



◀ Henry M. Rowan Hall, home of the Chemical Engineering Department.

View of the atrium and spiral staircase in Henry M. Rowan Hall. ▼



ChE at . . .
Rowan University

C. STEWART SLATER, ROBERT P. HESKETH, JAMES A. NEWELL, STEPHANIE FARRELL, ZENAIDA OTERO GEPHARDT, MARIANO J. SAVELSKI, KEVIN D. DAHM, AND BRIAN G. LEFEBVRE
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In recruiting Rowan's faculty and the first class of students, the Founding Dean, James H. Tracey, said, "Build it and they will come."—it was built, and they came! Doors were opened to engineering students in 1996, and the first class graduated in 2000. Today, Rowan University's undergraduate chemical engineering program is ranked third in the nation by *U.S. News and World Report's* "2005 America's Best Colleges." This success can be attributed to the dedication and talent of the faculty, the high quality of its students, and its state-of-the-art facilities. The faculty have pioneered an innovative curriculum for students at Rowan that spans the engineering disciplines and is characterized by a "hands-on, minds-on" approach to engineering education.

THE ROWAN GIFT

Rowan University's origins are as a teacher's college, and today it is still a leader in producing education majors for the state of New Jersey. Since its founding in 1923 as Glassboro

Normal School, Rowan has had two major events of international significance. The first was in June of 1967 when President Lyndon Johnson and Soviet Premier Aleksei Kosygin held the first summit between the U.S. and the Soviet Union—a meeting that led to a thaw in the cold war. The second event occurred in June of 1992 when Henry and Betty Rowan gave \$100 million to Glassboro State College—the largest contribution to a public university at that time. He gave this gift for the purpose of starting an "outstanding" engineering school to better serve the students of the southern New Jersey region. The institution was subsequently renamed in honor of the Rowans, and it achieved university status in 1997.

Planning for the new and innovative engineering program began in 1993 with the formation of a National Advisory Council, a group of prominent engineers from around the country. Then in 1994, the founding Dean, James Tracey, was hired and joined Zenaída Otero Gephardt, who served as Assistant Dean to this fledgling enterprise. In 1995, C. Stewart

Slater became the founding chair of chemical engineering, and new faculty was hired every succeeding year until it reached a complement of eight full-time faculty in 2000. Robert Hesketh, who joined the faculty in the fall of 1996, became chair in 2004. The first class graduated in May of 2000 and the department received accreditation by ABET the following year (retroactive to the first class). Dianne Dorland became Dean of the College of Engineering in 2000.

Stewart Slater was an enthusiastic and energetic chair, traits that were essential in creating a new chemical engineering program. He believed engineering education should be transformed and he knew that if given a chance, he could lead Rowan's chemical engineering department into a new and exciting future. The synergy among the Rowan faculty, as a result, is cohesive and has produced one of the best undergraduate programs in the country.

Today, Rowan University has more than 9,500 students in 36 undergraduate majors, 26 master's degree programs, and a doctoral program in educational leadership. The College of Engineering offers bachelor and master of science degrees from the departments of chemical, civil and environmental, electrical and computer, and mechanical engineering. There are currently 112 chemical engineering undergraduate majors and 12 graduate students.

Rowan is a selective, medium-sized state university located in southern New Jersey between Philadelphia and Atlantic City. The region is an eclectic mix of suburban and rural areas, and the home county of Gloucester is one of the fastest growing counties in the state. The average class size in chemical engineering is 14 and the student/faculty ratio is 10 to 1. All classes are taught by professors, which provides for an excellent student-centered learning environment.

ACTIVE LEARNING AND A PROJECT-BASED CURRICULUM

"Tell me and I forget, show me and I may remember, but involve me and I understand," a quote attributed to the statesman-inventor Benjamin Franklin, is a fundamental philosophy of the department. Students are involved in the learning process from the first day of the program. They participate through in-class cooperative problem solving, experiments and demonstrations, computer exercises, and small-scale and semester-long projects. This is accomplished through a curriculum that blends the fundamental chemical engineering knowledge with applications, design, and research in many of the emerging fields of technology. The hallmarks of the College of Engineering include a project-based curriculum,

the teamwork approach to problem solving, emphasis on communication skills, hands-on laboratories and modern computer tools, safety and environmental issues, economics and entrepreneurship, and industrial partnerships.

ENGINEERING CLINICS

The most innovative and unique feature of the engineering curriculum is the engineering clinic sequence. Loosely modeled after the medical school approach to teaching (first used in engineering by Harvey Mudd College), the eight-semester sequence gives students a real engineering experience on the very first day of their freshman year and culminates in a major project experience in their junior and senior years. Each section of the engineering clinic sequence involves students from all four of the engineering disciplines, and many of the clinic projects are funded by industry and faculty research grants.

The Rowan program was one of the first in the country to focus on providing a one-year freshman experience with engineering experimentation, multidisciplinary teamwork, and communication skills. In the fall semester, students conduct experiments from each of the four engineering disciplines to learn about engineering measurements and to become familiar with engineering in general. Many innovative experiments have been developed in chemical engineering. For example, a fluidized bed polymer coating experiment introduces basic chemical engineering concepts by using a fluidized bed

to demonstrate polymer coating and heat transfer, and a drug delivery experiment shows students some basic principles, such as rate control in the delivery of modern medicines. Students have even visited the campus cogeneration plant to examine the measurement techniques used in the production of steam and electricity for the campus. In the spring semester, students reverse-engineer a process or product—examples include an automatic drip coffee maker, a beer-brewing process, and the human body. The beer production project has been one of the most popular projects; students start the semester investigating the brewing process and finish by designing a new brewing process.

The Sophomore Clinic is a unique integrated course where professors in college writing and public speaking teach communication concepts through the use of an engineering project. These multidisciplinary design projects have focused on the design, optimization, and economic analysis of a baseball stadium, a NASA Mars mission, recycling, a stair climber for the disabled, a bridge design, and microbial fuel cells.

The Junior and Senior Clinics are the most ambitious part of the program. There, multidisciplinary teams (3-4 students

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on a team) work on real-world, open-ended projects in various areas that are linked to industry or to a grant from a state or federal agency. The majority of these projects run for an entire year (two semesters) and involve applied research, development, or design that solves some particular engineering problem. These projects emanate from a particular discipline, are led by that department's faculty, and typically involve an industrial mentor. The teams are matched by faculty project managers to achieve the best results in individual projects. Teams may combine various fields of expertise within a classical discipline (such as biochemical and polymer in chemical engineering) or combine other disciplines (such as science, business, and other engineering) as may be appropriate to the project goals. Students are required to meet weekly with a faculty advisor and/or an industrial mentor for project updates, they must write a final report or a paper/journal publication, and they must present an oral report at the end of each semester.

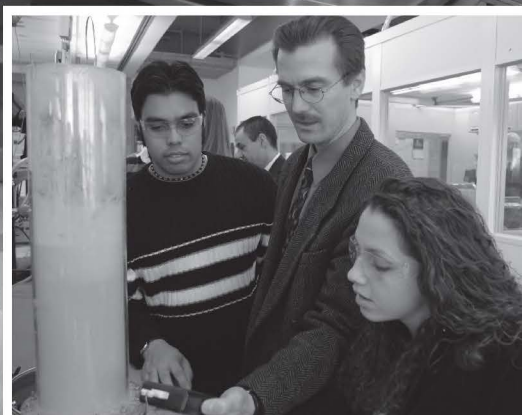
A recent Junior/Senior Clinic project involved evaluation of novel separation processes for recovery of precious metals from process streams, sponsored by Johnson Matthey, Inc. The student team was composed of chemical engineering and chemistry students. The project outcomes included a literature review, critical analysis of equipment potential, experimental testing, modeling and verification, and economic process analysis. The results of the project were incorporated in the processing plant. Such association of students and industrial partners has often led to full-time jobs as well as internships.

Another interesting Clinic partnership came as a result of the department's interaction with the Pillsbury division of General Mills. Pillsbury sponsored several Clinic projects for improvement and optimization of its dough line processes. One project focused on the analysis of raw materials, the second project optimized a process line, and the third investigated wastewater minimization.

These projects also provide student teams with an opportunity to perform research that is more typically associated with graduate students and encourages them to pursue advanced degrees. Work on high-performance polymers and composites, done in the Clinics under the supervision of James

Student at work in the bioprocessing and related bio areas research lab at Rowan. ►

One of the most popular labs is the food product development lab where students can create and test their products. ▼



▲ Fluidized bed for polymer coating experiment in the freshman clinic.

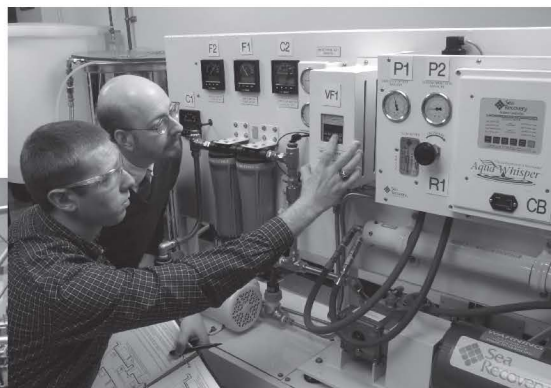
Newell, has resulted in four papers being published in peer-reviewed technical literature, and five of his undergraduate students have gone on to graduate study.

ChE-FOCUSED COURSES

The chemical engineering curriculum consists of the four-year engineering clinic sequence summarized above, coupled with a unique combination of chemical engineering subjects. Examination of the course names will reveal many of the core subjects, such as material and energy balances, fluid, heat, mass transfer, and thermodynamics, but these courses are not typical chemical engineering courses. Imagine trying to remove 14 credit hours from 131 credit hours, or more importantly 36 contact hours from the curriculum, to make room for a multidisciplinary project-based engineering clinic sequence! At Rowan, however, it has been proven that it is possible to make major changes in the chemical engineering curriculum. The process of transforming traditional chemical engineering courses began with the founding chair, Stewart Slater, and the curriculum continued to be evaluated and transformed as each new faculty member was hired. This process continues today through biannual evaluation meetings and involves in-depth participation of each of the eight faculty members. The faculty members evaluate the content of each course at meetings that last one to two days, and as a result, new and innovative topics have been integrated throughout the curriculum. Subjects and courses have been removed as

Grants from the NSF have funded lab experiments in novel areas such as this reverse osmosis membrane system. ►

The high bay laboratory, shown here, gives students exposure to industrial processes such as a 25-ft distillation column and a specialty chemical pilot plant. ▼



scale membrane experiments for outreach activities. Another NSF grant funded micro-mixing and other experiments for a reaction engineering course. Some innovative food engineering experiments have been developed and are included in the freshman clinic and outreach, also with NSF support. EPA funding has helped incorporate green and sustainable engineering into the curriculum and to disseminate this to many other schools. The faculty have

well as added, constantly improving the curriculum. The process that is now in place allows the department to continually transform the curriculum to better prepare engineers for the future. The ability to constructively evaluate and make these changes is directly attributed to the good working relationship between all chemical engineering faculty members.

Departmental faculty have also been successful in working with other colleges to reshape and improve traditional math, science, and general education courses, *e.g.*, the example of the sophomore clinics given above in which students are instructed by both communications faculty and engineering faculty on how to effectively communicate their results. In working with the biological science faculty, a new required course, “Biological Systems and Applications,” has been created that integrates microbiology and other life science topics into the sophomore year. There has also been cooperation with the chemistry and math departments in creating unique courses for engineering students.

ROWAN'S IMPACT ON CHE EDUCATION

The Rowan department is influencing chemical engineering education by sharing its innovations with other educators through publication, presentations, and workshops. It has received numerous grants from the National Science Foundation, the U.S. Environmental Protection Agency, and the State of New Jersey to innovate the curriculum and to discover how engineering students really learn.

For example, one of the NSF grants funded membrane experiments for the unit operations course as well as smaller-

been strong advocates of an interactive classroom with cooperative learning, experiments and demos, and unique learning methods. James Newell has developed a game-show class-participatory project using *Hollywood Squares* and *Survivor* to help students learn about material science and chemical principles, and the plant-design course has used a “business meeting” concept involving College of Business faculty and engineers from industry to review student design presentations. Kevin Dahm has taught process economic analysis with interactive economic simulation as a semester-long project. Zenaida Gephardt is leading the incorporation of experimental design in the curriculum.

The department has been a leader in developing assessment tools designed to address ABET criteria. This work has expanded through NSF funding to use profiles of student-learning preferences to develop metacognition in engineering students and to improve their performance in teams.

Bio and pharmaceutical engineering focused innovations have occurred at many levels in Rowan's chemical engineering labs and courses. Stephanie Farrell has been a pioneer in invigorating the Freshman Engineering Clinic with bioengineering experiments—drug delivery system testing, “Hands on the Human Body” biomedical experiments, and brewing-process investigations, etc. Food product and process engineering has been a recent theme of the department. As a first step in response to the regional emphasis on food processing, Mariano Savelski developed a course that integrates applied food engineering coursework and food chemistry experiments. This course provides students with skills directly rel-



The Rowan Chemical Engineering team: left to right, Susan Patterson, Zenaida Otero Gephardt, Brian G. Lefebvre, Kevin D. Dahm, Robert P. Hesketh, C. Stewart Slater, Mariano J. Savelski, Marvin Harris, James A. Newell, and Stephanie Farrell.

evant to the evolving needs of the food processing industry.

Rowan faculty have not only taught students in an innovative way, but have also helped improve the process of how chemical engineering is taught. In 1998, Stewart Slater and Robert Hesketh received funding from the NSF to conduct two workshops for other chemical engineering faculty on novel process science and engineering principles. The ASEE Summer School for Chemical Engineering Faculty and AIChE meetings have had Rowan leadership in workshops focusing on communication skills, assessment, experiential and inductive learning, and green engineering. Through these workshops, faculty at other schools have been impacted, and the Rowan innovations are now being used in educating chemical engineering students across the country. The faculty have also ventured into other parts of the world to spread the "Rowan way," as invited speakers at conferences and universities in Argentina, Australia, Brazil, Canada, Chile, China, Czech Republic, Mexico, Norway, Spain, and the United Kingdom.

STATE-OF-THE-ART FACILITIES

Henry M. Rowan Hall is the home of Rowan's Engineering College. This \$29 million engineering building, completed in 1998, is equipped with the latest chemical engineering equipment and instrumentation. The 95,000 ft² building is designed to facilitate problem-based learning with classrooms integrated with fully equipped modern laboratories. The high-bay facility and food product development lab (as well as the instructional and research laboratories) have pilot-scale equipment such as: an advanced distillation system designed for education with a 25-ft high column with full computer control; a specialty chemical pilot plant for the manufacture of flavors, fragrances, and other unique products; a reverse-osmosis system for water reuse and recovery in chemical processing; a climbing film evaporator that was used in pharmaceutical production; a supercritical fluid extraction system for the recovery of nutraceutical products; and clinical-grade cardiorespiratory, pulmonary function, and metabolic testing equipment. In addition to many other chemical engineering apparatus, these laboratories are supported by state-of-the-art analytical instrumentation.

FACULTY LEADERSHIP

Faculty members are leaders in chemical engineering education. Because of

TABLE 1

Rowan's Chemical Engineering Team

- **Robert P. Hesketh**, Professor and Chair
BS, University of Illinois; PhD, University of Delaware
Reaction engineering • Novel separation processes
- **Dianne Dorland**, Professor and Dean
BS, MS, South Dakota School of Mines; PhD,
University of West Virginia
Green engineering • Management
- **James A. Newell**, Professor
BS, Carnegie-Mellon University; MS, Pennsylvania State
University; PhD, Clemson University
Polymer science and engineering
- **C. Stewart Slater**, Professor
BS, MS, Rutgers University; PhD, Rutgers University
Membrane separations
- **Kevin D. Dahm**, Associate Professor
BS, Worcester Polytechnic Institute; PhD, Massachusetts
Institute of Technology
Reaction kinetics • Process modeling
- **Stephanie Farrell**, Associate Professor
BS, University of Pennsylvania; MS, Stevens Institute;
PhD, New Jersey Institute of Technology
*Controlled release • Pharmaceutical/food process
technology*
- **Zenaida Otero Gephardt**, Associate Professor
BS, Northwestern University; MS, University of
Delaware; PhD, University of Delaware
Experimental design • Particle technology
- **Mariano J. Savelski**, Associate Professor
BS, University of Buenos Aires; ME, University of
Tulsa; PhD, University of Oklahoma
*Design for pollution prevention • Food process
technology • Supercritical fluids*
- **Brian G. Lefebvre**, Assistant Professor
BE, U. of Minnesota; PhD, University of Delaware
*Biomolecular and protein engineering •
Bioseparations*
- **Marvin Harris**, Process Technician
- **Susan Patterson**, Secretary

their varied backgrounds and prior experience, the Rowan team is well-respected by its peers in both scholarly and technical pursuits. Many of the faculty have received national awards and recognition. Four (Stephanie Farrell, Robert Hesketh, James Newell, and Stewart Slater) have received the Dow Outstanding New Faculty Award, and four (Kevin D. Dahm, Stephanie Farrell, Robert Hesketh, and James Newell) have been recognized with the Ray W. Fahien Award of ASEE. ASEE's Joseph J. Martin Award has been given to Rowan faculty four times, and James Newell and Kevin Dahm have won a PIC-III best paper award. In 2004, Stephanie Farrell was selected to receive ASEE's National Outstanding Teaching Medal, while Robert Hesketh was recently given ASEE's Robert G. Quinn award, recognizing his distinguished accomplishments in experiential education. Stewart Slater has received such honors as ASEE Fellow Member status, and the George Westinghouse, John Fluke, and Chester Carlson awards for innovation in engineering education.

Faculty have also assumed leadership roles in professional societies, most notably the Dean of the College of Engineering, Dianne Dorland, was President of AIChE. Robert Hesketh and Stephanie Farrell have chaired the Undergraduate Education group of AIChE, and Robert helped create the AIChE National Chem-E-Car competition and has been its emcee. Stewart Slater has chaired the Chemical Engineering and Experimentation and Laboratory-Oriented Studies Divisions of ASEE. Mariano Savelski has also chaired the Division for Experimentation and Laboratory-Oriented Studies, and Stephanie Farrell is Chair of the Mid-Atlantic Section of ASEE.

AWARD-WINNING STUDENTS

In the Department's short history, its students have distinguished themselves in many ways. When they start their career at Rowan, they have already passed through selective admissions requirements resulting in average SAT scores of 1240 and high school class ranking in the top 86 percentile. Every Rowan student works on multidisciplinary teams of students that are closely supervised by faculty, and many of these students have presented their work and won awards at regional and national meetings.

Students have obtained internships and full-time employment in a wide variety of companies in the pharmaceutical, food, chemical, petrochemical, and materials technology areas. They have been accepted into leading graduate programs at a variety of universities such as Delaware, Princeton, Clemson, Virginia Tech, Lehigh, Massachusetts, and Colorado State. In addition to pursuing advanced study in chemical engineering, students have gone on to graduate business schools and several have entered medical school.

INDUSTRIAL PARTNERSHIPS

Another unique characteristic of the Rowan chemical en-

gineering program is its strong partnership with industry. Ever since it was founded, there was the belief that a program with active involvement in industry would be a win-win situation for industry, faculty, and students alike. Its location in the New Jersey, Pennsylvania, and Delaware tri-state region has been an asset since many of the well known (and less well known) names in the field are located within a couple hours drive.

Partnerships with the department have developed in many ways. Involvement in the clinic program provides the most intimate interaction and has led to numerous successful projects. According to our industrial advisors, students who engage in an industrial clinic project and participate in an industrial summer internship program compare favorably to graduates with full-time job experience. For example, Johnson Matthey, Inc., the world's leader in precious metals processing, initially sponsored scholarships for the first engineering class in 1996. It has gone on to hire students for both part-time and full-time jobs and has provided continuous sponsorship of clinic projects since 1998.

Industry has also helped shape the curriculum. The department has sought industry input for the program's objectives, curriculum, and assessment efforts through its Chemical Engineering Industrial Advisory Board. It also routinely looks to industry for guest lecturers and adjunct faculty.

FUTURE DIRECTIONS

The College of Engineering continues to develop its programs in undergraduate education, particularly through the engineering clinics, and innovation in educational delivery. The delivery of experiential education will benefit from a new Technology Park that will house significant clinic activities in conjunction with developing technology ventures. Tenants of the Park will have access to the research, development, and commercialization expertise of the Rowan University engineering and business faculty.

External research and development funding from federal, state, and private sources to the College and Department has increased, fueled primarily by engineering's strength in its outreach to industry. The chemical engineering faculty obtained over a half million dollars in external funding last year. Many of these grants are in multidisciplinary areas of biotechnology, nanotechnology, advanced materials, sustainability, and engineering pedagogy.

Chemical engineering has always been a dynamic field and while universities must adapt to the shifting marketplace, the department will not waver from its focus on producing skilled problem solvers who are capable of functioning in teams on diverse projects that expand beyond a single discipline, and who can effectively communicate their findings to many different audiences. Our commitment to developing these new engineers remains steadfast! □