ChE department

Chemical Engineering at . . .

The University of North Dakota

Harrington Hall is home to the ChE department's offices and laboratories.

Founded by the Dakota Territorial Assembly in 1883—six years before statehood—the University of North Dakota (UND) has remained a university with a strong liberal arts foundation surrounded by a variety of professional and specialized programs. UND is one of only 47 public universities in the nation with accredited graduate schools of both law and medicine, and is regarded as a national leader in rural and family health issues, aerospace, energy and environmental research, and educational programs for American Indians. Recognized for its extensive programming for native peoples, UND has more than 30 academic programs for American Indians. For example, 20% of American Indian doctors in the country were trained at UND through the Indians Into Medicine program (INMED).

The university's 292 tenured and 207 tenure-track faculty mentor more than 13,000 on-campus students and 21,000 distance-education and continuing-enrollment students in 193 fields of study from baccalaureate through doctoral and professional degrees. Fifty-one percent come from North Dakota; the rest represent all other states, seven Canadian provinces, and more than 50 other countries. UND is located in Grand Forks, a college town of 50,000 on the Red River of the North separating North Dakota and Minnesota. The campus includes 223 buildings (5.33 million square feet under roof) on 549 acres.

THE COLLEGE

Engineering programs began at UND in 1889 and the School of Engineering and Mines (SEM) was formed in 1916. SEM faculty instruct more than 1,000 students through programs administered by the departments of Chemical Engineering, Civil Engineering, Electrical Engineering, Geology and Geological Engineering, and Mechanical Engineering. Bachelor's and master's degrees are offered in chemical, civil, electrical, geological, and mechanical engineering, as well as in geology. Additional graduate degrees include master's degrees in environmental engineering and sustainable energy engineering plus doctorates in engineering (with specialty tracks), chemical engineering, and geology. SEM further provides its ABET-accredited engineering programs via distance education to industry and individuals through a Distance Engineering Degree Program (DEDP).

THE DEPARTMENT'S HISTORY

The Department of Chemical Engineering was established in 1926 and the first degree, an M.S.ChE, was awarded in 1928. The department has a five-year average undergraduate enrollment of 92 resident and 21 distance undergraduates per year with a Fall 2009 enrollment count of 122 and 35 resident and distance undergraduates, respectively. The graduate-student population grew substantially in the mid-2000s

to a current stable size of around 35 per year. See Table 1 for historical highlights.

Transfer students are a significant portion of our students—around 10%. We encourage this source of students by providing customized programs of study for transfer students that are shared with guidance counselors and chemistry professors at the community and four-year colleges in our region. We have also assisted regional two-year colleges in establishing pre-ChE programs. The key is our willingness to provide access to our introductory freshman course (ChE 102) and our sophomore fundamentals course (ChE 201) using distance techniques. This allows two-year transfers to enter into our junior-year curriculum. Formal agreements have been or are being put into place to establish formal Pre-Chemical Engineering programs at Minot State University (ND), Itasca Community College (MN), Hibbing Community College (MN), Minnesota State Moorhead, North Dakota State College of Science, Turtle Mountain Community College (a North Dakota tribal college), and Benedictine College (KS).

OUR MISSION STATEMENT

It is our vision to offer an unsurpassed, personal, undergraduate chemical engineering education, coupled with a top-tier-quality, research-centered graduate program. The department's primary objective is the education of undergraduate students so that, upon graduation, they are prepared to take responsible, entry-level positions in a wide range of industries. Research and professional activities by members of the faculty, conducted in collaboration with graduate and undergraduate students, provide training for our students on how to succeed as researchers.

EDUCATIONAL OBJECTIVES

The Chemical Engineering program prepares graduates who, in their professional careers:

1. *Have the knowledge and skills required to analyze and solve problems related to the field of chemical engineering and communicate these results in verbal and written form to a diverse audience.*

TABLE 1
The University of North Dakota Chemical Engineering Department — Historical Highlights

1889	College of Mines and College of Electrical and Mechanical Engineering founded
1916	School of Engineering and Mines formed from merger of the colleges of Mines and Electrical/Mechanical Engineering
1926	Initiation of Chemical Engineering Program at UND
1928	First Degree: Master's of Science in Chemical Engineering
1939	Program with four faculty accredited by the Engineer's Council for Professional Development
1942	Program loses accreditation due to faculty loss brought on by demands of WWII
1946	Program reaccredited with new faculty
1948	ChE moves into brand new building—Harrington Hall
1949	First doctoral degree: Fuel Technology; Charles R. Robertson Lignite Research Laboratory established
1972	Tom Owens receives the 1972 Dow Outstanding Young Faculty Award
1973	Project Lignite sponsored by the U.S. Office of Coal Research; UND Departmental Award for Excellence in Research
1982	Robertson laboratory ownership transferred from federal government to UND and renamed the Energy and Mineral Research Center
1989	Energy and Mineral Research Center merged with Mining and Mineral Resources Institute within the School of Engineering and Mines, and renamed the Energy and Environmental Research Center
1991	New doctoral degree: Energy Engineering; faculty size at five tenure/tenure-track positions
1992	UND Departmental Award for Excellence in Teaching
1993	UND Outstanding Faculty Development Award
1997	Major spring flood devastates Grand Forks and closes UND, final month of semester cancelled; extensive damage was sustained by UND buildings
2000	Tom Owens named North Dakota Teacher of the Year
2005	UND Departmental Award for Excellence in Research; John Erjavec receives UND's Award for Individual Faculty Excellence in Teaching; DOE EPSCoR IIP Award allows addition of sixth tenure/tenure-track faculty member
2006	Darrin Muggli receives UND's Award for Individual Faculty Excellence in Teaching; Michael Mann receives UND's Award for Individual Excellence in Research
2007	UND Departmental Award for Excellence in Teaching; Wayne Seames receives UND's Award for Individual Excellence in Research; research funding level allows the addition of non-tenured faculty member
2008	NSF EPSCoR RII award allows addition of seventh tenure/tenure-track faculty member
2009	Research funding level allows the addition of second non-tenured faculty member

2. *Can succeed in entry-level positions in the chemical process and broadly related industries, and demonstrate integrity, responsibility, ownership, and accountability for their work.*
3. *Have a thorough grounding in fundamentals, allowing them to obtain advanced degrees in chemical engineering or to pursue other professional interests such as medicine or law.*
4. *Have the teamwork, leadership, and lifelong-learning skills that prepare them for future professional growth in a broad spectrum of careers.*
5. *Understand the role of chemical engineering as a profession and their role in addressing societal issues, including sustainability, environmental responsibility, and safety.*

The program educational objectives and the departmental mission have remained largely unchanged over the past decade. They were developed and have been reaffirmed during that time by involving the departmental students, staff, alumni, key employers, and faculty in a variety of ways—many of them informal.

Alumni are invited to share their perspectives regarding the educational program offered by the department. As a part of our assessment process, we directly contact graduates from the program that have been out of the program for one and three years. Our annual newsletter (<http://www.und.edu/dept/sem/che/pdfs/ChE_2009Newsletter.pdf>) is our primary method of corresponding with the collective group. Formal processes to canvass employers of our graduates/alumni have been implemented, and we have maintained contact with companies who have traditionally hired our graduates. Alumni from the program frequently relay opportunities for permanent positions, as well as summer and co-operative education positions.

An Alumni/Industrial Advisory Committee has been in place since the early 1980s. The group meets every other year on campus with the departmental faculty. Participants are chosen to represent a range of ages, industries, and terminal degrees and typically include a member from a research-extensive university that is not a graduate of our program. The agendas for the alumni meetings normally include an update of department activities, a review of educational objectives and program-assessment activities, and a recap of proposed changes in the academic program. Those changes may include anything from evolutionary changes in courses to more significant curriculum modifications. We value the perspectives of our alumni advisory committee and have incorporated changes resulting from discussions with them.

Involving students in the process of developing program objectives and in the evolution of courses and degree requirements has been done for more than 30 years. The modest size of the program, both in numbers of students and faculty members, makes it possible to gather opinions of students throughout their studies and upon graduation and gather opinions of graduates as they pursue their various professional careers.

The Chemical Engineering Department performs a full assessment of our programs every year during a retreat. Although this represents a significant time commitment from the faculty, we feel that the benefits warrant the time invested. We use a formal plan that was developed in 1997 and continually updated based on input at our annual assessment meetings. As a part of this retreat, every fact of the program is reviewed. These two- to three-day sessions are used to explore all aspects of the program, to analyze and synthesize data collected during the past year, to evaluate the appropriateness of our objectives, to assess how our program is meeting these objectives, and to identify changes that are needed to ensure we continue to keep our program current based on the needs of our constituents. Material collected from our entire constituency base is used as a part of this evaluation. Major changes to the program are brought before the Alumni/Industrial Advisory Committee for feedback before implementation.

THE UNDERGRADUATE CURRICULUM

The curriculum is designed as a four-year, 133-hour chemical engineering program that provides exposure to the full breadth of the field. The entire undergraduate experience serves to prepare students for professional success. Classroom training includes an essential-studies component, basic mathematics and science, engineering topics, engineering design, and hands-on laboratories. Research opportunities and co-op or intern employment provide a valuable supplement to the classroom, and all students are encouraged to pursue these opportunities. In addition, teamwork and leadership are best learned by doing, and our curriculum stresses the use of teams in the classroom, in the laboratory, and in homework and project assignments across the curriculum. Students can use both their advanced science and technical electives to build expertise in a selected area. The current curriculum is shown in Table 2.

Capstone Design. ChE 412 is our capstone design course. Faculty-selected student teams of three to four members choose a project and develop an implementation plan for their semester's work activities. Each team is assigned a faculty technical advisor who assists the primary course instructor in helping student groups on a one-on-one basis. A full scoping study is prepared that includes at least two fundamentally different process alternatives. The scoping study report includes a budget brief, process description, an I/O diagram, block flow diagrams, process flow diagrams, a preliminary schedule, a preliminary cost estimate, a manufacturing cost estimate, an economic assessment, plus an environmental and safety impact statement. Upon completion of this report, students work on selected portions of the conceptual design including piping and instrument diagrams, plot plans, utility flow diagrams, instrument schedules, piping schedules, equipment specification sheets, and a description of the plant's automation system. Intermediate deliverables include technical review meetings. At

least two faculty members read each intermediate deliverable and participate in the technical review meetings.

The final deliverable is a formal presentation to a panel of the entire faculty, each of whom represents a different job function on a capital project review team (management, finance, process specialist, EHS specialist, etc.). Our senior design projects include multiple-variable constraints and are often performed with industrial partners/mentors. Others are theme-sponsored projects from foundations or governmental agencies. Recent examples include vegetable oil extraction and purification plants (*e.g.*, corn, canola, soybean, cotton), coal gasification with carbon capture, activated carbon from coal, methanol from syngas, renewable diesel from algae for a mission to Mars, and magnesium from seawater.

Faculty participation in the capstone design course provides each faculty member with valuable feedback concerning the assimilation and retention of the key concepts from each of the core recitation courses in the curriculum. We use this feedback to improve our teaching effectiveness in these foundation courses. For example, we found that students were not easily and fluently able to perform complicated mass balances, even though these were covered extensively during the sophomore year. In response we began adding mass-balance problems to various homework sets throughout the curriculum to reinforce the techniques learned earlier. As a result, student performance generating mass balances during the capstone design courses improved significantly. This level of faculty participation also stresses to our students the importance we place on the design component of the curriculum and on the capstone design experience in particular.

The Laboratory Sequence. A core value in our undergraduate program is the importance of laboratories to produce a graduate with hands-on experience. In addition to the required labs in chemistry and physics, students must take a four-semester sequence in the department. The early labs are focused on the development of good laboratory techniques, to reinforce fundamental principles, and to introduce software tools. The nature of the experimental problems gradually grows in complexity and rigor as students progress through the sequence. Upper-level labs introduce students to the use of the lab to answer research-based questions and how to use published journal articles as the basis of setting up experiments to answer specific questions. In the final lab, students confront open-ended, vague problem statements where the experiments in the laboratory serve as data-gathering tools used in problem solving. Students determine how to use the laboratory apparatus to generate the data and determine the number of replicate sample sets they need to validate their results statistically. The use of computer tools is incorporated to demonstrate the importance of combining experimental results with simulation.

All laboratory classes are supervised by faculty. We also utilize these labs as a tool to integrate a variety of skills into one experience. It is our philosophy that outside of cooperative education and internships, the laboratory classes, if structured properly, provide the best opportunity to expose students to the set of skills that are best obtained through experiential learning. Therefore, rather than having our laboratory classes focused only on reinforcing chemical engineering principles, we embed a variety of other learning goals. To accomplish

TABLE 2
The University of North Dakota Chemical Engineering Curriculum

First Year					
Math 165	Calculus I	4	ChE 102	Intro to ChE	2
Chem 221	Chemistry I	3	Math 166	Calculus II	4
Chem 221L	Chemistry Lab I	1	Chem 222	Chemistry II	3
Engl 110	College Comp I	3	Chem 222L	Chemistry Lab II	1
Arts & Humanities Elective		3	Phys 251	University Physics I	4
Social Sciences Elective		3	Arts & Humanities Elective		3
		17			17
Sophomore Year					
ChE 201	ChE Fundamentals	3	ChE 206	Unit Operations	3
Math 265	Calculus III	4	ChE 232	ChE Lab I	2
Phys 252	Physics II	4	ChE 315	Statistics & Numerical Methods	3
Engr 201	Statics	3	Math 266	Differential Equations	3
Engl 125	Technical & Business Writing	3	Chem 240	Survey of Organic Chemistry	4
		17	Chem 240L	Survey Organic Lab	1
					16
Junior Year					
ChE 301	Transport Phenomena	4	ChE 332	Che Lab III	2
ChE 331	ChE Lab II	2	ChE 305	Separations	3
ChE 303	ChE Thermodynamics	4	ChE 321	ChE Reactor Design	3
EE 206	Circuit Analysis	3	ChE 340	Professional Integrity	3
Technical Elective II		3	Business/Entrepreneurship Elective		3
		16	Technical Elective I		3
					17
Senior Year					
ChE 408	Process Dynamics & Control	3	ChE 412	Plant Design II	5
ChE 431	ChE Lab IV	3	Arts & Humanities Elective		3
ChE 411	Plant Design I	4	Social Sciences Elective		3
Chem 465	Physical Chemistry II	3	EngSci Elective		3
Advanced Chemical Science Elective		3	Advanced Chemical Science Elective		3
		16			17

these goals we have formally mapped course content with each specific lab. This was done to ensure that the content of each of the labs was consistent with the educational objectives of the department and independent of the faculty teaching the course. The current listing is shown in Table 3.

DISTANCE EDUCATION

Since 1989, UND has offered its ABET-accredited bachelor's degree program in chemical engineering using a distance delivery program concurrent with our local courses. Designed for working adults who are unable to complete a full-time, on-campus program, the distance program uses the same curriculum as the on-campus program.

Courses are offered asynchronously, which provides great flexibility in accommodating student schedules. As core courses are taught for on-campus learning, they are captured digitally and made available through the Blackboard learning environment, usually within two hours of class completion. This allows students to watch recorded classroom lectures, access course materials, submit assignments, and take tests at the time of day and place of their choice within a time window for each assignment.

The four-lab sequence is consolidated into three two-week, on-campus intensive lab experiences taken over the course of three summers. This provides important face-to-face contact between faculty and students and between students within the same peer group (facilitating group work throughout the curriculum). We also allow local students to participate in these summer labs, which provides useful and exciting synergies between on-campus and distance students.

UND provides extensive student support services, such as online tutoring, library access, tech support, and advising services to ensure that the students can easily and readily access the resources they need for success. In 2004, UND received the WOW Award given by the Western Cooperative for Educational Telecommunications for being on the cutting edge of using technology for distance engineering degree programs.

Distance students are held to the same high standards of excellence as on-campus students. Participants have come from all over North America. We even had one student complete a significant portion of the program while working on an offshore oil platform! Most work in process-related jobs that motivated their interest in a chemical engineering degree but at least one student was a stay-at-home mother of two.

TABLE 3
Mapping of Learning Goals to Laboratory Sequence

Content Area	Lab I	Lab II	Lab III	Lab IV
ChE Principles	mass balances energy balances intro thermodynamics ChE principles	fluid flow heat transfer mass & energy balances intro transport phenomena	separations transport phenomena thermodynamics kinetics	process dynamics process control reactor design separations design
Statistics	mean range significance standard deviation	confidence intervals hypothesis test linear regression	propagation of error simple DOE simple ANOVA linearization residual analysis	nonlinear analysis sources of error response surface method DOE
Data Analysis	data → information identify trends in data	explain trends error analysis (qual/quant) sources of error	empirical modeling error budgets causes of data reasonableness	significance of results factors affecting data fuzzy quantification error testing
Writing	basic writing skills tables figures technical report content	style technical clarity writing instruments editing & revisions	drawings levels of detail audience additional instruments	capstone synthesis standards of excellence
Oral Communication	basic presentation skills content of presentation	style, delivery, clarity methodology of formal talks	informal presentations cohesiveness engagement	impact conclusions recommendations meetings
Teamwork	basic principles of groups team roles manage, coordinate time	group analysis methods priority setting	conflict resolution collaboration, compromise accountability	negotiations
Integrity	plagiarism referencing	manipulation of data presentation of data	doing your share accountability	
Professionalism	levels of attire	working with support personnel	communication etiquette	independence standards of excellence
Safety	formal lab safety training basic lab safety	formal lab safety training safety concerns in reports MSDS	formal lab safety training MSDS PHAs	formal lab safety training operational safety

We recognize the time commitments and family sacrifices that are necessary for these nontraditional students to complete this program (including their summer vacations for three years!). Faculty try to be accommodating with work conflicts and assignment due dates while still moving students toward course and program completion. Faculty and staff try to provide at least the same level of personal attention and accessibility to distance students as to on-campus students. This may involve online dedicated problem solving or review sessions to ensure that distance students can participate in engagement learning methods similar to on-campus students.

ACCOMPLISHMENTS AND AWARDS

The current faculty members are proud to have maintained the department's long tradition of providing the highest quality education available to undergraduate students in chemical engineering. Annual analysis of data from our assessment instruments (undergraduate, alumni, and employer surveys; performance on standardized tests; etc.) shows that we are meeting and usually exceeding all of our educational objectives. Our department is accredited by ABET, with our most recent accreditation visit in Fall 2009. The faculty is dedicated to excellence in teaching, and the atmosphere in the department is especially conducive to learning.

- *The department was recognized with UND's 1992 and 2007 Departmental Awards for Excellence in Teaching.*
- *Dr. Tom Owens, then professor and chair (now professor emeritus) received the 1972 Dow Outstanding Young Faculty Award and the 1993 UND Outstanding Faculty Development Award, and was named the state of North Dakota's Educator of the Year in 2000.*
- *Dr. John Erjavec, then associate professor (now professor emeritus) received UND's 2005 Award for Individual Faculty Excellence in Teaching.*

The Current Faculty in the University of North Dakota Chemical Engineering Department

Michael Mann (distinguished professor, chair). Research interests: Performance issues in advanced energy systems firing coal and biomass, emission control; renewable and sustainable energy systems; development of energy strategies coupling thermodynamics with political, social, and economic factors.

Frank Bowman (assistant professor). Research interests: Atmospheric aerosols; organic aerosol partitioning; mathematical modeling of multicomponent aerosols; air quality modeling; educational technology; assessment of student learning; educational air pollution models.

Edward Kolodka (associate professor). Research interests: Polymer reaction engineering; synthesis, rheological, and mechanical properties of polymers; development of polymers from agricultural products; synthesis and characterization of conducting polymers.

Gautham Krishnamoorthy (assistant professor). Research interests: Computational fluid dynamics; simulations of combustion reaction flows; carbon capture technologies; radiative heat transfer.

Wayne Seames (professor). Research interests: Novel process technologies; renewable fuels and chemicals; advanced combustion technologies; mitigation of the environmental impact of heavy metals; trace element partitioning from combustion and incineration.

Brian Tande (assistant professor). Research interests: Polymer science and engineering with applications in sustainable energy; rheology of complex fluids; block copolymer morphology; neutron scattering; effect of polymer branching on membrane transport; polymers and composites from renewable sources.

Steve Benson (professor). Research interests: Efficient and clean utilization of renewable and fossil fuels in gasification and combustion systems; ash formation and fireside ash deposition; carbon products; carbon dioxide separation and capture.

Yun Ji (assistant professor). Research interests: Renewable and sustainable energy; chemicals and fuels from renewable sources; biomass pretreatment; biochemical and thermo-chemical of biomass for fuel production, enzymatic hydrolysis; integrated energy and environmental projects; process simulation; forestry biorefinery; pulp and paper technology; lignin utilization.

Bob Wills (associate professor). Research interests: Non-thermal drying of solids by chemical dehydration; vegetative oil extraction and product enhancement; increasing process efficiencies in the fermentation industry.

- *Dr. Darrin Muggli, then associate professor (now adjunct), received UND's 2006 Award for Individual Faculty Excellence in Teaching.*
- *Drs. Wayne Seames, Darrin Muggli, Frank Bowman, and Brian Tande were voted by the students as SEM Professor of the Year in 2006, 2007, 2009, and 2010, respectively.*
- *UND ChE student Mitch Braegelmann, BSChE08/ MSChE09, was named a Tau Beta Pi Engineering Honor Society Laureate. This prestigious national award has been given to only 60 undergraduate engineering students since it was started in 1982.*

Strong, active research programs have also become a trademark of the department. Five faculty members have been honored in the past three years by the Technology Transfer Office for submitting patents and/or patent disclosures. The number of graduate students currently enrolled has stabilized at around 35 (34 enrolled in Fall 2009 including seven in the Engineering Ph.D. program with ChE advisors). Qualified full-time students are all fully supported on GRAs and GTAs.

- *The department was awarded the Fellows of the University Award of Excellence in Research in 1973 and 2005.*
- *Dr. Michael Mann, then professor (now distinguished professor, chair, and associate dean for research), received UND's 2006 Award for Individual Excellence in Research.*
- *Dr. Wayne Seames, then associate professor (now professor and director of ND SUNRISE) received UND's 2007 Award for Individual Excellence in Research.*
- *Yongxin Zhao, Ph.D., Energy Engineering (advised by ChE professor Michael Mann), received UND's 2006 Outstanding Doctoral Dissertation Award.*
- *April Hoffart (advised by ChE professor Wayne Seames) and Chris Flakker (advised by ChE professor Darrin Muggli) were awarded UND's 2005 and 2008 Outstanding Master's Thesis Awards, respectively.*

PRINCIPLES AND VALUES

How did a program with a small five-person faculty emerge as one of UND's signature departments? UND ChE's academic excellence is due primarily to a set of principles that govern faculty selection and interaction. Preeminent among these is that the faculty must function as a team. Industry stakeholders are consistent in highlighting the ability to work in teams/groups as one of the most important tools they want chemical engineering departments to teach their students. At UND we do not believe this is feasible unless the faculty members model this behavior. Every new faculty member comes into the department with the understanding that they must function within a team environment. The keys to effective faculty teaming are collaboration, consensus, and communication. Administrators that do not know our department closely are often surprised at the consistency of voice expressed from ChE department faculty. This isn't because faculty do not have different opinions. It is that those differences are expressed within the group in discussions that lead to group consensus.

UND ChE student Mitch Braegelmann, BSChE08/ MSChE09, was named a Tau Beta Pi Engineering Honor Society Laureate.

Operating as a faculty team also has allowed us to more efficiently use the resources at our disposal. For example, research laboratories and equipment are shared. Faculty do not have designated laboratories but share space as required. Graduate student offices are integrated across all advisors with purposeful mixing of students with different nationalities and different project topics. Co-advising of graduate students and collaborative proposals are the norm, not the exception. Most graduate students have two or three equally responsible faculty co-advisors overseeing their research projects.

A second key principle is that outstanding teachers must have superior communications skills. So in addition to looking for faculty members that will work well in a team environment, faculty recruitment also focuses on oral and written communications skills and the ability of candidates to listen effectively. This emphasis on communications is passed on to our students. UND ChE is known within the university for the quality of communication preparation included in the curriculum. Students are taught that the best ideas are unlikely to be adopted if no one can understand them or if the credibility of the engineer proposing the ideas is questioned. Good oral and written communication skills cannot be taught by those that do not have this ability within themselves. It is also difficult to teach complex concepts and problem-solving skills if the way these concepts are communicated inhibits understanding.

Some other key principles that are adopted by the entire faculty team are:

- *The primacy of education as the department's mission.*
  - *Education should not be compromised for research or service.*
  - *An important element of faculty selection is the candidate's passion for teaching and demonstrated competency in education.*
  - *Engagement teaching methods should be maximized.*

- *Every member of the department attends the University of Buffalo's Case Studies in Science workshop to learn how to incorporate case studies and problem-based learning methods into science-oriented courses.*
- *Experiential learning is essential. Lab courses are not secondary courses in the curriculum and teaching quality is as important in these courses as in recitation courses. All ChE lab courses are taught by faculty. All lab reports are graded by faculty. Teaching in recitation courses is weighted heavily towards engagement methods rather than lecture.*
- *Teaching objectives can be achieved across the curriculum not just within individual courses. This is made possible by teamwork and allows more objectives to be achieved in less class time. Current across-the-curriculum topics are shown in Table 4.*
- *Research projects should be student-centered. Research for research sake is not a priority in our department. Rather, we conduct research as a tool to teach students at all levels how to formulate and solve complex problems and to learn deeply in specific topic areas.*
- *Faculty members limit travel during the academic year in order to avoid lessening the quality of education. This means that UND ChE faculty are purposely less involved in national conferences and other service activities that take them away from Grand Forks. As a consequence, the department is not as well known outside the local region as would be expected based on the level of research accomplishment achieved.*

■ *Faculty mentoring is the responsibility of experienced members of the faculty.*

- *In a faculty team, peers are not seen as competitors, they are seen as resources.*
- *Informal interactions between faculty lead to improved performance as faculty members share ideas and experiences. This is made effective by the department's teaming philosophy.*
- *Senior faculty write collaborative research proposals with new faculty within the first couple of months to help them learn the process and to integrate the new member into the department's research team.*
- *Faculty share their course resources when new faculty take over a class so that new faculty have a model for how to teach effectively.*

■ *Students deserve personal attention.*

- *We employ mandatory faculty advising every semester for every student with the same faculty advisor for their entire program. (Students are free to request a different advisor if they are uncomfortable with their mentor.) This results in high student retention and minimizes graduation requirement issues.*
- *All faculty have an open door policy rather than posted office hours. Unless there is a compelling reason, all faculty are accessible during normal business hours.*
- *We have no interest in retaining students that do not want to stay in the program for valid reasons. On the other hand, we do not want to lose students because of a poor experience in a science or math foundation course giving them the wrong impression about whether or not they will enjoy chemical engineering as a career. We conduct exit interviews with students who took our Fundamentals (ChE 201) class and passed with a C or better but elected not to enroll in the next technical chemical engineering class, Unit Operations (ChE 206). In the 2007-08 academic year, two students transferred to other programs.*
- *Our department conducts a senior exit interview. On a scale of 1 to 5, with 5 being very satisfied, our graduating seniors rated the quality of advisement as 4.4. Comments from these interviews are taken seriously and reviewed by all faculty at the annual retreat.*
- *Graduate programs are custom-designed for each student. For example, there are no required graduate classes in our ChE master's degree programs. Faculty advisors work with students to develop a program mutually acceptable to both that will best prepare students based on their objectives for obtaining an advanced degree.*

■ *Core values for graduating students.*

- *We identified the following set of core values that every student graduating from our program should possess:*
  - *The ability to work in teams,*
  - *Respect for ethics and integrity*
  - *A firm understanding of key fundamentals of chemical engineering*
  - *The ability to communicate effectively*
  - *Fluency in the use of statistical methods*
  - *Competency in chemistry*
  - *Independence and self-discipline*
  - *An understanding of professional standards of quality in both technical content and personal conduct*
- *These values are built into our curriculum and reinforced through multiple learning experiences. For example, they were used to identify our across-the-curriculum themes that are incorporated into individual courses within the program.*

■ *Experience in Applied Engineering.*

- *There is great value in having a significant fraction of faculty members with applied engineering experience.*

- *Most of our undergraduate students will go directly into industry (60-80%). Applications-oriented courses in the curriculum are best taught by those who teach what they know rather than those who teach what they learned.*
- *In general, applied engineering jobs teach certain skills more effectively than most research jobs, such as teamwork, multitasking, planning, supervising other engineers, commercialization, and communications. Many of these are skills that our stakeholders want to see us teach to our students.*
- *Applied engineering experience is equally valued to research experience within the faculty team.*
- *Students are encouraged to participate in cooperative education assignments, internships, and/or undergraduate research. These experiential learning opportunities help students develop insight into what they are studying and motivation to apply themselves in their studies. Although these opportunities are voluntary, almost all UND ChE students participate in at least one of them.*

■ *Teaching and research excellence are not mutually exclusive.*
- *Faculty hires must have doctoral degrees and demonstrated competency in research.*
- *Faculty are mentored in grant writing and project management to increase their effectiveness.*
- *Reasonable, but nontrivial, published tenure requirements allow faculty the freedom to take risks and reach for excellence. Patents and nontraditional venues for documenting research productivity are valued equally with peer-reviewed publications. For example, initiating a startup company based on faculty research is a valid productivity measure. In fact, in the current environment where universities are expected to be engines for economic development, entrepreneurial activities are highly valued. Four of the current faculty are associated with start-up/spin-off company ventures.*
- *Faculty are considered full members of the team regardless of their contract status (tenured, tenure-track, nontenure-track). This improves team building and allows faculty resources to be used most effectively.*

SUNRISE: THE CHEMICAL ENGINEERING-CHEMISTRY PARTNERSHIP

Faculty in ChE began collaborating on research projects with faculty in UND's chemistry department in the 1990s. These collaborations intensified in the 2000-2003 timeframe and in 2004 a decision was made to transform these small-scale collaborations into a more extensive partnership. The two departments established the Sustainable Energy Research Initiative and Supporting Education (SUNRISE) program. Seeded with around $1 million in research projects funding from existing collaborations, SUNRISE has since grown to include 33 faculty in 13 departments at both UND and North Dakota's other research university, North Dakota State University. Also participating are two faculty from North Dakota nondoctoral institutions. Working in three principle focus areas—renewable fuels and chemicals, the long-term sustainable use of coal, and harvesting energy from diverse sources—SUNRISE has received over $32 million in research funding over the past six years.

All of the UND ChE faculty are expected to maintain active research programs and to bring in research funding sufficient to continuously support at least two graduate students. At present, all ChE faculty participate in SUNRISE along with 75% of the UND Chemistry faculty. Due to the ChE department's accomplishments in research, UND agreed to add two tenure-track faculty positions. These positions are funded during their initial three-year period with funding from the North Dakota EPSCoR program, with state-appropriated funding picking up the cost after that time. In addition, due to the level of research funding the department has received we have been able to add three nontenure-track faculty positions, one full-time and one half-time grants and contract officer positions, one instrument technician, two research chemists, three research engineers, and one marketing/outreach administrative assistant. In addition to assisting in the research mission of the department, these extra positions allow us to increase our course offerings and improve our service to the students.

A WINNING RECIPE

Collaboration, consensus, and communication are the cornerstones of UND's Department of Chemical Engineering. By continually demonstrating their commitment to teamwork, our faculty members consistently prioritize the needs of our students and the industries and universities that eventually employ them. ❐

TABLE 4
Across-the-Curriculum Themes in UND Chemical Engineering

Teamwork
Sustainability
Communication: writing, speaking, listening
Professionalism and Integrity
Environment, Health, and Safety
Instrumentation and Control
Independent Learning
Statistical Analyses of Data
Computational Tools