

Academic Program Review of Mechanical Engineering Program University of New Mexico

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Overall Program Strengths

The APR committee was very impressed with a number of important aspects of the Mechanical Engineering Department at the University of New Mexico. First, junior faculty expressed great enthusiasm about their careers at UNM, and appreciate the institutional support from the administration, senior faculty colleagues, and staff. Undergraduate students appreciate the many choices available in courses and activities and they too feel well-supported to achieve their educational goals. Finally, the leadership at all levels is dynamic, optimistic, and engaged in visioning the future growth in departmental research activities and raising the visibility of the university, college and department. They also appear to have creative solutions to the financial challenges faced by higher educational institutions across the country. These strengths, and others highlighted herein, form a strong foundation for UNM ME to have strong impact and wide visibility in academia and to serve the needs of the State of New Mexico in all of its core missions.

Criterion 1: Student Learning Goals and Outcomes

Overall Findings: Met (M)

Strengths:

- Student learning goals and outcomes are appropriate for training modern mechanical engineers

Weaknesses:

- None

The learning goals for UNM's ME undergraduate students are (1) to prepare students with the background necessary to compete successfully in a global work place, (2) to prepare qualified students for advanced studies, if desired, and (3) to prepare graduates to pursue leadership positions in their profession and communities. To achieve these goals, the department adopts learning outcomes that are aligned with ABET's a-k outcomes as they are measurable. ABET's a-k outcomes call for technical competency as well as the ability to use modern techniques for problem solving, understanding of modern and contemporary issues, and recognition of lifelong learning, and ethics and professionalism.

The undergraduate student representatives that the review committee met appeared to have high degrees of confidence in the education they have been receiving in preparing them for the three learning goals cited above. With regard to their pathways upon graduation, some of the students indicated that they are pursuing the combined accelerated BS/MS program at UNM. Another student has been admitted to a flagship university in another state to pursue his Ph.D. study, while

the others feel prepared and excited to enter the workforce. These students expressed confidence and appreciation for the support the department gave them to achieve their goals.

The graduate programs (both MS and Ph.D.) emphasize critical thinking and in-depth problem solving dovetailed with effective communication. The department presumes that graduate students already have the training and met the learning outcomes that the UNM ME undergraduate program provides from their undergraduate institution since all accredited programs must meet ABET requirements and these requirements are the basis for the UNM ME goals for undergraduate students.

Criterion 1 is met.

Criterion 2: Teaching and Learning: Curriculum

Overall Findings: Met with Concerns (MC)

Strengths:

- Diversity of capstone design projects.
- Students appear to be confident in planning their career goals upon graduation.
- The commitment of the department to offer all required courses every semester.
- The ME graduate curriculum is well conceived.

Weaknesses:

- High student-to-faculty ratio could impact student learning.
- MTTC can be better utilized for stronger educational purposes by ME and SOE.
- Students have limited knowledge of undergraduate research opportunities.

The ME undergraduate curriculum has several strengths. The capstone design class offers a variety of projects, including FSAE (Formula-1 race car design and competition), Solar Splash (a solar-powered boat design project), and Rocket Design, among others that students can choose from. This array of capstone design opportunities, particularly that competition projects are integrated into the curriculum, is rarely seen in other undergraduate ME programs. Students expressed appreciation that the department offers required courses every semester, which facilitates many more viable pathways to timely graduation. It seems that this approach is important for a school like UNM where there are a number of non-traditional students enrolled whose circumstances require a high degree of scheduling flexibility to be successful. The undergraduate student representatives that the review committee met with were confident that the current undergraduate curriculum is successfully preparing them for future pursuits (employment, graduate and/or professional programs).

The ME graduate curriculum is well conceived, requiring a broad range of foundational courses covering mathematics, thermal-fluid sciences, solid mechanics, and dynamics/control to ensure a baseline of knowledge and capability for all Masters and PhD graduates, while also allowing ample opportunities select courses that will deepen their knowledge and expertise in chosen areas. The joint Master of Engineering in Manufacturing Engineering (MEME) program could be coupled with the MBA program for practice-oriented students and practicing engineers.

The high student-to-faculty ratio is a cause for concern in a number of ways. First, as class size is limited to ensure quality instruction, the teaching load of the faculty is much higher than at peer institutions (the standard is 3 courses per year at top 50-75 engineering programs). As a consequence, students receive less personal attention from faculty members outside of the classroom which can be particularly important for students pursuing non-traditional pathways to their degree (as is the case for many students at UNM). The adverse effects of high teaching load for faculty is not limited to instruction as it reduces the time that faculty can allocate to pursue research. It is our understanding that UNM wishes to grow its research enterprise and the overall impact of its graduate program, particularly in engineering. These goals are not possible in the ME department as things currently stand. There are several reasons for this, one of which is the excessive teaching load carried by the ME faculty. The current research environment of acquiring external research funding, recruiting capable graduate students to pursue the funded research and disseminating the work in an increasingly competitive publishing environment requires significant time and effort for faculty success. The current situation in UNM ME is counter to this notion, despite a faculty desire to have successful research programs. Finally, this ceiling on research productivity limits the research opportunities for undergraduate students that might be interested in pursuing advanced degrees and a research-focused career.

The committee's meeting with undergraduate student representatives suggests that many of their peers might not be aware of opportunities to participate in research. They stated that many more EE students than ME participate in undergraduate research, despite a demand from ME students. The department is encouraged to broadly advertise opportunities.

The MEME degree production appears to be small and continues to decline. The role of MTTC in the educational mission of the ME program is unclear; however, it has vast potential to be a source of very strong academic experiences for both undergraduate and graduate students in the ME Department and the School of Engineering.

Criterion 2 is Met with Concerns

Criterion 3: Teaching and Learning: Continuous Improvement
Overall Findings: Met* (M)

Strengths:

- New assessment process is well conceived.

Weaknesses:

- Faculty commitment and buy-in to assessment and continuous improvement is important.

Since the ABET visit in 2017, the department has put in place a well-conceived assessment process, with the results to be reported in the future. It is clear that the department is dedicated to ensuring the continuous improvement process for the undergraduate curriculum leads to on-going refinement of the courses in the curriculum to ensure student learning effectiveness. The

rubrics for MS and Ph.D. program outcomes are well designed, though the continuous improvement process for these programs is not described. Perhaps it can follow the same process as for the undergraduate program. Regardless of degree level, it is imperative for the faculty to buy in to and be involved in continuous improvement exercises.

Criterion 3 is Met with one caveat (hence the asterisk above): Given the recent implementation of a new assessment approach, the department needs to have this to come full circle in terms of effective assessment and determination and execution of adjustments to the curriculum in response to assessment results.

Criterion 4: Students

Overall Findings: Met

Strengths:

- Students are satisfied with advising.
- Recent opportunities to hire faculty/lecturers will enable the department to begin addressing significant enrollment growth to achieve an appropriate student-to-faculty ratio
- Graduate degree production is stable.

Weaknesses:

- A more coordinated effort between faculty and advising staff would further improve student advising.

The department has a large undergraduate student population, with Fall 2017 enrollment reported as 586 undergraduate students. The department has experienced significant enrollment growth with the undergraduate student body increasing by more than 60% between 2006 and 2015 (before the SOE started assigning pre-majors to individual departments). With 14 regular faculty, the undergraduate student-to-faculty ratio is greater than 40:1, which is higher than ME departments in most peer institutions. The department has begun to address the significant enrollment growth by hiring additional faculty to reduce the student-to-faculty ratio. The department also has about 80 graduate students (53 masters and 30 PhD) and these numbers have been steadier over the past decade. Undergraduate degree production has risen with enrollment, and graduate degree production is stable.

Student advising is performed by both advising staff and faculty. The department has two advising staff; one has been in the department and the other is new. Because of the large number of undergraduate students, all of the faculty participate in advising. The students expressed satisfaction with the advising process. However, advising staff reported that sometimes advising discussions between faculty and students were not effectively relayed to the advising staff who might be tasked with executing decisions made in student-faculty advising meetings, resulting in some confusion. A more coordinated effort between faculty and advising staff would further improve student advising.

Overall, students were satisfied with the department and the education they were receiving, and felt they were getting the support they needed to achieve their goals. They thought that there is a

good variety of choices in electives and activities within the department. They appreciated the variety of choices available for the senior design project. They did note that fewer students participate in undergraduate research than some of the other departments in engineering, and felt that this might be due to a lack of awareness among students about the research choices that were available. The students suggested some sort of event to make students more aware of research opportunities.

Criterion 4 is met.

Criterion 5: Faculty

Overall Findings: Met with Concerns (MC)

Strengths:

- Faculty are strongly committed to their education and research missions.
- Reduced teaching load for junior faculty.
- Junior faculty are satisfied with mentoring.
- Recent faculty hires show great promise.

Weaknesses:

- The high student-to-faculty ratio likely adversely impacts all aspects of faculty productivity and student learning.

The department's 14 faculty are strongly committed to their education, research and service missions. The faculty that met with the APR committee all appeared to be satisfied with the situation in the department. Junior faculty indicated they were well supported by the department, and appreciated the reduced teaching load that allowed them to focus their early years at UNM to developing strong research programs. The junior faculty indicated they are satisfied with the mentoring they receive. The research productivity of one junior faculty member was being hindered by the lack of a suitable laboratory for his use, which is a concern considering the high expectations for junior faculty to develop strong research programs in an increasingly competitive scholarly environment.

The most significant concern with respect to the faculty is the relatively small faculty body for a student population of this size. A lack of faculty critical mass leads to larger teaching loads and a high student-to-faculty ratio, which likely has a negative impact on virtually all aspects of faculty productivity. The heavy load on the faculty may adversely impact student learning as well, although there wasn't evidence of decreased student learning during the site visit. The recent faculty hires show promise to relieve some of the heavy load on the faculty, but additional hires of both tenure-track and teaching faculty must be made to bring teaching loads and the student-to-faculty ratio in line with peer institutions.

Criterion 5 is Met with Concerns.

Criterion 6: Resources and Planning
Overall Findings: Met with Concerns (MC)

Strengths:

- Opportunity to hire faculty will enable long-term strategic planning.

Weaknesses:

- Appointment of a permanent chair is needed for vision and stability.
- Stronger communication among department constituents would improve faculty and staff productivity and student experiences.
- Staff turnover rate is high.
- Appropriate laboratory space for faculty.

The department currently does not have a permanent department chair, which hampers long term strategic planning and stability. The current interim chair appears to be an effective leader but appointment of a permanent chair is needed for vision and stability. In addition, the opportunity to hire additional faculty to reduce the student-to-faculty ratio will enable long-term strategic planning and execution.

The department has been suffering from high turnover of staff. Some of this turnover may be related to frustration with job responsibilities. Stronger communication among department constituents would improve faculty and staff productivity and student experiences.

The ME Building is showing its age, and some of the laboratory space available to faculty for conducting research appeared to be in need of improvement. In particular, one junior faculty member who was hired in September did not have laboratory space suitable for him to develop a research program in his area of expertise, despite his tenure clock having started in fall.

Criterion 6 is Met with Concerns.

Criterion 7: Facilities
Overall Findings: Met with Concerns (MC)

Strengths:

- Funding and space for FSAE laboratory.
- Unique ME Building attributes can provide student learning experiences.

Weaknesses:

- Safety in teaching and research laboratories will protect faculty, students, and staff.
- Some instructional laboratories are small, which could limit effectiveness of teaching.
- Appropriate laboratory space for faculty.

All departmental teaching, research, faculty and staff space is currently housed in the Mechanical Engineering Building. Until recently, the Chemical Engineering Department was also housed in this space due to renovations in other buildings. Even after they left the ME Building, the ME

department is in desperate need of both space relief and modernized space to ensure that the department can meet its teaching and research missions. The FSAE program is a very unique cornerstone of the department, both from an educational perspective and as a high-visibility activity that showcases the immense talent of the ME students. Given its importance, it is excellent to hear that this program will receive modern space in the basement of Ferris Engineering Center due to generous benefaction from alumni. Not only will this serve to showcase this program and likely allow it to become even more competitive on the national stage, but this move will also free up a bit of space in the ME Building. Finally, the ME Building has unique attributes (solar and energy efficiency, for example) that could provide unique student learning experiences.

A few teaching and research laboratories were toured as a part of the APR review. In general, the instructional labs are small and thus ill-suited to handle the high undergraduate student enrollments in the department. In addition, the experimental and computational infrastructure in the instructional labs was not on par with that seen at peer institutions. Coupling the high enrollments with a lack of suitable, modern lab experiences with enough repetition in experiences to allow small-student groups to work together could severely degrade the effectiveness of instructional laboratory activities and thus adversely impact student learning.

With regard to research laboratories, it was clear that the current space was not sufficient to support faculty research programs. One junior faculty member still did not have a usable lab space despite beginning his tenure track appointment in fall 2017. Other faculty indicated that a lack of modern research space has limited the growth of their research portfolios because they do not have the space nor infrastructure to support such endeavors.

Finally, safety in laboratory spaces (both teaching and research) was a discussion point with multiple departmental constituents. Visits to teaching and research labs, coupled by concerns related to consistency in following appropriate safety measures (and mixed commitment by faculty to enforce such requirements in their own research laboratories), highlights a need to revisit how safety measures are developed and implemented in the department. One lab contained equipment that required proper ventilation and so the window was used for this purpose. This is an example of an unsustainable approach to safety. Establishing expectations in this regard is critical for everyone's safety.

Criterion 7 is Met with Concerns.

Criterion 8: Peer Comparisons

Overall Findings: Met with Concerns (MC)

Strengths:

- Unique diversity of capstone design experiences.

Weaknesses:

- Student-to-faculty ratio exceeds that of peers.

Comments on comparisons to peers appear in multiple criteria discussed above. Before addressing specific comparisons, the APR committee thought that the department should re-think who they consider as peers. Peers need not simply constitute institutions that are geographically close. They should be chosen to reflect key similarities in mission, operational structure (state schools instead of private), enrollment, economic and social diversity (the ME department has a large number of non-traditional students that it serves), etc. In this regard, places like Texas A&M, U. Texas Austin, Arizona State, and others of similar ilk cannot be considered peers for evaluative purposes. Such comparisons will yield few if any insights into addressing challenges at UNM and frankly could reduce faculty, student and staff morale if such comparisons are made. Rather, schools like Texas Tech, U. Kansas, U. California-Riverside, New Mexico State, etc. would serve as excellent peers against which UNM ME could benchmark. In what follows, the APR committee removed peers deemed as inappropriate peers for benchmarking purposes.

The UNM ME Department's cornerstone co-curricular activities (like FSAE, Solar Splash and Rocket Design) is unique compared to most other mechanical engineering departments across the country, even the most highly ranked ones. These student programs provide students with unique experience that is undoubtedly helpful on the job market. The School of Engineering's support of these activities is vital for UNM to maintain this unique attribute compared to its peers. UNM, in general, is also in a unique position given its close proximity to Los Alamos National Laboratory, Sandia National Laboratories and the Air Force Research Lab. It is understood that UNM, and the School of Engineering in particular, has tried to forge productive research relationships with these entities. It was heartening to hear from the Engineering Dean that he has new ideas on how to more fully maximize the vast potential of relationships with these high-quality research entities, including programs that would have positive impact on UNM's teaching mission. This proximity, and relationships formed because of this, is another very unique and positive attribute for UNM ME and for UNM in general.

There are also a number of critical areas for which UNM ME Department does not compare favorably to its peers. The first is student-to-faculty ratio where the department is currently 40:1 and peers sit anywhere between 20-30:1. This issue is clearly tied to a lack of faculty for the number of students being serviced. UC-Riverside, for example, has a similar number of undergraduate students yet 22 faculty (compared to 14 in UNM ME). Same with U. Kansas who has 21 faculty members to service 495 undergraduate students. Even for programs with larger numbers of undergraduate students (U. Houston has 964 students), the faculty size is commensurate with the student population (Houston has 29 faculty). Not surprisingly, these institutions have higher graduate enrollments, even when scaled by faculty size, because a lower student-to-faculty ratio implies lower teaching load compared to UNM ME and thus higher research productivity on the part of the faculty. Finally, though not detailed in the department report, the APR review committee members have visited many of the relevant peer institutions for seminar visits, reviews, etc. and it is apparent that the UNM ME facilities and infrastructure is not on par with many of these institutions. People (i.e., faculty and staff) and infrastructure (space and facilities for teaching and research) are the two foundational pillars for academic success and UNM ME is behind its peers in both of these key aspects.

Criterion 8 is Met with Concerns.