Creating an Entrepreneurial Culture at a Startup Engineering Program

Anthony J. Marchese*, John L. Schmalzel# and K. Mark Weaver+,
Rowan University
201 Mullica Hill Rd.
Glassboro, NJ 08028

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 that 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 a variety of policies/programs including creating an 8-semester engineering clinic sequence, creating an undergraduate venture capital fund and developing the Technology Entrepreneurship Concentration. This paper will describe the impact of these and other related initiatives that have helped create 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 and Texas¹. 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.

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

* Associate Professor of Mechanical Engineering (http://engineering.rowan.edu/~marchese)
# Professor and Chair of Electrical and Computer Engineering
+ Rohrer Chair of Entrepreneurial Studies, College of Business
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.

Henry M. Rowan Hall opened in January 1998, and was dedicated that April. The $28 million, 95,000 SF 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. 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.

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,
- 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. The Engineering Clinic is a course that is taken each semester by every engineering student at Rowan. 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 Table 1, while each clinic course has a specific theme, the underlying concept of engineering design pervades throughout\(^10\).

<table>
<thead>
<tr>
<th>Year</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>Engineering Measurements</td>
<td>NSF Competitive Assessment Laboratory</td>
</tr>
<tr>
<td>Sophomore</td>
<td>Quality / Written Communication</td>
<td>Entrepreneurship / Public Speaking</td>
</tr>
<tr>
<td>Junior</td>
<td>Multidisciplinary Design Projects</td>
<td>Multidisciplinary Design Projects</td>
</tr>
<tr>
<td>Senior</td>
<td>Multidisciplinary Design Projects</td>
<td>Multidisciplinary Design Projects</td>
</tr>
</tbody>
</table>

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 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 in 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.

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 with 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 (See Fig. 2) and a biological fuel cell powered robot.

In the final four semesters of a student’s career, the Engineering Clinic continues 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 and 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. 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 in the College of Engineering devotes 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%.
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, for example, electrical engineering support can recruit team members to the project.

The Undergraduate Venture Capital Fund (UVCF) 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. The UVCF has been generously supported by a series of grants by the NCIIA and private donors. To date, over $100,000 has been raised.

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 preliminary 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, a 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 Marchese, et al., 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 5 years, UVCF proposals have been accepted from over 25 multidisciplinary student teams. This figure represents approximately 5% of the roughly 400 Junior/Senior Clinic projects completed during this same period. In total, 35 ECE students, 32 ME students, 9 CEE students, 5 ChE and approximately a dozen business students have participated in UVCF projects. To date, these projects have resulted in 4 startup companies and 2 patents pending.

Marchese, et al. 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 here. The SnoRhino™ is an original student invention developed by Rowan Engineering students Jeff Gladnick '03, Matt Eberhardt '03 and Pete Boyle '03. 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 (See Fig.4).

![SnoRhino](image.png)

**Figure 4.** prototype installation on ski-lift accommodating a snow boarder and skier.
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.

The NSF Competitive Assessment Laboratory contains 5 consumer appliance test stations featuring PC-based data acquisition systems capable of measuring a variety thermocouple and voltage/current signals. Figure 5 show one of the Competitive Assessment Stations. 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 an 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 µ-Business student group was formed with eight students. The mission of the µ-Business 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 µ-Business. 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.

Mechanical Design. The major thrust of mechanical design is to provide customers with package and mechanism design services. At Rowan, students design 3-D solid models in SolidWorks, perform stress analysis using the finite element model 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 25 student inventions, 2 patents pending and 4 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.

The Technology Entrepreneurship Concentration

With the Rohrer 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 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 certificate program.

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.

![Curriculum flow chart for engineering and business students enrolled in the Technology Entrepreneurship Concentration certificate program.](image)

**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 take one or more approved courses within their curriculum that focus on entrepreneurship and/or product development. Engineering students in the TEC are 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 are required to take the Management Consulting course that will be offered in the College of Business. The final course is a new course in Finance and Legal Issues that is 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 was 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 2004 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 2004.
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. 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 an 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 small initiatives and build upon each initiative as the momentum for entrepreneurship develops.

Acknowledgments

The UVCF has been supported by NCIIA grants 142-98, 203-98, 312-99 and a grant from the Rowan Family Foundation. The Technology Entrepreneurship Concentration was also supported by an NCIIA grant. Resources used in these projects were supported in part by NSF under the grants DUE-9751651 and DUE-9850563.

Bibliography


**Biographical Information**

**K. Mark Weaker** is the Rohrer Professor of Entrepreneurial Studies and the Director of the Center for Innovation at Rowan University. He is an internationally known scholar and consultant in the area of strategic alliances and new venture development. He received his B.S. and PhD from Louisiana State University.

**Anthony J. Marchese** is an Associate Professor of Mechanical Engineering at Rowan University. He holds a Ph.D. from Princeton University and B.S. and M.S. degrees from Rensselaer Polytechnic Institute. He has previously held positions at United Technologies Research Center in East Hartford, CT and NASA Glenn Research Center in Cleveland. In 2001, he was named a Carnegie Scholar by the Carnegie Foundation for the Advancement of Teaching.

**John L. Schmalzel** is Professor and Chair of Electrical and Computer Engineering at Rowan University. He is an internationally recognized expert in communication and networking standards, and computer architectures and networking. Schmalzel received his B.S., M.S., and PhD in Electrical Engineering from Kansas State University.