critical mass of research-active faculty in the areas in which the Department has chosen to focus, and (iv) sufficient infrastructural support and staffing required by (i-iii).

Faculty

We met with the Chair for a total of approximately 3 hours, with various tenured faculty during discussions and lab tours, and met separately with the junior faculty for approximately an hour. The faculty was uniformly positive about the Chair's commitment, leadership, mentorship, and ability to create a supportive and positive environment within the Department.

It is generally acknowledged that the Department has both research-active and research-inactive faculty, as measured by a combination of research funding, supervision of graduate students, and papers published in refereed journals. The distinctions and awards to the senior faculty reflect this situation. The senior faculty includes 4 Fellows of the ASME, 1 IEEE Fellow, and a relatively small number of society awards. It is significant that the great majority of Associate and Assistant Professors are research-active. Most of the Associate Professors and all of the Assistant Professors have outstanding potential and are of national or international caliber for their age and rank. The committee commends the Department on its hiring practices in recent years, resulting in an optimistic picture for the future.

The UG curriculum and teaching obligations are well met, but see below for some comments about the frequency of course offerings. The teaching load for research-inactive faculty is 3+3, while that for research-active faculty is 2+2, a number that the team feels is too high. The norm at the very top engineering schools is 1+1 or less and that at institutions comparable to UNM is at most 1+2. Although the Chair has a goal of reducing teaching loads to 1+2 for research-active faculty, it may be difficult to achieve for reasons outlined below.

Research program

Graduate students

We met with a very small number of graduate students so their comments may not be representative. They also commented on the noticeable decline in the number of graduate electives being offered and opined that this may be due to a lower number of adjunct teachers being hired as a result of recent budget cuts. They were aware of the frustrations that the faculty experience in grant administration (see below).

Research areas

The Department has chosen to focus its graduate research program on three core areas of Mechanical Engineering: (in our jargon), Thermalfluids, Mechanics and Materials, and Dynamics and Control. In order to move up in the ratings, the Department will need to have an organized, highly visible, *PhD program* with full-time PhD students in each of these areas. The team considers these areas to be well-chosen and, with critical mass in each, they will enable the Department to move aggressively into new fields and launch new initiatives in exciting areas of research that are aligned with main campus-wide thrusts. Some of this is already in evidence, as demonstrated by the current programs in such emerging fields as:

- Energy – Control and optimization of smart buildings, catalyst synthesis, batteries, advanced materials
- Sustainability – Zero net-energy buildings
- Nanotechnology and nanomaterials – catalyst synthesis, carbon reinforcements, MEMS and NEMS devices

There are also nascent efforts in other fields that show great promise, e.g. in the mechanics of biomaterials involving characterization and optimization of materials such as dental fillings and pharmaceutical coatings, and studies of blood flow and bone mechanics.

Faculty size

The *minimum* critical mass necessary to achieve coherence and visibility that will in turn impact ratings is 5-6 research-active faculty in each of these three areas. Only one of the three (Mechanics and Materials) is considered by the team to be at critical mass. As measured by a combination of research funding and current supervision of graduate students, there are currently 8 faculty who are oriented toward growth in the PhD program. Given the current composition of the faculty, reaching critical mass implies a growth in faculty size over the next 5 years to a total of 22-23 faculty (not counting possible retirements) against a current total of 17. Putting it another way, the Department should be hiring at least one research-active faculty per year. In the section below, we suggest some specific areas in which to focus new hires.

This projected faculty size is also commensurate with the majority of comparison institutions ranked in the top 40-50 programs by US News & World Report: refer to page 43 of the self-study. Unless this serious shortfall in faculty size is addressed, segments of the Department's research programs are in danger of losing viability.

We were apprised of the current policy regarding faculty positions vacated by retirements and separations. It is critical that these be returned to the Department: faculty growth over the next 5 years is absolutely essential to meet the goal of top 50 ranking.

Key areas of opportunity

As the Department moves forward in hiring new, research-active faculty, the team encourages it to think strategically about key areas of opportunity. We suggest three.

The first is in the general area of Energy. With the first revision of US Energy policy in the last 35 years, compounded by the increased awareness of green technologies and global change, there is no doubt that energy efficiency, utilization, storage and retrieval constitute both major challenges and opportunities. In the Southwest this hinges on issues of solar and thermal heating and cooling, energy systems, and zero energy-use smart buildings. These in turn relate to all three of the main research foci of the Department – Thermalfluids for thermal solar, energy storage and retrieval; Dynamics, and Control for control and optimization of energy systems; and Mechanics and Materials for advanced materials for photovoltaics, batteries, and catalytic materials. The Department has recently launched a one-faculty-member effort in building systems. We urge the Department and the administration to build on the momentum, visibility and vision they have already established by considering the authorization of at least 2-3 searches in these areas that will stimulate programs, activity, synergisms, and a possible coupling to the Basic Energy Initiatives of the USDoE and the National Labs.

The second relates to gender balance. There is no doubt that improving the gender balance of engineering faculty is a widely-held objective, but highly qualified women faculty candidates are relatively scarce and competition is stiff. The Department has made one excellent female hire recently and should continue to be vigilant and proactive in pursuing opportunities to hire promising women faculty who have interests that are aligned with the goals and emphases of the research program.

The third area concerns the program in manufacturing an area in which the ME Department also has a potential opportunity. US manufacturing is making a comeback and the $1B investment in manufacturing in the stimulus package will definitely provide a boost to manufacturing research. New science and technologies for manufacturing of nano-scale devices will need to be developed. Companies like Intel are already investing billions in this area. UNM with its proximity to DOE labs and the semiconductor industry has the opportunity to become a major player. Manufacturing Engineering Program (MEP), whose director and many primary researchers are in Mechanical Engineering, already has a significant externally-funded research program (with funding from the State of New Mexico, Department of Energy and National Science Foundation), and the space and infrastructure necessary to have a major impact on Ph.D. education. While the current participation in MEP is mostly from the dynamics and control faculty (Lumia, Starr, and Wood), it is likely that future challenges in manufacturing science will require the active participation from faculty in Thermalfluids and Mechanics and Materials. Indeed there is already some participation from a Mechanics and Materials faculty member (Leseman) at this center connected to MEMS fabrication and charaterization. We suggest that the Department and the MEP discuss ways to leverage existing strengths in manufacturing and move forward aggressively to hire several faculty over the next five years in order to build a PhD research-based program in this general area.

Total funding

Research funding in ME is robust and has shown a significant increase over the last few years. Funding through the ME Department is now approximately $\$1.8 \times 10^6$/year. It is noteworthy that a significant fraction of the research funding and the research-active faculty are concentrated in the junior faculty. ME faculty also participate in the MEP, which is primarily a MS-level program. When expenditures of the ME faculty in the MEP are included (as is appropriate, since this program has a significant number of ME faculty participants and its center of mass is in ME), they total approximately $5 million/year. It is important to continue on that trajectory, maintaining the momentum the Department has built up in recent years.

Graduate student body composition

The majority of graduate students at present are MS as opposed to PhD students. Since the metrics that go into rankings, as well as research productivity and impact, are best maximized by the education of PhD rather than MS students, the team recommends that the effort in graduate recruitment be refocused on PhD student recruitment. A reasonable expectation is that a vital active PhD program will have 2-3 PhD students per research-active faculty. While acknowledging that some fraction of the PhD students will be part-time (e.g. from the National labs), the preferable model is to have the majority of PhD student be full-time and on campus. Assuming a critical mass of 15-18 research-active faculty covering the three research areas, this translates to a PhD student population of 30-50 PhD students in residence. This represents a significant challenge that will have to be met by renewed vigor in graduate recruitment and the availability of resources for outreach and recruitment as well as graduate student research assistantships.

Graduate curriculum

The graduate curriculum at present is unstructured and fragmented, with courses not taught on a regular basis. (When courses do not reach a minimum enrollment, they are cancelled. The fact that this occurs with graduate level courses suggests that the graduate study body is not yet large enough to sustain a curriculum.)With the growth and simultaneous reorientation of the graduate program to emphasize the PhD degree, it will be necessary to build a coherent graduate curriculum consisting of regularly taught core grad courses and high level research-oriented courses in specialty areas. Faculty staffing for the graduate curriculum will have to be accomplished by a combination of reduction of the number or frequency of undergraduate course offerings (see below), efficiencies gained by combining forces with other Departments (see below), and faculty growth.

Undergraduate program

Undergraduate students

We met with a small randomly-chosen cohort of seniors. As a group they were very impressive, articulate, and thoughtful individuals. They were all involved in UG research projects and estimated that 50% of their classmates do some kind of independent projects. They expressed admiration for the faculty and commented on the excellent classroom teaching and rigor of the program. They saw room for improvement in upgrading of the labs, and more hands-on experience.

Undergraduate curriculum

The student body is made up of more part time and more mature students than might be the norm at other institutions. In recognition of this, the average time to degree is approximately 5 years, which we consider appropriate given the demographics. However, the Department has chosen to accommodate this unusual make-up of the student body by offering every required course every term. This places drives up the teaching loads, making it difficult for the Chair to meet the teaching obligations of the Department while simultaneously lowering the teaching loads for research-active faculty. The Department also provides service courses in key areas of UG engineering education at UNM. We recommend that the Department examine this issue carefully and over time reduce these multiple course offerings wherever appropriate. In addition, we encourage the Department to seek alliances with other Departments with the objective of achieving efficiencies by combining course offerings when it makes sense to do so in the core UG courses in engineering.

Facilities

We visited a number of the laboratories for both elective and required lab courses. (Heat Transfer, Fluid Mechanics, Engineering Materials Science, Measurements, LegoRobotics, and Microfabrication). The sophistication and content of the experiments was considered adequate. However, in an unacceptably large number of cases, the equipment and instrumentation is outdated and falls well below the standard expected of an ABET-accredited program. Since this was cited as a deficiency in previous ABET visits, it will be especially critical to have an infusion of funds in order to address the issue this academic year. There is an immediate and pressing need for significant upgrading of all the required laboratories.

Infrastructure and staff support

Space

The space allocation for the Department appeared to us as adequate at present, but of course there will be increasing pressure on space as the Department grows its graduate PhD program, particularly in new areas that require substantial infrastructure, utilities, and high quality space.

Staffing

Administrative staffing at its full complement is adequate, but only barely so. The position of UG/Graduate program assistant has been vacant since the freezing of all open positions. This is an unacceptable situation as it disenfranchises the Department's deserving undergraduate population while simultaneously stymieing any attempt to launch a more vigorous graduate recruitment effort. It is essential that the Department be allowed to fill this position.

The Department is operating the machine shop with a single machinist. His responsibilities include *both* the supervision of ABET-required student machine shop courses *and* providing machine shop services to researchers and PIs within the School of Engineering. The courses involve 20-30 students being present and working in the shop at any given time. It is obvious that this situation is inefficient in terms of splitting time between the specialty machining for researchers and providing the attention required of undergraduates. It also raises potential safety issues, since standard practice (if not the letter of the occupational health and safety laws, e.g., CalOSHA in the State of California) requires two trained professional machinists present at any given time. The Department and the School would be well-served by adding an additional machinist over time.

The Department is currently operating without a trained technician who would normally support the research and teaching labs. This position is the second of two to have been frozen. Given the pressing need to do something about the required undergraduate labs, it is essential that this position be restored. In the long run, the Department will require at least two such technicians, one to support the IT hardware and software needs and the other to support the mechanical and electronic design needs of the Department.

Administration

Research administration

Many of the research-active faculty at all academic ranks we spoke with expressed some dissatisfaction about research administration. Even some advanced graduate students were aware of and had experienced difficulties. In some cases, the level of frustration was very high. There are major issues with the School's and University's administration of research, all the way from preparation of budgets to submission of grant proposals to establishment of post-award internal accounts, and executing of subcontracts. There are bottlenecks at the School level, and there are unacceptable delays and lead times at the Office of Research that makes submission of proposals a long and frustrating process that involves inappropriately large amounts of faculty time. In spite of discussions with the Vice Provost for Research, the Acting Dean of Graduate Studies and the Associate Dean of Engineering, we were not convinced that the central administration understands the seriousness and urgency of the problem and the deleterious effects on faculty morale and initiative in the grant submission process. We suggest instituting a "PI Boot Camp", especially for faculty new to UNM, so that they may learn the ins and outs of the system from the beginning of their careers here.

Budget and planning

The committee acknowledges that UNM is going through a period of reorganization and financial uncertainty and that the central administration is working hard to solve very challenging problems. There is still some way to go in implementation of reorganization plans and communication with the operating units. This has a particularly negative impact on Department Chairs, who have to continue to lead under conditions of great uncertainty regarding their budgets. The team recommends continued efforts to improve communications with the operating units as the institution struggles to achieve financial stability.

Questions, responses and recommendations

1. What curricular or programmatic changes would you recommend to move our undergraduate and graduate programs to a US News and World Report Top 50 ranking?

Team response – The Department may be offering too wide a breadth of course offerings. We recommend a focus of the UG curriculum on ABET outcomes. The practice of offering every required course every term may be part of the tradition of the Department but it comes as a opportunity cost, as it drives a significant fraction of the teaching requirements and hampers the development of a coherent graduate curriculum. In terms of programmatic changes, in order to grow the PhD program, the Department needs to develop a coordinated core of course offerings for PhD students. The Department should consider taking advantage of courses taught by other Departments and eliminating duplications of course offerings in the School in order to support the core and to achieve efficiency. The three focus/thrust research areas within the Department are appropriate.

2. Are the required labs for the undergraduate program adequate?

Team response – The equipment and instrumentation in the required UG labs are outdated and inadequate. The level of technical support is inadequate and the currently vacant technician position should be filled. The content and organization of the laboratory experiments is appropriate and adequate but the lack of acceptable equipment and instrumentation places the Department at serious risk vis-à-vis ABET accreditation.

3. In your view, are there current practices in the ME Department that are impediments to improving our status?

Team response – We do not discern practices that are impediments. The practice of requiring every required UG course every semester represents a significant demand on teaching resources and a conflict between competing Departmental goals: see answer to question 1.

4. Are the focus areas and the size of the graduate student population appropriate for a top 50 ME program?

Team response – The focus areas for growth of the research program are appropriate to a good graduate program. Interactions with other Departments and emerging areas are either established or in the process of being established. This is a very positive trend that should be encouraged and incented. There is a pressing need to bolster the PhD enrollments, which directly influence rankings and to address the current imbalance between MS and PhD enrollments. A reasonable target would be that research-active faculty ought to have at least 2-3 PhD students.

5. Do we have sufficient faculty to support our educational and research missions and become a Top 50 program? If not, what areas would you recommend be strengthened?

Team response – The UG program and education is good, but there are issues of laboratory improvement and technical staffing that may jeopardize the ABET accreditation: loss of accreditation would be catastrophic. The graduate program is in need of strengthening in terms of numbers and quality of PhD students and the addition of research active faculty in at least two of the three core areas.