

Development of Multifunctional Laboratories in a New Engineering School

C. Stewart Slater, T. R. Chandrupatla, Ralph A. Dusseau and John L. Schmalzel
School of Engineering
Rowan College
Glassboro, NJ 08028

Abstract

Laboratories have been designed for the ultimate flexibility to serve the new Engineering School at Rowan College. A special feature of the new Henry M. Rowan Hall will be flexible laboratory modules that will allow for future modifications. The new engineering programs will be hands-on and team oriented and thus rely heavily on laboratory space to meet program objectives. Several examples of multifunctional laboratory spaces are those that can be utilized for clinic projects, multiple disciplines, teaching/research, and those that accommodate multiple course instruction.

Introduction

In 1992, Henry and Betty Rowan pledged a \$100 million gift to Glassboro State College [1]. Mr. Rowan is the founder and CEO of Inductotherm, Inc. which has headquarters in Rancocas, New Jersey. Inductotherm is the world's leading and largest induction melting equipment manufacturer with plants located internationally. The gift has challenged Rowan College with the opportunity to develop an innovative and forward looking engineering school. The Rowan School of Engineering will educate engineers who will serve as innovators and entrepreneurs for the future. As the State's comprehensive institution for Southern New Jersey, one of the missions will be to contribute to the economic growth of the region. With the help of the industrial community the School of Engineering will help set the pace for engineering education into the 21st century.

The Rowan School of Engineering offers baccalaureate degrees in Chemical, Civil, Electrical and Mechanical Engineering and a Master of Science in Engineering degree. From these classic disciplines new directions emanate through technology focus groups. Currently the technology focus groups are

- Manufacturing / Processing Engineering
- Environmental Engineering
- Information / Communications Engineering
- Computer Engineering / Robotics

The technology focus groups will provide for the maximum interdisciplinary interaction among students for projects and in technical electives and required courses. These areas will be continuously monitored to stay on the leading edge and to change focus topics as technology advances. The School is not highly structured with formalized departments to foster the greater multidisciplinary aspect of the educational process.

The Engineering School will begin undergraduate classes in Fall 1996, which will form the founding group of students, the "Class of 2000." Students have been recruited from the Middle Atlantic and Northeast



regions of the country for the first class which will consist of about 60 students. Steady state undergraduate enrollment plans are for 450 students. The school is targeting applicants that are calculus ready, in top 20% of their high school classes with SAT scores of 1200 and above.

The multidisciplinary aspect of the Rowan educational experience will produce a uniquely qualified professional. In addition to individual program requirements for discipline accreditation, the school will promote a high level of multidisciplinary education. This will be through engineering clinics that are vertically integrated throughout the curriculum. These clinics will present a broad-based approach to engineering in the lower level and progress in depth and in technological and industrial relevance as the student progresses through the program. The nature of the clinics will allow students and faculty to work together in a hands-on project environment that promotes teamwork to find solutions in complex multidisciplinary projects.

Shortly after the Rowan gill a National Advisory Council [2] was formed to help in the preliminary design of the curriculum and facilities. The key components of the Rowan program are focused on technical excellence, communication skills, and a well-rounded general education. This is achieved through undergraduate programs that include the following elements [3], many of which are recommended by ASEE's recent project report, *"Engineering Education for a Changing World"* [4].

- Strong foundation in mathematics and basic sciences
- Strong engineering core program to provide inter/multidisciplinary experiences
- Technology focus area approach to add depth and accommodate rapidly changing technology
- Integrated curriculum emphasizing engineering applications beginning in the Freshman year
- A "hands-on" project oriented approach to engineering
- Team work and cooperative learning throughout the curriculum
- Strong commitment to the Humanities, Social Sciences and Arts
- Strong commitment to integrate communications throughout the curriculum
- Extensive use of computers throughout the curriculum
- Exposure to business principles in engineering

Collaborations with industry and guidance from an Industrial Advisory Board will help develop and maintain a leading-edge School of Engineering. Summer internships for students with local industry will start in the summer after the Freshman year. Industry will be solicited to direct and sponsor clinic projects for students. These projects will use the flexible laboratory space as described below.

Engineering Building

The 93,000 sq.ft. \$30 million Henry M. Rowan Hall is a 3 story building that has been designed for maximum flexibility for use today and into the future. It has a flexible module design, where all spaces are based on a unit that is repeated throughout the building. The modules can be used as a classroom or laboratory space or a combination of both. The laboratory modules measure 22 x 40 ft. Modules can be easily joined so that a large work space can be accommodated. In reality, an entire wing of a floor could be opened-up into one contiguous space. The principal architect on the project is Mr. Terry Steelman of the Philadelphia-based firm Ballinger Co.

Each module has technology spines which are conduits that run through the floor. The technology spine is actually a multiple channel conduit that sits in a recessed floor trench that contains air, vacuum and water. Other process fluids such as specialty gases could be transported if needed. Electrical power and computer connectivity are also floor accessible. Since all utilities come from the floor, the functionality and aesthetics of the laboratory space are met and only those experiments requiring utilities need be connected. The technology



spine is covered by removable plates at 4 foot intervals allowing utility connections to be made to laboratory table or equipment.

The benchwork and casework for the laboratory modules has also been developed with the goal of flexibility. The benchwork concept developed by GPR Laboratory Planners (White Plains, NY) is a metal support frame on which various forms of upper and lower drawers, cabinets, and supports can be added. The benchwork is known as “smart benches” by their developer. The most important feature of the design is that the benchwork is not permanently mounted to the floor or permanently connected to the utilities. The benches can be repositioned and the connections to the trench utilities are through quick-connections. Therefore a laboratory module can be set-up in one semester with benches of various configurations around a perimeter and the next semester move them to form “islands” or make a “peninsula” in the laboratory space.

Chemical Engineering

Chemical engineering students will be utilizing some of the multidisciplinary project space as is found throughout the building and in specific areas. The laboratory experience for chemical engineering students is integrated directly with courses rather than having a stand-alone unit operations or senior laboratory as most schools have. Students also obtain laboratory experience through their clinics, which become more technology focused and industrially based in their junior and senior years. The integration of the laboratory experience in the courses and various uses of laboratory space for project and research activities makes the flexible laboratory concept a must. Future faculty interests and changes in technology are accommodated in this manner.

Several laboratory areas have been developed that will serve the needs of required chemical engineering courses, multidisciplinary technical electives and technology focus projects in process engineering. One of the laboratory spaces that does not neatly fall into the standard laboratory module layout is the Separations Laboratory. This module is a high bay that is designed to accommodate many of the pilot-scale equilibrium-staged and rate-controlled separation processes that require more vertical room than the normal module height. This module is one of only a few in the building with process steam. These units are typically free-standing so minimal benchwork will be required and the experiments will be placed along the perimeter of the laboratory. These experimental units will be dual purpose so that they maybe utilized both for instruction to support the courses and for project based activities. Although the primary use of the laboratory will be for several senior courses, students in lower level courses will use the lab to examine the differences between bench and pilot-scale unit processes.

Laboratory space has been allocated for Reaction Engineering and Novel Processing to support both courses and project work. Experimental units involving basic kinetics and reactor design will be included in addition to some more novel areas of catalysis technology. These experiments can be computer integrated so the students can learn about process dynamics and control. Bioprocessing experiments will also be included in areas such as fermentation and downstream processing. While some of aforementioned bench-scale biotechnology units can be set-up using the laboratory benchwork, others have been planned for in advance. A walk-in hood has been included for projects in supercritical fluid extraction. Some point source exhausts have been incorporated for pervaporation, vapor permeation and novel combustion systems. Experiments in bulk solids processing, food and beverage processing, chemical thermodynamics, process safety, and electrochemical engineering processes are also planned.

Laboratory space for the instruction in the various transport processes will serve many disciplines and functions. Transport, a.k.a. transfer processes include momentum, heat and mass transfer and combinations thereof. The ultimate flexibility is needed here as various courses will use this laboratory to aid in the hands-on



portion of instruction. Experiments for core courses in heat and mass transfer will serve multiple disciplines and the majority of experiments will reinforce basic concepts. This will be complemented by advanced experimental units for topics such as transport phenomena that combine all the transfer processes. Additionally, clinic projects related to transfer processes can be conducted here. Some of the basic principles of material and energy balances will also be demonstrated in this laboratory for the sophomore level introductory chemical engineering core course.

Civil Engineering

The Civil Engineering Laboratory will provide lab space for three critical areas within the Civil Engineering program: 1) technology focus courses and research, 2) discipline courses and research, 3) student team projects. The Civil Engineering laboratory will initially use three of the standard 22 x 40 ft. modules plus a laboratory support area of 22 x 12 ft. The three contiguous modules will form an open area of 66 x 40 ft. The open area will be separated into two equal halves by a small classroom area that will seat 18 students and will include a media board and projection screen.

One half of the Civil Engineering Laboratory will be dedicated to the Environmental Engineering option within the Civil Engineering program. Courses and research conducted in this section of the lab will include water and wastewater treatment, solid and hazardous waste management, groundwater remediation, hydraulics, and hydrology. The other half of the Civil Engineering Laboratory will be dedicated to the Infrastructure Engineering option within the Civil Engineering program. This section of the lab will be used to conduct courses and research in the traditional areas of geotechnical engineering (soil mechanics) and civil engineering materials (concrete and asphalt). The laboratory support area will be dedicated to computer workstations and experiments for student project teams, graduate research, and transportation engineering education.

The classroom area within the Civil Engineering Laboratory will be centrally located and will be served by 30 rolling lab benches which will comprise approximately half of the total benchwork within the lab. These rolling benches will be used to bring experimental equipment, scales, and other equipment to the classroom area for laboratory instruction purposes. In this way, the classroom will serve as the hub or center of activity of the laboratory around which all or most of the formal instructional labs will take place.

Electrical Engineering

The traditional collection of electrical engineering labs that might be expected to be found in large, well-established programs might be expected to consist of: electronics, digital systems, controls, communication, digital signal processing, power, solid-state, and various project and research labs, etc. This list exceeds the available space that can be dedicated to each of these areas. Thus, accommodating electrical engineering laboratories in the building will consist of a balance between lab areas with a nearly exclusive discipline focus, combined with space sharing for project, research, and interdisciplinary work. Laboratories can also be organized to meet application areas. For the Rowan EE program, this provides the most obvious structural input since a number of the initial technology focus areas are strongly related to electrical engineering. Specifically, information/communication, computer engineering/robotics, and manufacturing/process engineering, all imply strong EE involvement.

The Communication & Information Engineering Laboratory will provide equipment and resources to support electronics, communication, and digital signal processing. Combining electronics and communication together is particularly useful since there are numerous opportunities available for developing basic electronic circuits that perform fundamental communication functions. A related consideration is that of bandwidth.



Communication electronics can be developed at essentially any bandwidth, but the higher frequencies associated with practical communication systems such as wireless, require high-frequency electronics. Low-frequency electronics traditionally associated with instrumentation, can also be accommodated in this lab facility; however, more measurement-oriented lab work will be coordinated with mechanical engineering.

A Computer Engineering & Robotics Laboratory provides the equipment to conveniently support digital systems, microprocessors, and controls. In addition, the sensor/effector aspect of robotics provides another opportunity for instrumentation. This lab area is also closely tied to the third focus area: manufacturing and process engineering. However, manufacturing/process engineering is viewed as being more closely tied to mechanical (computer-integrated manufacturing) and chemical (processing) engineering, so will receive predominant support from lab facilities in those programs.

Design project and research needs will have to be met through sharing of these and other lab spaces. One feature of the labs that will also be helpful is the availability of a “prep/storage” room at the back of each classroom module. Located adjacent to laboratory modules, these 250 sq. ft. rooms provide additional graduate student and faculty research space.

Mixed use of computer laboratories will also satisfy substantial EE program needs. There is a computer laboratory on each floor of the building. The first-floor computer lab is a two-module lab that will house personal computers and workstations in support of all four disciplines. The second-floor computer lab can also be used to support interfaces to digital system boards and development systems. Interfacing applications for measurements and control can be piggy-backed on the third-floor computer lab.

Mechanical Engineering

Mechanical engineering laboratories cover areas of design, manufacturing, heat, power, and fluid science. The closest interaction among the various branches of engineering is evident in shared equipment in various laboratories. Experiments in heat transfer are shared with mechanical and chemical engineering, and those in fluid mechanics are shared with civil, mechanical and chemical engineering. A materials laboratory consists of equipment for experimenting in processing and testing of different types of materials such as metals, polymers and ceramics. Equipment for the evaluation of metals include polishing and etching, and various microscopes. A universal tensile testing machine and data acquisition facilities will be installed in a high bay area. The thermodynamics laboratory includes experiments in heat engines, refrigeration, and air conditioning. There is a separate area designated for engine testing with dynamometer facilities.

Students will carry out engineering clinic projects from conceptual stages to design and production. Ideas in tolerance, quality, experimental design, invention and innovation will be presented in the clinics. The school will work closely with neighboring community and county colleges to make use of some unique state supported facilities. Students will get hands-on machining and production methods during the freshman and sophomore years. Computer aided machining facilities will be used in the production of prototype components.

Computer labs will support all disciplines with high powered PCs and workstations. AutoCad and other state-of-the-art computer aided design (CAD) and computer aided machining (CAM) software will be available to support laboratory and lecture activities. Part design and computer simulation of production will be carried out here. Facilities to support student project work include a machine shop, woodworking shop, and welding shop.



Conclusions

Very few institutions have the opportunity to develop a new engineering school from the ground-up. There are certainly many challenges and opportunities ahead as the Rowan Engineering School builds its program. The building must be designed to take into account the overall needs in curriculum, faculty, students, and industrial partnerships. Forecasting future needs is a difficult task and therefore a flexible design is the best concept to accommodate the many changes in technology that lay ahead.

References

1. H.M. Rowan and J.C. Smith, *The Fire Within*, Penton Publ., Cleveland, OH, 1995.
2. *Engineering Education for the 21st Century*, Rowan College, 1994.
3. *Rowan School of Engineering - A Blueprint for Progress*, Rowan College, 1995.
4. *Engineering Education for a Changing World*, Joint project report by the Engineering Deans Council and Corporate Roundtable of the American Society for Engineering Education, Washington, DC, 1994.

Biographic Information

C. Stewart Slater

C. Stewart Slater is Professor and Program Chair of Chemical Engineering at Rowan College. Prior to joining Rowan he was Professor of Chemical Engineering at Manhattan College. Dr. Slater's research and teaching interests are in separation and purification technology, laboratory development, and investigating novel processes for interdisciplinary fields such as biotechnology and environmental engineering. He has authored over 50 papers and several book chapters. Dr. Slater has been active in ASEE, having served as Program Chair and Director of the Chemical Engineering Division and has held every office in the DELOS Division.

T.R. Chandrupatla

T.R. Chandrupatla is Professor and Program Chair of Mechanical Engineering at Rowan College. Previously he was Professor of Mechanical Engineering and Manufacturing Systems Engineering at GMI Engineering and Management Institute. He has additional faculty experience at the University of Kentucky and the Indian Institute of Technology in Bombay. Among Dr. Chandrupatla's interests are the study of finite element analysis, design optimization, and manufacturing engineering. To educate others and to enhance development in these areas, Dr. Chandrupatla serves as a consultant to industry and has published many research papers. He holds two U.S. Patents and is the author of the widely used text, *Introduction to Finite Elements in Engineering*.

Ralph A. Dusseau

Ralph A. Dusseau is Professor and Program Chair of Civil Engineering at Rowan College. Prior to his appointment he was a faculty member in the Civil & Environmental Engineering Department at Wayne State University in Michigan. His area of expertise is finite-element modeling and analysis and he has over 20 publications. At Wayne State, Dr. Dusseau won eight awards for teaching excellence and five awards for service. He has industrial experience with Bechtel Power Corporation and Ghafari and Associates.

John L. Schmalzel

John L. Schmalzel is Professor and Program Chair of Electrical Engineering at Rowan College. Previously he was with the University of Texas at San Antonio in the Division of Engineering. He has been involved in the field of instrumentation development for 20 years; this work has included development of data acquisition systems and other microprocessor-based instruments to support research in a number of areas; e.g., cardiovascular, cardiopulmonary, gastroenterology, and urology. He has authored numerous papers and a book chapter. He is active in laboratory development; his NSF-ILI project work has been reported on at ASEE regional and national conferences

