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Creating an Entrepreneurial Culture at a Startup Engineering Program

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Abstract - *In 1992, the College of Engineering at Rowan University was created as the direct result of a $100 million gift from entrepreneur Henry M. Rowan. Mr. Rowan's requirements were that the gift be used to create a high-quality, public undergraduate engineering institution and to impact the economic development of southern New Jersey, a region which has historically lagged behind northern New Jersey. Having started with a clean curriculum slate during a period of national change in engineering curricula in response to ABET 2000, we had the opportunity to infuse an entrepreneurial culture into our engineering program from its inception. Specifically, we have developed the following policies/programs:*

- *Created an 8-semester Engineering Clinic course sequence in which hands-on design projects are completed every semester.*
- *Developed a "job-fair" model for student clinic project staffing in which students get "hired" into their Engineering Clinic projects by marketing themselves and their capabilities to faculty,*
- *Created an Undergraduate Venture Capital Fund where students can obtain funding up to $2500 per semester to develop their own original inventions,*
- *Created the Competitive Assessment Laboratory for competitive benchmarking of consumer products.*
- *Developed a micro-business model in which some Engineering Clinic project teams provide engineering services (design, fabrication, modeling, etc.) to other projects,*
- *Hired (College of Business) an endowed chair in entrepreneurial studies,*
- *Created the Technological Entrepreneurship Concentration, which is a certificate program that will be populated jointly by Engineering and Business students,*
- *Obtained state funding to build the South Jersey Technology Park and Technology Business Incubator adjacent to the Rowan campus.*

This paper will describe the impact of each of these initiatives toward creating an entrepreneurial culture in our undergraduate students. It should be noted that many of these initiatives do not require a new program or major curriculum reform. Rather, our results suggest that it is possible to start with some small initiatives and build upon each initiative as the momentum for entrepreneurship develops.

Introduction

In 1992, the local industrialist Henry M. Rowan made a $100 million donation to the then Glassboro State College with the ambitious goal of establishing a high-quality engineering school in southern New Jersey. To achieve this goal, the university appointed a National Advisory Council in 1993 chaired by Simon Ostrach of Case Western Reserve University and including prominent leaders in engineering academia such as the late C.L. Tien of University of California, Berkeley and deans of engineering at M.I.T, University of Colorado, Illinois, Cornell

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and Texas[1]. The advisory council helped to create a blueprint for the university to design a bold and innovative engineering curriculum and to infuse entrepreneurship into every level of the curriculum.

From 1994 through 2001, beginning with the recruiting of founding Dean James Tracey, a diverse 32-member faculty was recruited from top engineering programs such as Stanford, Princeton, Cornell, M.I.T., Michigan, Texas, and Penn State. The present faculty has a diverse set of skills and expertise but shares a common vision of multidisciplinary project-based learning. The current full-time tenure track faculty roster is 25% female and is led by Dean Dianne Dorland, who joined Rowan in 2000.

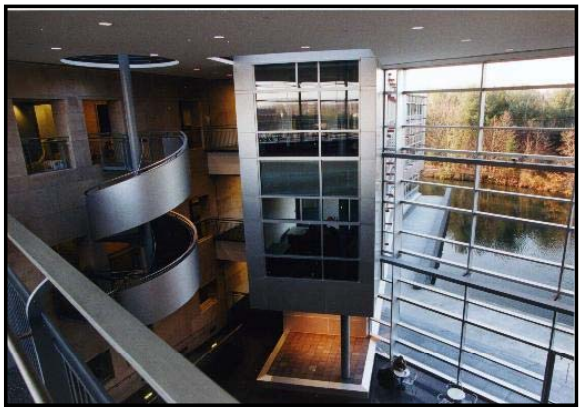


Figure 1. A view from the atrium at Henry M. Rowan Hall. The $28 million, 95,000 sq. ft. facility was completed in Jan. 1998.

Henry M. Rowan Hall opened in January 1998, and was dedicated that April. The $28 million, 95,000 sq.ft. building was designed to accommodate seamless integration of teaching, research and project-based learning. Figure 1 shows a view from the atrium of Rowan Hall. Classrooms have easy access to laboratories and laboratory-support rooms. Non-load-bearing walls separate classroom and laboratory modules so that they can be easily modified. The building contains a technology spine, which is a key to the building's flexibility. The technology spine consists of a covered trench in classroom and laboratory modules. This trench contains utilities and cables for ready-use in the modules. Computers networked throughout the building allow students and faculty to make optimum use of computer technology.

Today, the College of Engineering at Rowan University is composed of four programs: Chemical Engineering (ChE); Civil and Environmental Engineering (CEE); Electrical and Computer Engineering (ECE); and Mechanical Engineering (ME). Each program has been designed to serve 25 to 30 students per year, resulting in 100 to 120 students per year in the College of Engineering. The size of the college has been optimized such that it is large enough to provide specialization in separate and credible programs, yet small enough to permit the creation of a truly multidisciplinary curriculum in which laboratory/design courses are offered simultaneously to all engineering students in all four disciplines. In 2000, the inaugural class of 85 students graduated (with a retention rate of 85%) and, in the following year, each of the four programs received accreditation under ABET 2000.

In addition to the challenge from Mr. Rowan, the curriculum at Rowan Engineering was also heavily influenced by a growing national movement to reform undergraduate engineering education, which gained momentum during the same period and culminated with the new ABET 2000 criteria. Also, during this same period a national movement toward incorporating entrepreneurship into engineering curricula also began. A grant from the Lemelson Foundation established the National Collegiate Inventors and Innovators Alliance (NCIIA) in the mid 1990s with the mission to nurture a new generation of innovators by promoting curricula designed to teach creativity, invention, and entrepreneurship.[2] A new Entrepreneurship Division of the American Society of Engineering Education followed in 1999 and grew from 15 to 201 members in its first 2 years of existence[3].

Thus, having started with a clean curriculum slate during a period of national change in engineering curricula, Rowan University had the unique opportunity to infuse an entrepreneurial

culture into its College of Engineering from its inception. Specifically, the following policies/programs have been developed:

- Created an 8-semester Engineering Clinic course sequence in which hands-on design projects are completed every semester[4],
- Developed a "job-fair" model for student clinic project staffing in which students get "hired" into their Engineering Clinic projects by marketing themselves and their capabilities to faculty,
- Created the Competitive Assessment Laboratory for competitive benchmarking of consumer products[5],
- Created an Undergraduate Venture Capital Fund where students can obtain funding up to $2500 per semester to develop their own original inventions[6],
- Developed a micro-business model in which some Engineering Clinic project teams provide engineering services (design, fabrication, modeling, etc.) to other projects[7],
- Hired (College of Business) an endowed chair in entrepreneurial studies,
- Created the Technology Entrepreneurship Concentration[8,9], a certificate program that will be populated jointly by Engineering and Business students, and
- Obtained state funding to build the South Jersey Technology Park and Technology Business Incubator adjacent to the Rowan campus.

Each of these initiatives will be described briefly below in this paper. Many of the initiatives described in this paper are made possible by development of the Engineering Clinic sequence taken by all engineering students at Rowan. The Engineering Clinic will be described in the following section.

The Engineering Clinic

The multidisciplinary, project-based Engineering Clinic sequence is the hallmark of the engineering program at Rowan University is the multidisciplinary, project-oriented Engineering Clinic sequence. The Engineering Clinic is a course that is taken each semester by every engineering student at Rowan University. In the Engineering Clinic, which is based on the medical school model, students and faculty from all four engineering programs work side-by-side on laboratory experiments, design projects, applied research and product development. The following table contains an overview of course content in the 8-semester engineering clinic sequence. As shown in the table, while each clinic course has a specific theme, the underlying concept of engineering design pervades throughout[10].

Most engineering programs currently include a Capstone Design course to meet the design needs, but this approach has some shortcomings. In a one- or two-semester long course, the need to include such varied skills as communications, project management and teamwork necessarily takes away from the focus on design skills development. Furthermore, the traditional Capstone Design course is not multidisciplinary, which is a valuable experience for preparing students for the workplace. Finally, since the Capstone project occurs at the end of a student's undergraduate career, it does not allow students to continuously apply skills learned in the supporting coursework. The Engineering Clinic allows students to practice a wide range of engineering skills in a multidisciplinary environment while honing their design skills throughout their four-year career.

Table 1. The 4-year Engineering Clinic Sequence at Rowan University[11].

Year	Fall	Spring
Freshman	Engineering Measurements	NSF Competitive Assessment Laboratory
Sophomore	Total Quality Management / Written Communication	Entrepreneurship / Public Speaking
Junior	Multidisciplinary Design Projects	Multidisciplinary Design Projects
Senior	Multidisciplinary Design Projects	Multidisciplinary Design Projects

In the first semester of the freshmen year, students learn basic engineering skills (problem solving, teamwork fundamentals, engineering measurements and computer tools) and are introduced to the variety of activities in each of the four disciplines at Rowan (Chemical, Civil and Environmental, Electrical and Computer, and Mechanical Engineering). In the second semester each student engages in an intense study of engineering design through reverse engineering and competitive assessment (instrumentation, testing and side-by-side comparison of technical performance) of a consumer product.

In the sophomore year, the emphasis of the Engineering Clinic shifts toward formal training in technical communications skills and the application of design. The students are organized into "corporations" that design and build products using advanced design and prototyping tools, and they develop speaking and writing skills through embedded assignments. Professors from the College of Communication at Rowan teach along side the engineering professors during this year and are responsible for evaluating the students' progress on achieving the communications objectives for the course. Past projects have included electromechanical devices for crack detection in aircraft skins, guitar effects pedals, small-scale bridges[10], and a biological fuel cell powered robot.

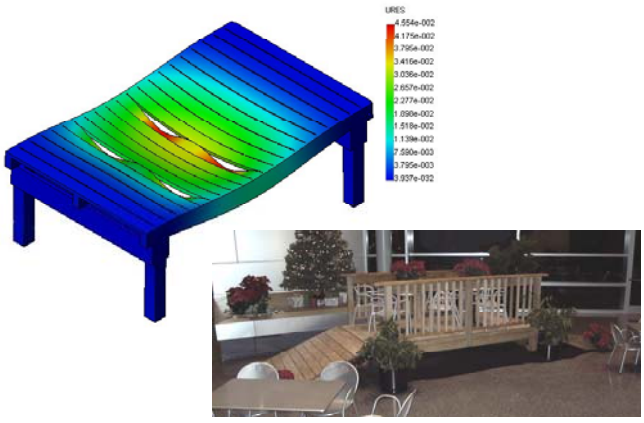
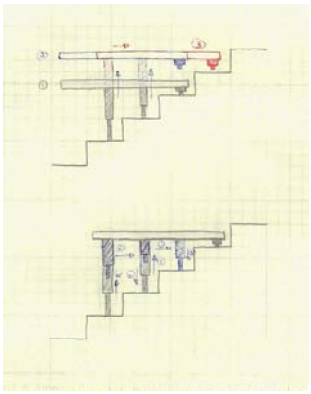
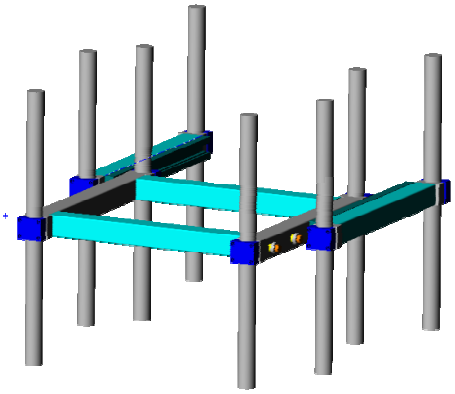


Figure 2. Examples of the Backyard Bridge, a Sophomore Clinic design project[10].

In the final four semesters of a student's career, the Engineering Clinic continues with the format of multidisciplinary teamwork with the added dimensions of year-long projects and the inclusion of both Junior- and Senior-level students in 3-5 member teams. Each multidisciplinary team works closely with two professors (usually from two disciplines) who act as Project Managers to guide the team. In Mechanical Engineering, Junior/Senior Engineering Clinic projects are guided by the mantra of "Design, Build, Test". Figure 3 shows an example of this process, as applied to the development of a human-powered stair-climber, which is an on-going project funded by a local patron with a personal interest in the device.

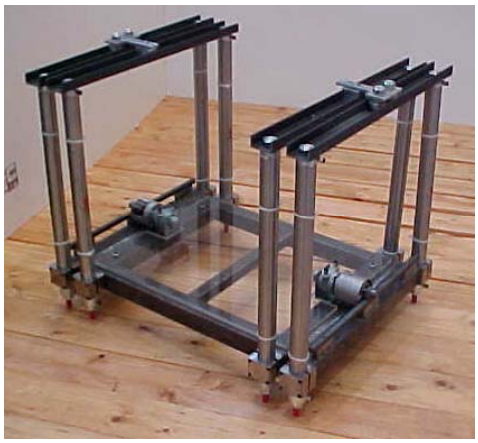


(a)



(b)

(c)



(d)

Figure 3. The "design, build and test" product realization process in the Engineering Clinic at Rowan University showing initial design (a), modeling (b), construction (c), and final product (d).

In general, Junior/Senior Clinic projects are inspired by a mix of industry-sponsored activities and professors' interests, and typically centered on a technical problem, product or process. Funding comes mainly from government and private sources in the form of industry and research grant sponsorship. Each department and the College of Engineering devote significant time throughout the year to make industry contacts and develop proposals to seek funding for the Junior/Senior Clinic projects. Since 1998, when the Junior/Senior Clinic was first offered, the portion of projects that are externally funded have risen from approximately 20% to over 90% in the current semester.

The Clinic Job Fair

Since many projects have an industry sponsor (typically a small local company) who demands real deliverables, virtually all Rowan engineering students are exposed to the ideals of entrepreneurship by participating in 4 consecutive semesters of Junior/Senior Engineering Clinic. To further foster the spirit of entrepreneurship, we require each student to market themselves and their skills/capabilities to the faculty project manager in order to be "hired" into the project of their choice. Specifically, at the beginning of each semester, all faculty members in the College participate in the "Job Fair," in which brief two-minute presentations are made for each project. Using the "Job Fair" model, mechanical engineering projects requiring, say, electrical engineering support can recruit team members to the project.

The Venture Capital Fund (VCF) at Rowan University

Engineering programs often attract many of our brightest and most creative high school students who dream of becoming the next Thomas Edison or Bill Gates. Such students often make early exits from engineering programs after spending their first two years besieged by the necessary, but seemingly irrelevant, mathematics and science requirements. As described above, the Engineering Clinic features a mixture of projects funded by industry and faculty research interests. Clearly, projects such as these are central to developing the design and problem solving skills that are lacking in the typical engineering curriculum. However, these real-world projects still fall short of expectations for the student who enters engineering with desire to invent.

One way to promote the entrepreneurial spirit is to provide students with the opportunity to propose their own original enterprises. Accordingly, we have created the Undergraduate Venture Capital Fund (UVCF), specifically ear-marked for the development of original products by multi-disciplinary student teams within the Junior and Senior Engineering Clinics[6]. The UVCF has been generously supported by a series of grants by the NCIIA.

Funding of up to $2500 per semester is competitively awarded to student teams based on student-generated proposals to the UVCF. To be funded, a student proposal must describe an enterprise that meets the following criteria:

- The team must be multidisciplinary, including engineering students from at least two disciplines and, if possible, a student from outside engineering.
- The team must be organized into a company and must submit a business plan.
- The team must appoint a project director from the College of Engineering, an advisor from the College of Business, and an advisor from industry.
- The enterprise must consist of an original product idea that can be successfully designed, developed and prototyped in a single semester.

The latter criterion is possible given the unique set of rapid prototyping resources in place at Rowan University created in part by two separate NSF grants. The Competitive Assessment Laboratory (NSF DUE-9850563) features dedicated test stations for the complete engineering assessment of consumer products. Stereolithography: A Distributed Partnership (NSF DUE-9751651) has created a rapid prototyping center featuring a 3-D systems SLA-250 stereolithography machine, an ThermoJet multi-jet modeling (MJM) rapid concept modeler, and a QuickCircuit rapid circuit prototyping machine. In addition to the externally funded projects described above, the College of Engineering has developed a state-of-the-art fabrication facility featuring advanced CNC and manual machine tools.

Each semester, the Junior/Senior Engineering Clinic has a total enrollment of approximately 200 students distributed equally from each of the four engineering disciplines. However, all of the

students do not embark on an entrepreneurial endeavor as described above. The competitive UVCF proposal process, which rewards only those with original and thoroughly planned ideas, requires a significant effort at the start of the semester. In short, it is much easier for students to get "hired" into an industry- or faculty-sponsored project. However, with the availability of real funding, and the prospect of managing their own funds for a semester, interested and committed students with good ideas and entrepreneurial spirit choose to submit proposals. Furthermore, as discussed in Ref. [6], these students generally devote more time to their projects and, by their own assessment, are required to perform more in-depth engineering analysis than their counterparts who are engaged in faculty sponsored projects.

During the past 4 years, UVCF proposals have been accepted from over 20 multidisciplinary student teams. This figure represents approximately 5% of the roughly 400 Junior/Senior Clinic projects completed during this same period. In total, 25 ECE students, 22 ME students, 7 CEE students, 4 ChE and approximately a dozen business students have participated in UVCF projects. To date, these projects have resulted in 3 startup companies and 2 patents pending.

Ref. [7] presents a detailed assessment of the first several years of the UVCF at Rowan. One way to assess the effectiveness of the UVCF is to assess the amount of effort that students devote to their project per week. The Junior/Senior Engineering Clinic formally meets 6 hours per week, but it is expected that students devote approximately 10 hours per week total to their projects. In UVCF projects conducted during the 1998-2000 period, 88% of respondents reported that they work more than 10 hours per week versus 42% for the non- VCF projects. Clearly, students who work on the UVCF projects are generally more motivated than the average engineering clinic student. This is not altogether unexpected since, generally, only motivated students decide to submit proposals for UVCF funding. However, these are precisely the students who should be rewarded and allowed to work on project of their own invention. It is precisely this ownership that results in students working longer hours and utilizing a higher degree of technical expertise to complete their projects. One of the more successful endeavors is described briefly below.

Example UVCF Project: The SnoRhino™

The SnoRhino™ is an original student invention developed by Rowan Engineering students Jeff Gladnick '03, Matt Eberhardt '03 and Pete Boyle '03. Product development was funded from the Rowan/NCIIA Undergraduate Venture Capital Fund. Although there have been countless innovations in equipment for snowboarders, the student team recognized a need for modifying chair lift designs to accommodate snowboarders. The SnoRhino™ solves this problem, making the long ride up the mountain dramatically more enjoyable for snowboarders. The student team has incorporated as Uphill Enterprises and is in the process of marketing the SnoRhino directly to ski resort owners.

In Spring 2002, Uphill Enterprises received an Advanced E-Team Grant from the NCIIA to complete design of the pre-production prototype (See Figs. 4a and b). In Fall 2002, the student company obtained financing from a private investor to finance production of a mold for injection molding of the final production hardware. The first run of production hardware was completed in Nov. 2002 and the SnoRhino™ has recently undergone successful field-testing[12].

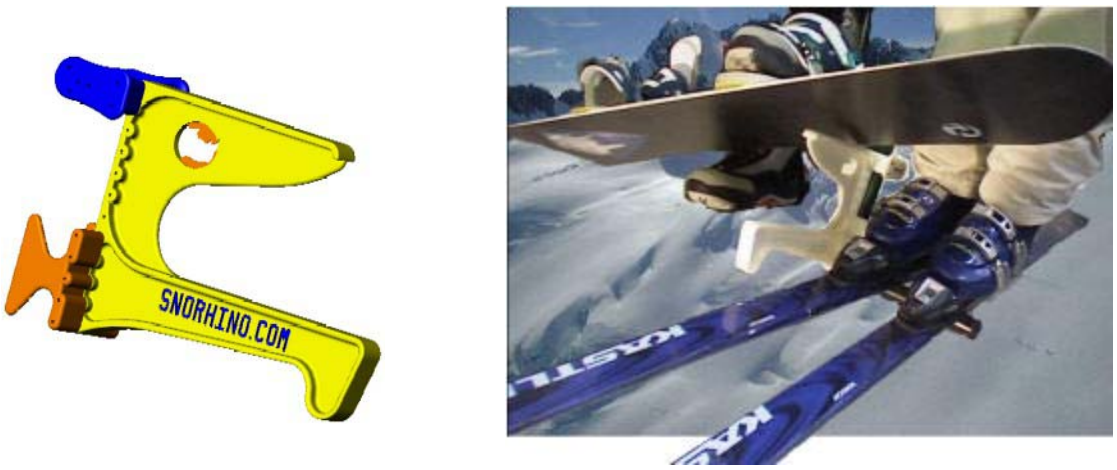


Figure 4. a) Solid model of pre-production SnoRhino™ prototype and **b)** prototype installation on ski-lift accommodating a snow boarder and skier[12].

The NSF Competitive Assessment Laboratory

For engineering students who are interested in developing their own ideas into engineered products, it is important that they have the skills and resources to evaluate currently existing product lines of their would be competitors. Indeed, it is imperative for any would be entrepreneur to keep abreast of the technological advances and design innovations incorporated into competing product lines. The term *competitive assessment* has been coined by manufacturers to describe the process of ethically acquiring, inspecting, analyzing, instrumenting and testing the product lines of other manufacturers. With the support of the National Science Foundation, Rowan University has created the Competitive Assessment Laboratory, which has been incorporated directly into the Freshman Engineering Clinic II, as described above.

In the Competitive Assessment Laboratory, multidisciplinary teams of freshman engineering students from each of the four engineering departments perform each of the above tasks on a consumer product. In addition to introducing freshman students to the science and art of design, the Competitive Assessment Laboratory is a resource that is available for all engineering students and local industry. The objectives of the Competitive Assessment Laboratory at Rowan University are as follows:

1) Provide the launching pad for an innovative, four year design curriculum by introducing freshmen to the science and art of design by evaluating the work of practicing designers,

2) Introduce multidisciplinary groups of freshman engineering students to unifying engineering science principles such as fluid mechanics, solid mechanics, thermodynamics, transport and electricity/magnetism using the consumer appliance as a test bed,

3) Enable freshman students to determine how scientific principles, material properties, manufacturing techniques, cost, safety requirements, environmental considerations and intellectual property rights impact the design of a product,

4) Allow freshman students to actively participate in a meaningful design effort by instrumenting and evaluating the performance of a consumer appliance,

5) Provide a facility for all entrepreneurial engineering students (and local industry) to perform competitive benchmarking studies on competing engineered product lines.

The Competitive Assessment Laboratory contains 5 consumer appliance test stations featuring PC-based data acquisition systems capable of measuring thermocouple and voltage/current signals. Each station is also equipped with mechanical measurement equipment and portable materials testing equipment. Each station is equipped with the following instruments:

- Dell Optiplex GX1 PC, with flat panel monitor
- HP34970A Data Acquisition/Switch Unit
- 20 thermocouple channels
- 12 analog voltage channels
- 4 digital I/O channels
- Valhalla 2100 Digital Power Analyzer
- 2 HP33120A Function/Arbitrary Waveform Generators
- HP54645D Mixed Signal Oscilloscope
- Keithley 2000 Multimeter
- HP3631A Power Suppy (0-6 V, 5 A; 0-25 V, 1 A
- Hand tools, inspection equipment, instrumentation, soldering station, etc.

Each PC is configured with LabView, HPVee, Office 2000, etc. and all HP instrumentation is linked with the computer via HPIB interface. The mobile test stations are also outfitted with wireless Internet cards so they can be deployed anywhere in Rowan Hall. Figures 5a and 5b show one of the Competitive Assessment Stations and a powered stair lift undergoing benchmarking testing.

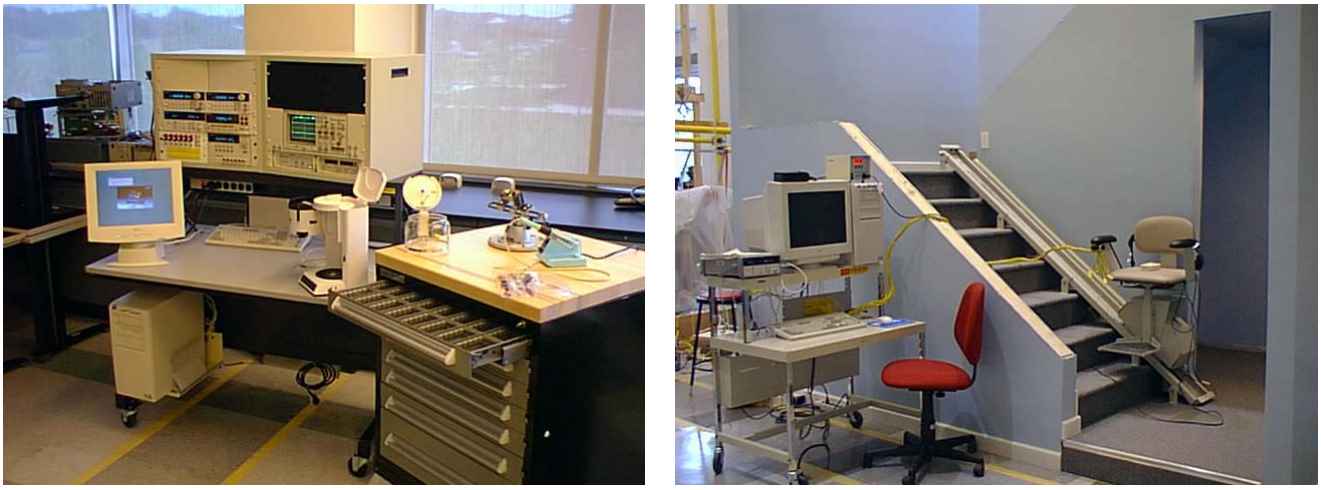


Figure 5. a) Competitive Assessment test station and **b)** electric stairlift undergoing competitive assessment testing.

To date, consumer appliances such as coffee makers, electric toothbrushes, hair dryers, bread makers, water filters, blood pressure monitors, carbon monoxide sensors, electric stair lifts, etc. have been instrumented and tested in courses such as Freshman Clinic II, Design for X, and Junior/Senior Clinic. In addition to incorporating the Competitive Assessment Laboratory into coursework, the laboratory has been used by local industry who are interested in competitive benchmarking of competitor's products but do not have the in-house capability.

Entrepreneurship and Engineered Services: The μ-Business Model

Although engineering students often think about inventors and innovators in terms of developing engineered product, the reality is that many entrepreneurs provide engineered *services*, rather than develop engineered products. During the fall 2000 semester, the College of Engineering

began to plan on alternative models to improve our ability to support prototype development via an internal student company that would market their product development capabilities to other Engineering Clinic teams. These ideas gelled in the form of an integrated product team that would provide the major prototyping resources all tied together in one organization. The ideas were solidified after a visit to a local defense electronics company that is organized along *Micro-Business* (μ-Business) lines. Their company has been transformed to a collection of small business units that are each separately budgeted and fiscally accountable. Advantages of the approach include the ability to rapidly respond to new business requirements by adding new units or modifying an existing μ-Business. Employees take ownership of their μ-Business and are more directly involved with operation and management of their work.

The initial experiment with a μ-Business model in the Rowan engineering program was begun in the spring semester of 2001. The μBusiness student group was formed with eight students. The mission of the μBusiness is to provide timely, high quality services in support of project requirements for engineering design and fabrication services. The company consists of a CEO and 4 separate sub-divisions that focus on electronics hardware, software, marketing and mechanical design. Each of these functions is summarized below:

- *CEO.* One student is designated as the CEO of the μBusiness. His or her responsibilities include ensuring that the experiment is aggressive and stay on track. He or she directly coordinates with three supervising faculty.
- *Electronics Hardware.* Electronics design and fabrication capabilities are primarily focused on design circuits and producing prototypes. We have a “Quick Circuit” PCB mill that allows very simple boards to be made; however, for high-quality boards with plated-through holes are sent out for fabrication. This incurs a substantial tooling charge (typically $300) for high-quality boards with silkscreens, etc. We have in-house PCB design capabilities using fully integrated tools; some of the on-line web houses provide software for layout. *Software.* Many projects require some type of software development. This may range from firmware for embedded microcomputer-based applications, to visual interfaces for PC-based systems.
- *Marketing.* The μ-Business strives to attract clients through marketing of their products and services to other project teams. This consists of a web presence and direct marketing efforts.
- *Mechanical Design.* The major thrust of mechanical design is to provide customers with package and mechanism design services. At Rowan, our students design 3-D solid models in SolidWorks, perform stress analysis using the finite element model plug-in Cosmos Works, export the model to our ThermoJet rapid concept modeler or stereolithography machine for a quick 3D model, iterate on the process, then export the completed part to MasterCam to prepare the model for CNC machining. The entire process can be performed in several days.

The Rowan Center for Innovation and Entrepreneurship

As described above, the UVCF has been supported by NCIIA Grants and has resulted in development of 20 student inventions, 2 patents pending and 3 startup companies since 1998. Unfortunately, with the possible exception of the SnoRhino™, the rate of success of bringing undergraduate engineered products to market has been hindered by the lack of business expertise on the projects. As described in the next several sections, the university has taken ambitious steps to create an environment for undergraduates to convert their intellectual property into successful business ventures.

The first step in the transforming the concept of entrepreneurship from a small College of Engineering initiative to a campus wide culture was the creation of the Rohrer Chair for Entrepreneurial Studies and appointment of K. Mark Weaver to this endowed chair position. The development of the Rowan Center for Innovation and Entrepreneurship is the second step for 2002. To begin to fulfill the mission of creating a campus-wide entrepreneurial culture, the Center hosted an Entrepreneurial Boot Camp for non-business faculty in 2002 as its first interdisciplinary effort. Faculty from engineering, communications, education, sociology, instructional technology, computer science and liberal arts developed model programs, products, institutes, and business opportunities.

The Technology Entrepreneurship Concentration

With the Rhorer Chair and Center for Innovation and Entrepreneurship in place, the missing ingredient was a curriculum that leveraged and integrated the campus-wide strengths in place at Rowan. In Spring 2002, a integrated business and engineering curriculum proposal was developed to address these issues. The Technology Entrepreneurship Concentration (TEC) is a concentration and certificate program that integrates the core entrepreneurship concepts that increase the chances of success that reside in the College of Business with the outstanding Clinic/project orientation that exists in the College of Engineering. Two new elements include: 1) the opportunity analysis/business plan and 2) entrepreneurial finance and legal issues. In addition, use of an elective course selected from existing engineering courses and a new course in Management Consulting in the College of Business is used to fulfill the 12 credit hour concentration and certificate program.

All four courses in the TEC program are team-based courses. The logic is that one person does not posses all of the knowledge and skills needed to create and launch a successful business. Combining the talents and skill sets from the multiple colleges is a way to enhance the performance of each team. Exercises from books like *What a Great Idea,* Inc.s *How to Really Start Your Own Business*, and repeated iterations of exercises shapes ideas into high potential ventures. The goal is to think about “problems” that need solving rather the possible technology. This opportunity/need focus is a basic entrepreneurial tenant and underlines the need for the integration of the business and technology approaches. Exposure to College Advisory Boards provides business owners and key advisors to help students develop an entrepreneurial view of a venture.

As shown in Fig. 6, the core for the TEC program is the successful existing Clinic model that is project-based and flexible. The curriculum plan shows that, in the Junior year, engineering students, will be given credit for Junior Engineering Clinic I if they enroll in the New Venture Development business course. The course allows students to decide whether their product idea is an opportunity or just a nice idea. Estimates are for 10-15 technology students and 10-15 business students in the New Venture Development Course. The ideas could come from any team member and require technical or business related skill sets. Even service or distribution companies could be formed as E-teams.

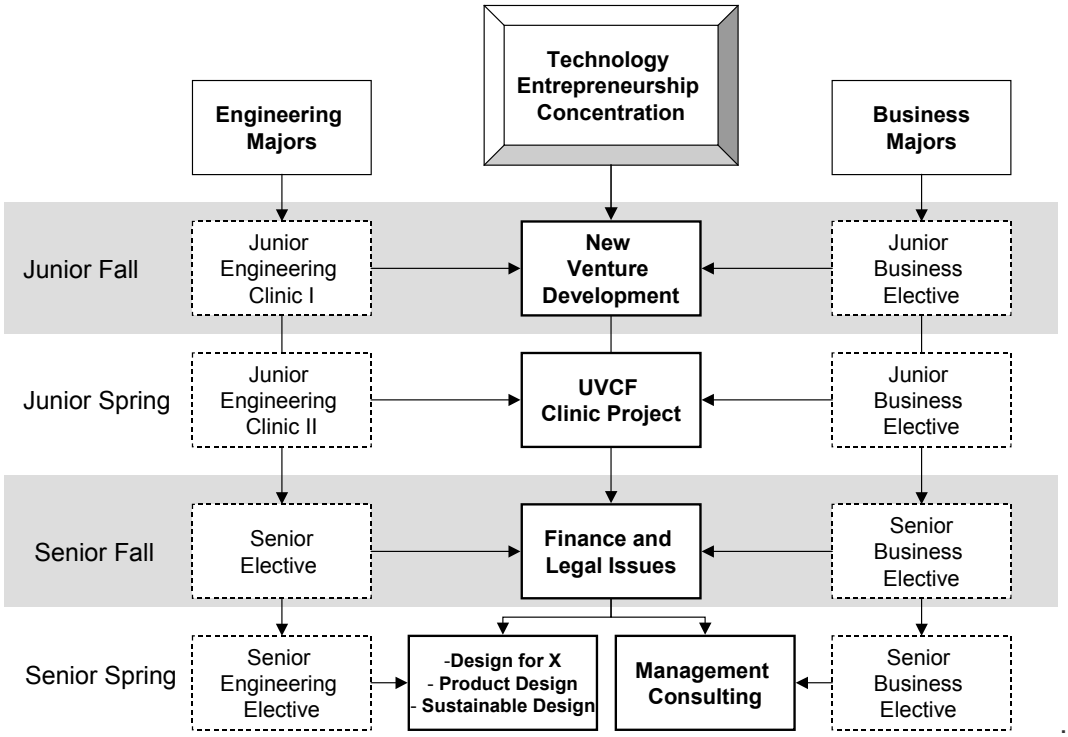


Figure 6. Curriculum flow chart for engineering and business students enrolled in the Technology Entrepreneurship Concentration certificate program

Winning E-teams then enroll in Junior Engineering Clinic II with funding from the UVCF to develop their prototype. Rowan University has a successful history of using the UVCF within the Engineering Clinic to develop original student hardware. The TEC concentration aids in a student's attempt to turn hardware into a successful business enterprise by providing students with the knowledge and incubation services necessary to compete. It should also be noted that, as part of the TEC initiative, business majors are given credit for enrolling directly in the Engineering Clinic to work side-by-side with engineering students on their UVCF E-team clinic project.

Concurrently with their E-team experience, engineering and business students enrolled in the TEC will take one or more approved courses within their curriculum that focus on entrepreneurship and/or product development. Engineering students in the TEC will be required to choose one of the product design courses such as Design for X, Product Design or Sustainable Design. Business students can enroll in these courses at the discretion of the instructor. Business majors in the TEC will be required to take the Management Consulting course that will be offered in the College of Business. The final course will be a new course in Finance and Legal Issues that and will be required by all students. In Fall 2002, a Course and Program Grant was obtained from the NCIIA to pilot this program and the New Venture Development course was approved by the Rowan University curriculum committee. The New Venture Development course will be offered for the first time in Spring 2003.

The South Jersey Technology Park at Rowan University

With entrepreneurship incorporated directly into the undergraduate engineering curriculum and a growing entrepreneurial culture with the university at large, perhaps the final step in the process is developing the capability to incubate student and faculty startup companies to

promote successful business ventures and transform the regional economy. Accordingly, in 2001, Rowan University was awarded a grant of $6 million by the New Jersey Economic Development Authority to establish the South Jersey Technology Park (SJTP) at Rowan University. The goal of the SJTP at Rowan University is to lead the economic revitalization of southern New Jersey through an integrated strategy of science and technology initiatives. The mission of the SJTP is to:

- Expand and strengthen the unique research and learning environment of Rowan University,
- Establish a technology-based entrepreneurial economy, and
- Create value for its surrounding communities in their economic, physical and social development.

In 2002, to fulfill this mission, the South Jersey Technology Park was incorporated as a tax-exempt 501.c3 corporation, a strategic plan was developed in consultation with the University City Science Center (UCSC), and a Board of Directors was elected. Land has been acquired to integrate the SJTP into a new 580-acre Rowan University West Campus and a master plan for the SJTP currently under development by an architectural planning firm.

The first phase of the SJTP will begin in 2003 with construction of the 50,000 SF *Innovation Center at Rowan University*, which will immediately provide a critical nucleus of high tech activity at the Rowan West Campus by:

- accommodating the diverse R&D program areas already in place at Rowan,
- providing sufficient laboratory space to attract the level of external funding necessary to sustain graduate level research,
- leveraging the strengths of the Rowan Industrial Affiliates program,
- attracting small high tech incubator tenants,
- providing administrative office space for the SJTP staff and incubation services,
- providing professional meeting space (including teleconferencing) for incubator tenants, and
- providing a common design, brainstorming and prototyping space that promotes creativity and innovation among students, faculty, staff and incubator tenants.

Capital costs for the Innovation Center are projected at $12 million and ground breaking is anticipated for Summer 2003.

Summary

The College of Engineering at Rowan University was born in response to a gift and challenge from a local entrepreneur. Henry Rowan started his business in the 1950s in his garage and today Inductotherm Industries consists of a family of over 50 companies, including Inductotherm Corporation, the world's leading and largest manufacturer of induction melting equipment[13]. Given his entrepreneurial background, Mr. Rowan's desire was to incorporate an entrepreneurial culture into a public undergraduate engineering institution to impact the economic development of southern New Jersey, a region which has historically lagged behind northern New Jersey.

In the decade following his gift, the university designed an entrepreneurial curriculum, recruited an entrepreneurial faculty and developed campus wide initiatives aimed at creating a entrepreneurial campus culture. With the planned SJTP, the university is poised to affect

economic growth in the region. Much of this work was accomplished during a period of national change in engineering education in which the need to incorporate entrepreneurship into engineering curricula was recognized and rewarded by available grant opportunities. While it is understood that some of the initiatives described in this paper were made possible by the opportunity to start with a clean curriculum slate, it should also be recognized that each of the initiatives are portable and can be implemented individually into existing programs. Indeed, many of these initiatives do not require a new program or major curriculum reform. Rather, our results suggest that it is possible to start with some small initiatives and build upon each initiative as the momentum for entrepreneurship develops.

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