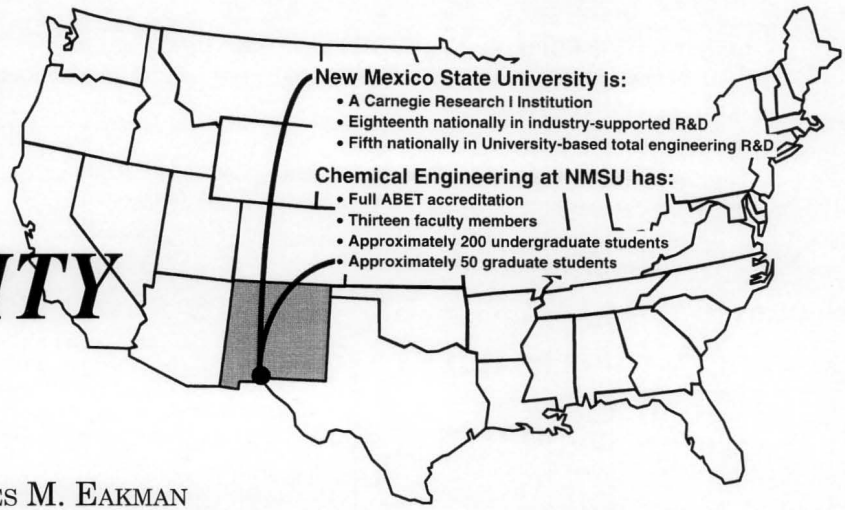
ChE department

Chemical Engineering at . . .

NEW MEXICO STATE UNIVERSITY



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New Mexico State University • Las Cruces, NM 88003

Responding to the growing needs of the burgeoning Southwest, in 1924 the Board of Regents at New Mexico State University (NMSU) decided to institute a curriculum in chemical engineering. The first assistant professor of chemical engineering arrived on campus in 1926 and the Department of Chemical Engineering was formed in 1944, making it New Mexico's oldest chemical engineering department.

A department is partially defined by the success of its graduates, and ours have had success in a variety of fields. One of the first graduates, Bruce Sage, went on to become a professor at Cal Tech and established an international reputation in thermodynamics. Another of our graduates, Robert Davis, became President of Chevron Chemical Company, and yet another alumni, Charles Johnson, is probably the only PhD chemical engineer ever to quarterback a National Football League team.

Las Cruces is New Mexico's second largest city and has a population of about 65,000. Situated at one of the United States' major gateways to Latin America, NMSU is thirty-five miles from the border cities of El Paso, Texas, and Ciudad Juarez, Mexico. The area has a combined population of over two million.

The Department's location capitalizes on the strengths of national research facilities in New Mexico, including Sandia National Laboratory, Los Alamos National Laboratory, White Sands Missile Range, the Air Force Phillips Laboratory, the NASA White Sands Test Facility, and the Army Atmospheric Science Laboratory. The Department has helped NMSU earn the distinction of being designated as

- *A Carnegie Research I institution*
- *Third in the nation in NASA research and development (R&D) expenditures*
- *Fifth among the nation's universities in university-based engineering R&D expenditures, as ranked by the American Society for Engineering Education in 1992*
- *Eighteenth among the nation's universities in industry-funded R&D*

Recent trends in the Department show growth in student population (see Figure 1), number of faculty, and levels of research funding. Since 1988, the undergraduate student enrollment has increased almost 150% to its current level of 198 students. During the same period, the graduate student enrollment also increased to 29 Master's and 19 Doctoral candidates. As the Department has grown and changed over the years, scholarly research has also significantly increased.

Underpinning our approach to undergraduate education is a firm commitment to providing a quality program with fundamental science and engineering principles integrated into a curriculum-wide emphasis on design and creative problem solving.

UNDERGRADUATE PROGRAM

During its formative years, the Department developed an educational philosophy focused on the students' needs and on preparing them for a variety of careers. Underpinning our approach to undergraduate education is a firm commitment to providing a quality program with fundamental science and engineering principles integrated into a curriculum-wide emphasis on design and creative problem solving. Thus, during the first two years, in addition to twelve semester credits of mathematics, sixteen credits of chemistry, and six credits of physics, NMSU chemical engineering students take an additional nineteen credits of engineering science and design. Of these credits, ten are from the Chemical Engineering Department while the others build a broader engineering knowledge in statics, dynamics, and circuits.

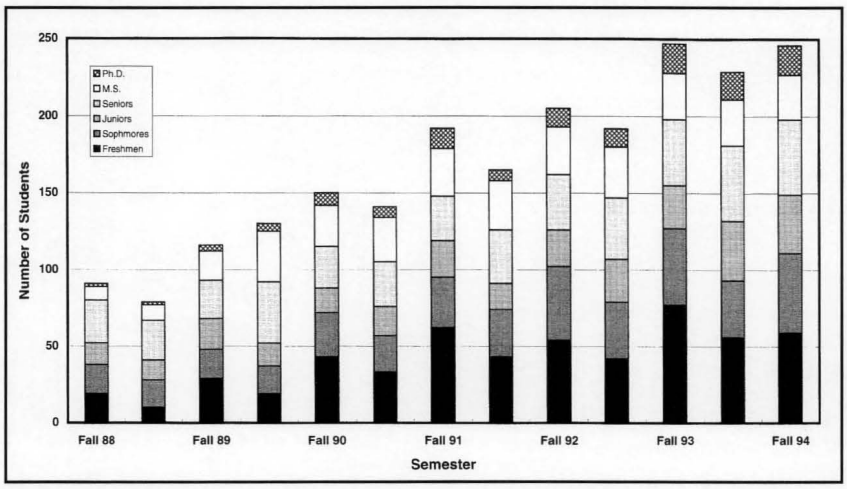


Figure 1. *Climbing enrollments demonstrate the department's quality and concern for student well being.*

The first two years of chemical engineering classes are structured to develop the students' problem-solving skills and to provide a sound basis in mass and energy balances in addition to computer programming and applications. In fact, computer skills are introduced in the very first class and are continually developed throughout the four-year program. Early in the program, the students gain experience with standard PC-based software (including graphics packages, spreadsheets, and word processors), high-level language programming in C, a symbolic equations processors, and an introduction to the Aspen Plus® process simulator.

During the junior and senior years, classes focus on the traditional foundation of chemical engineering and also provide opportunities for the students to explore the emerging frontiers of our discipline. Thermodynamics, transport phenomena, staged operations, engineering materials, and a chemical engineering instrumentation laboratory are all taught during the junior year. During the senior year, reaction kinetics, process control (including a laboratory for hands-on experience in closed-loop computer control of interacting systems), engineering economics, and two additional laboratories are taught. Three chemistry classes (physical chemistry and two electives) are also a part of the student's final year. Engineering electives taken in the last two years come from areas as diverse as advanced materials, biochemical engineering, computer-aided engineering, environmental science and engineering, food science, and waste management.

We do not believe, however, that providing only the fundamentals will truly develop a student's full potential. We have therefore integrated open-ended design problems throughout the curriculum, culminating in two capstone process design courses (one each semester during the senior year) within the core curriculum. The first capstone design course is fairly traditional, using individual, small-group, and large-group design projects. The second design course uses the annual American Institute of Chemical Engineers (AIChE) design problem with all its accompanying rules and regulations, including the thirty-day time limit, as a final exercise in individual design. These design projects include the typical process development and refinement stages, but in recognition of the changing roles and responsibilities of chemical engineers, they also include significant emphasis on ethics, environmental, safety, and health issues. This emphasis is also reflected in the nationally used safety manual coauthored by a department member.[1]

Significant courses are also taken in composition, communication skills, and technical writing. Reflecting our value on communication, a writing guide coauthored by a faculty member[2] is used throughout the curriculum as a model for all written work. Completing the student's coursework are classes establishing both a breadth and depth in the humani-

ties and social sciences.

Co-op, internship, and summer employment programs are also strongly supported and encouraged by the Department. We feel that, in today's marketplace, a graduating senior with relevant work experience is more employable than one without such experience. Therefore, our courses are scheduled so having a co-op, intern, or other industrial position has a minimal effect on the student's graduation date.

Students completing this curriculum have been trained to be practical, problem-solving engineers ready to contribute to industry or to continue their education at the graduate level. Many of our students have been nationally recognized for their excellence. AIChE-sponsored awards won by NMSU in recent years include:

- Mark Montoya: First Place, AIChE National Student Design Competition (1988)
- Michelle Fullerton: Honorable Mention, AIChE National Student Design Competition (1992)
- Kathy McKinney: Marx Isaac's Award for the Best Student Published Newspaper, AIChE (1992)
- Karol Holmes: First Place-Environmental Division, AIChE Annual Meeting Student Poster Session (1992)
- Richard Blauw: Marx Isaac's Award for the Best Student Published Newspaper, AIChE (1994)

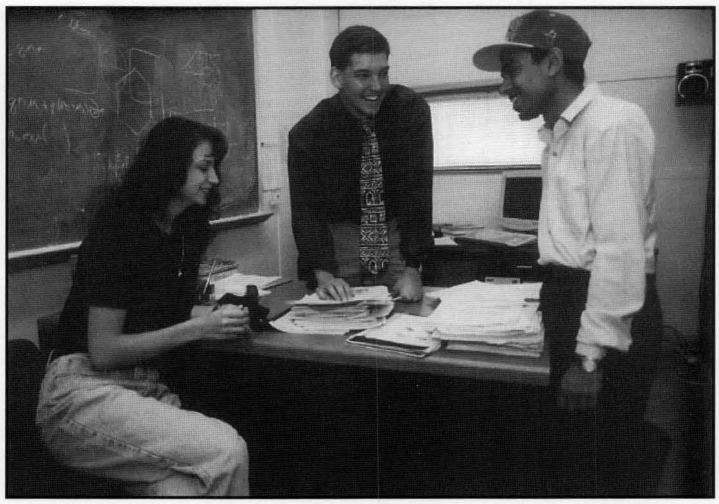
GRADUATE PROGRAMS

NMSU offers both Master's of Science in Chemical Engineering and Doctor of Philosophy graduate degrees, and we currently have 29 and 18 students enrolled in those programs, respectively.

The goals of the Master's program are threefold:

- To increase the student's understanding of chemical engineering fundamentals
- To deepen the student's knowledge within a specialized area of chemical engineering
- To broaden the student's knowledge in basic science and engineering

These goals are achieved by a combination of required courses, elective courses, and independent thesis research. The required courses are in thermodynamics, transport phenomena, reaction kinetics, and advanced engineering analysis. Elective courses come from the areas listed above for the undergraduate program and also from outside the department and the college. Popular courses outside the college are taught by the chemistry and biochemistry, the experimental statistics, the mathematics, and the physics departments. The research topics are given in a subsequent section in this paper.



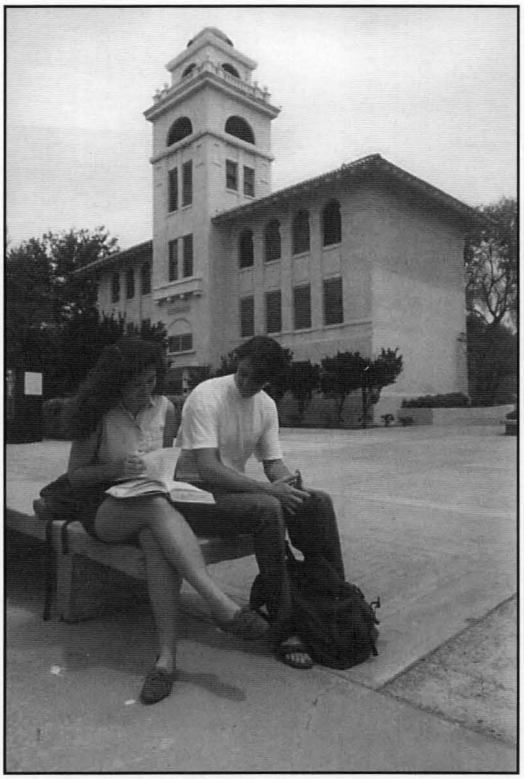
Individualized help outside the classroom is available from all faculty members. (Shown, left to right: Janice Jenks, Dr. Mark Montoya, and Aijaz Ali.)

Computer-aided design and process simulation using ASPEN PLUS™ is introduced at the freshman level. (Shown, left to right: Stephen Stocke, Dr. Stuart H. Munson-McGee, Kimber Rawdon, and Khaled Al Hajeri.)

The program's design emphasis includes the opportunity to participate in the Waste-Management Education and Research Consortium (WERC) sponsored annual international design contest. (Shown: David Garcia.)

The goals of the Doctoral program are to develop expertise within a field of chemical engineering, breadth in advanced engineering topics, an ability to conduct independent research, and an aptitude for identifying significant research issues. The Doctoral candidate is not formally admitted to candidacy until after passing both a qualifying examination and a comprehensive exam. The first exam, usually taken after the first semester, covers the fundamentals of chemical engineering practice, including thermodynamics, transport and unit operations, reaction kinetics, and engineering design and economics. The comprehensive examination, usually taken nine to twelve months after the qualifying exam, focuses on the candidate's proposed research—it's scope, objectives, and justification. During this time, the required coursework is also being completed through courses selected with the approval of the candidate's advisor.

Once the qualifying exam has been passed, candidates focus on their research. These projects are tailored to the interests of the students such that the scope of the research satisfies both the requirements for the degree (specifically, originality and a combination of both theoretical and experimental work) and the requirements of the funding agency. Frequently, the candidate is able to significantly influence the direction of the research based on knowledge gained while preparing for the comprehensive exam.



An early-April afternoon finds students Rae Ann Boisvert and Britt Brownfield outside historic Goddard Hall.

FACULTY

NMSU has eight full-time tenured and tenure-track faculty positions. The current faculty members, the year they came to NMSU, and the areas of their research interest are:

- **Ron K. Bhada**; 1988; environmental engineering, waste management, pollution control, energy conversion
- **James M. Eakman**; 1993; computer-aided design, particle technology, environmental engineering, reaction engineering
- **Richard L. Long;** 1981; transport phenomena, bioengineering, environmental engineering, separations
- **Stuart H. Munson-McGee;** 1991; advanced materials, composites, environmental engineering, experimental techniques
- **Mark Montoya;** 1994; advanced materials, modeling and simulation, statistical thermodynamics

The faculty will shortly be increased by three new members. **Sarah Harcum** (from the Food and Drug Administration's Center for Biologics Evaluation and Research) will be joining the faculty this summer to enhance our bioengineering research program. **David Rockstraw** (from Conoco/DuPont) has accepted an offer for an Assistant Professor position and will join us for the fall 1995 semester, and we are conducting an international search for a third candidate whom we hope to have aboard by the spring 1996 semester.

In addition to the faculty listed above, additional expertise is brought to the department by our emeriti (**J. Patton, R. Roubick, and E. Thode**) and research (referred to as "College") faculty members (**F. Del Valle** and **S. Holbrook**). Assistant Dean **Joe Creed** also actively participates in the department's laboratory teaching program, and **Paul Anderson,** taking his sabbatical from Purdue University, is currently teaching the freshman computer programming class and developing research topics in improved mass transfer in electrochemical reactions using a rotating disk electrode.

Our faculty has an unusual wealth of industrial experience. Only two of the faculty joined NMSU without at least four years of industrial experience, and the faculty average of eleven years of industrial experience enables us to explain to our students the need for mastering the subjects within the curriculum and to examine the role that knowledge will play in their future jobs.

RESEARCH PROGRAMS

Research at NMSU is conducted by students at all levels: undergraduates, Master's candidates, and Doctoral candidates. An important component of this research is that the students each have their own project, regardless of their level, tailored to their abilities and interests. Thus, we do not have students who are "dishwashers" for more advanced students.

Table 1 lists some selected titles from current student research. These projects are being supported by over $565,000 this year in research contracts and grants. This funding has

grown 46% in the last year and is expected to continue to grow at this rate as new faculty members come on board.

INTERDISCIPLINARY PROGRAMS

In recognition of the changing roles of chemical engineers, the evolving interdisciplinary teamwork is also strongly reflected in the department's research and education projects. In particular, four broad areas have been identified as critical to the future of the department: environmental engineering, advanced materials, food engineering, and bioengineering.

The environmental program is led by Ron Bhada, Associate Dean and Director of the Waste-Management Education and Research Consortium (WERC). This consortium, funded principally by the Department of Energy, includes Los Alamos and Sandia National Laboratories, the state's research universities (NMSU, University of New Mexico, and New Mexico Institute of Mining Technology), many of the state's junior colleges, and private industry. This $13 million/year program supports a wide variety of research, education, outreach, and technology transfer programs across many academic disciplines, including chemical engineering, chemistry, civil engineering, mechanical engineering, biology, public policy, and government affairs, among others.

The second major interdisciplinary program within the department focuses on advanced materials, including composites, liquid metals, ceramics, and polymers. The research and education are broad-based. Topics cover new manufacturing technologies to long-term (20 year) performance and range from technology demonstration to theoretical studies. Headed by Stuart Munson-McGee and Mark Montoya, this program includes members from the chemical, mechanical, and civil engineering departments as well as from engineering technology.

The food engineering program, a collaborative effort with the College of Agriculture, is growing from a foundation placed by Francisco Del Valle. The program is poised to grow significantly as the agricultural industry in southern New Mexico shifts from selling raw produce to out-of-state processors to more in-state processing. This effort will focus especially on regional commodities such as dairy products, chilies, pecans, cotton, onions, and other truck-farm items. One of the unexpected results of this program is a developing collaboration between the food engineers and the materials scientists resulting from the significant similarities between the two disciplines. For example, both can involve similar process technologies (such as extrusion).

The department has a vigorous research program in biochemical engineering focusing on optimization of recombinant systems being led by Sarah Harcum. Previous research projects have included scale-up of xanthan gum and acetic acid fermentation, waste-water treatment using novel biological reactors, experiments in high-pressure fermentation, and the theoretical modeling of biological processes such as human muscle contraction/extension. Contributions to interdisciplinary projects have included algae cultivation for wastewater treatment and as a food additive with the Chemistry Department, and development of control systems for growth chambers with Biology. Currently, the department operates a 75-liter fermenter in cooperation with Chemistry and has a fully operational microbiological laboratory.

FACILITIES

The department's educational facilities are adequate for our current teaching load. We have a variety of experiments that the undergraduate students can conduct (see Table 2). The research laboratories strongly reflect the needs and interests of the faculty

TABLE 1

Selected Current Research Topics and Principal Investigators

- Analysis of a Liquid-Liquid Extraction Process Using a Two-Phase, Plug-Flow Recycle Reactor • *R. Long*
- Aspen Plus Flowsheet Models for Waste Cleanup Processes • *J. Eakman*
- Calculation of Liquid-Vapor Equilibrium for Metallic Systems • *M. Montoya*
- Calculation of Thermodynamic and Transport Properties Using Molecular Dynamics and Monte Carlo Methods • *M. Montoya*
- Coupling of ATP Hydrolysis with Mechanical Work in Muscles • *R. Long*
- Dirac Delta Function Approximations in the Kernel Method • *R. Long*
- Encapsulation of Hazardous Wastes • *S. Munson-McGee*
- Estimation of Kinetic Parameters from Multi-Reactor, Multi-Response Data • *J. Eakman*
- Experimental and Theoretical Studies of Magnetic Materials Processing and Synthesis • *M. Montoya, S. Munson-McGee*
- Fundamental Behavior of Fluidized Beds with Broad Particle Size Distributions • *J. Eakman*
- Kinetics and Thermodynamics of the Combustion of Chlorinated Hydrocarbon Mixtures • *S. Holbrook*
- Mass Transfer in the Laminar Ripple Flow of the Conical, Centrifugal Film Reactor • *R. Long*
- Mass Transport in Bubble Column Reactors • *S. Holbrook*
- Multivariable Control of Continuous Processes • *C. Skowlund*
- Performance of Conducting Ceramics in Acidic Environments • *S. Munson-McGee*
- Probability Density Function Model of Concentration Fluctuations Over Kuwait Oil Fires • *R. Long*
- Removal of Condensable Acidic Gases and Entrained Droplets from Digester Exhaust Gases • *S. Holbrook*
- Robust Control of Batch Processes • *C. Skowlund*
- Theoretical Study of Liquid Phase Atomic Structure • *M. Montoya*

with each faculty member or group equipping his or her laboratory in the most suitable manner. For computing requirements, the department has its own state-of-the-art PC cluster with a variety of educational software as well as common commercial software applications. In addition, a network of ten UNIX workstations is being installed in the department. At the University level, our students have access to several campus mainframes as well as a CRAY® supercomputer.

FUTURE PLANS

In the coming few years the department will continue its excellence in engineering education and to do so is undertaking three major projects that will effect the entire program:

- Expansion and renovation of Jett Hall
- Facilities enhancement
- Distance learning using instructional television

The department is currently housed in approximately 15,300 square feet in Jett Hall. The space includes offices, teaching and research laboratories, and shops as well as classrooms. The New Mexico legislature has approved a new engineering building at NMSU, and when it is completed in 1997 additional space will become available in Jett Hall, nearly doubling the department's present square footage. Plans are already well underway to renovate and modernize these expanded facilities.

As part of the expansion, we are aggressively pursuing upgrading our basic teaching laboratories. In particular, new unit operations (including an industrial pilot-scale distillation column with interchangeable tray and packing sections, and a computer data acquisition and control system integrated throughout the department's laboratories) and reaction engineering laboratories are being planned. With the assistance of our Industrial Advisory Board, these experiments are being designed to give our students an understanding of the basic principles involved and also to give them a taste of the types of facilities that may be available to them after graduation. Furthermore, the Advisory Board in assisting us in acquisition of the new equipment and software.

One characteristic of New Mexico that significantly effects our secondary and post-secondary education is our great geographic proportions combined with a small population. In fact, New Mexico's population of 1.54 million covers 122,000 square miles—to have the same population density, New York city's population would have to be spread over an area greater than the fourteen Atlantic Coast states plus Ohio, Pennsylvania, West Virginia, Kentucky, Tennessee, and Alabama (*e.g.,* the eastern sixth of the United States)!

Effectively reaching this population requires that we use the tools and methodologies of distance learning to the fullest extent possible. The department is currently offering graduate-level courses by instructional television. One of the four graduate core courses is offered each semester in a cycle that repeats every two years. A minimum of one additional graduate course is also offered each semester. This method has proven to be very effective in delivering graduate instruction to Masters and PhD candidates with full-time employment at widespread locations.

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TABLE 2
Experiments that Enhance Undergraduate's Understanding of Basic ChE Principles and Practice

- *Basic Principles of Chemical Engineering*
  - Computer-aided data acquisition
  - Physical and rheological property measurement
  - Excessive properties of mixing
  - Fluid flow
  - Transient heat transfer
- *Unit Operations Experiments*
  - Fluid mixing
  - Characteristic behavior of pumps
  - Co-current and counter-current heat exchange
  - Batch reaction
  - Residence time distribution
- *Staged Operations Experiments*
  - Fractional distillation
  - Packed tower performance

SUMMARY

New Mexico State University's chemical engineering program is based on a tradition of building strong fundamental skills, but also has additional emphasis on design and open-ended problem solving throughout the curriculum. Our students, who have won a number of national awards, are recognized for their common sense and their practical approach to solving engineering problems. Our faculty has a strong industrial background that brings a realistic perspective to the classroom and laboratory. The department's camaraderie is based on our genuine concern for the students' educational and professional development. Research within the department is varied and research expenditures are growing as we explore both the traditional and nontraditional fields of chemical engineering. As the future beckons, we anticipate continued growth and evolution to meet the demands of a changing profession.

REFERENCES

1. Whitmyre, G., and R.L. Long, *Guide to Safety in the Laboratory for Chemical Engineers* (1987)
2. Long, R.L., B. Barna, C.W. Bridges, A. Rakow, and D.B. Wilson, *Guide to Writing and Problem Solving for Chemical Engineers* (1985) ❐