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Development of an Institutional Culture to Encourage and Teach Entrepreneurship - The Technogenesis Model at Stevens

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DEVELOPMENT OF AN INSTITUTIONAL CULTURE TO ENCOURAGE AND TEACH ENTREPRENEURSHIP - THE TECHNOGENESIS MODEL AT STEVENS

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Background to Creating an Entrepreneurial Campus Culture

As a key component of its strategic plans, Stevens Institute of Technology has undertaken to foster a campus environment that provides an orientation to entrepreneurship that permeates the broad institutional mindset, from undergraduate programs through to graduate programs and faculty scholarship. This direction evolved from a series of strategic planning activities going back to 1997.

- **Strategic Planning**

Stevens Institute, as part of its ongoing strategic planning process, initiated a series of retreats commencing in 1997. These brought together, faculty, staff and trustees in an informal setting to plan the future direction of the Institute. The first two retreats focused on evaluating the core values of the Institute, its heritage and the environment in which our students and faculty must succeed. Some of the relevant points were:

  - **The founders of the Institute in 1871 were entrepreneurial engineers, in fact Col. John Stevens, the patriarch of the founding family, was one of those who lobbied Congress to establish the first patent laws**
  - **Since its founding the Institute has adhered to a broad-based engineering curriculum with a strong business orientation**
  - **Small size offers the opportunity for institutional responsiveness to change while still retaining core values**
  - **Recognition of the fundamental changes occurring in the global economy and its impact on the employment environment for our graduates**

- **Environment**

On the last bullet point above, the present reality is that job growth is not occurring in large companies, jobs are being created in small companies and start-up ventures[1]. This

[1] National Science Foundation, Division of Science Resources Studies, "*Will Small Business Become the Nation's Leading Employer of Graduates with Bachelor's Degrees in Science and*

has been paralleled by the fact that major corporations have been forced by intense global competition to fundamentally change their structures to become leaner and more agile. This has led to increased use of contract professionals, more emphasis on flexible multidisciplinary teams (in many cases operating internationally) and corporations taking a different stance to new product development. The latter includes buying in new technology once it has been proven rather than developing in-house. It also includes promotion of intrapreneurship, including spinning off successful internal ventures to maximize value. For engineering graduates entering this environment, an entrepreneurial orientation and associated knowledge and skills will be a key career enabler.

Several follow up retreats, again involving faculty staff, and trustees, focused on how to cultivate a more entrepreneurial culture at the Institute. These meetings were structured to include breakout group explorations of the implications for undergraduate and graduate education, faculty scholarship and research, infrastructure and outreach to our constituencies.

During this period of strategic planning a couple of faculty members, who had become leaders in themselves engaging in entrepreneurial activities growing out of their research, proposed that the environment that we were attempting to create be given a name as a kind of banner around which to rally. They coined the name Technogenesis. The President and key trustees quickly embraced the idea and the name. Debate ensued as to what this really meant and its use gained momentum on campus. An official definition is thus: "*the educational frontier wherein faculty, students and colleagues from industry jointly nurture the process of conception, design, and marketplace realization of technology*". The name was trademarked.

Implementation

- **Technogenesis Task Force**

One key outcome of the strategic planning was formation of a Technogenesis Task Force to determination how best to promote an entrepreneurial culture. The Task Force was made up of the Deans of the three Schools at Stevens together with faculty members and senior staff. The Task Force:
    - **established a set of objectives, actions, timelines, projected costs and responsibilities**
    - **determined a set of desired student attributes**
    - **engaged the Trustees and established a Technogenesis Fund**

- **Incentives**

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*Engineering?",*NSF 99-322, Project Officers, John Tsapogas and Lawrence M. Rausch; Mary Collins, Westat (Arlington, VA 1999).

- **Administrative encouragement**

The encouragement of faculty and students to engage in a more entrepreneurial approach to their activities has been apparent through the retreats, student forums, on campus publications including the Stevens website and in communications to alumni and the corporate world. It has been promoted from the Trustees and President down through the Department Directors as something that will be viewed as advancing the Institute.

- **Technogenesis faculty grants**

In order to encourage faculty research that has the potential for development of intellectual property which can possibly lead to commercialization, the Technogenesis Task Force created a competitive research seed grant program supported from the Technogenesis Fund. A requirement of the program is that students be involved in the research. These TG Faculty Seed Grants were tied to specific deliverables and were intended to be used for high risk/high gain type projects that would not normally attract external funding at that stage of concept development, but had the strong potential to do so once proof of principle was shown. The Fund has supported 22 projects since 2001 and awards were in the 20-70K range.

- **Technogenesis student summer scholarships**

The Task force additionally provided for a program to fund undergraduate summer scholarships. The goal was to support students through a stipend and on-campus housing in the summer to work with faculty on research with the same goal as that of the TG Faculty Grant Program (some of which projects had the TG Faculty Seed Grant support) and/or research conducted by the several start-up ventures created by faculty in the Stevens incubator.

- **Consideration in performance evaluation**

The Deans and Department directors in evaluating faculty performance included contributions to the Technogenesis initiative as part of the annual assessment. In explicit terms, patent disclosures and awards were included as metrics, but also a more holistic consideration was promulgated in regard to educational contributions to Technogenesis.

- **Promotion and Tenure**

Considerable discussion at the retreats and other forums centered on the potential ramifications that Technogenesis might have on the promotion and tenure process. In fact to put it another way, how could the initiative succeed in influencing faculty unless adequate recognition of more entrepreneurial activities was embedded in P&T decisions? At the same time it was recognized that the traditional expectations

of excellence in scholarship, teaching and a commitment to internal and external service would still remain as the cornerstones of promotion and tenure expectations. There have been discussions of developing P&T guidelines that explicitly embrace entrepreneurial activities as long as proper balance is achieved. Also, recognition that leaves of absence may be needed and that the tenure clock might need to be temporarily stopped under such circumstances. To date no formal resolution has emerged, but it is an area of continued active consideration within the faculty.

Infrastructure

- **Stevens Technologies Inc.**

Technology transfer at Stevens had historically been limited to attempts to license a small intellectual property (IP) portfolio. Subsequently a for-profit organization, Technology Holdings LLC, was established to provide additional support for commercialization through licensing and to encourage new ventures built around Stevens IP. Technology Holdings did not have the resources to provide capital funding but was responsible for licensing Stevens generated IP to several startups and providing them with contacts and other professional support. Under the TG initiative, a new larger organization, Stevens Technologies Inc., was established to provide a commercialization support structure to include:

- **IP development and management**
- **Venture formation**
- **Business plan development**
- **Networking, including identifying potential managers**
- **Fundraising**

As part of the latter function a venture fund is being established to help provide angel funding for new Stevens ventures.

- **Technology Ventures Incubator**

Stevens Technology Ventures Incubator (TVI) was started in 1991 on the campus of the Institute. Its location has helped it become an integral part of campus life as the Technogenesis initiative has progressed, with many students and faculty working with the resident companies. It has proven very successful in nurturing startup companies to success and has won several awards. It has assisted 56 resident companies and helped them to raise over $55M. However, until relatively recently these were companies that came to Stevens rather than being started by Stevens personnel. Since 1998, TVI has sought to be the location of choice for Stevens' own technology transfer initiatives, providing office space, business experience and networking opportunities to start-ups that license and commercialize Stevens' patented technology. In the last four years eight companies have been formed that involve Stevens faculty, in addition several companies have been started by recent graduates during that period. Some 80% of the incubator companies, and all those started by faculty, engage students in their activities.

Impact on the engineering curriculum

- **Student Attributes**

The Technogenesis Task Force identified a set of desirable student attributes in several general categories that Technogenesis should promote:

- **Innovation/Imagination**
  - **Independent problem formulation and problem solving**
  - **Creative and critical thinking skills**
  - **Practices a variety of creative thinking methodologies**
  - **Recognizes team and personal approaches that foster innovation**
- **Self-Reliance/Independence**
  - **Can tackle open-ended, vaguely formulated, problems**
  - **Possesses effective teaming skills**
  - **Capable of self-learning**
  - **Confident working with a new product development team in industry**
- **Entrepreneurship**
  - **Knows the types of IP and protection**
  - **Understands something of the world of venture capital**
  - **Understands the components of a successful business plan**
  - **Able to estimate the market for a product**
  - **Familiar with effective leadership skills**
- **Business Practice**
  - **Effectively manage a development project**
  - **Understand financial matters well enough to work with venture capitalists**
  - **Has basic accounting understanding for new product research and development**
  - **Possesses the communications skills to convince management or venture capitalists to fund a new enterprise**
- **Understand the Interaction of Social and Technological Forces that Shape our World**
- **Network Attitude**
  - **Has the skills to reach divergent groups who could have an impact on a project**
  - **Developed the ability to broaden his/her circle of resources**

- **Implementation in the curriculum – a two tier approach**

For undergraduate engineering students there are two levels of engagement. This is in recognition of the fact that most students will not wish to start their own business in their near future, but rather will go to jobs in established companies. However they will benefit from a base level introduction to entrepreneurship materials in the core curriculum, in this

regard the focus is really on equipping them to succeed in an environment where intrapreneurship is valued.

This base tier is implemented primarily through the core design course sequence that extends through all eight semesters, and through increased focus on project and problem-based learning. The Design Spine includes fundamentals of marketing, finance, business development and project management.

A second tier provides for students with a much stronger desire to be entrepreneurs to supplement the core material with an elective senior year course that focuses on both intrapreneurship and entrepreneurship aspects of business. Seminars on Intellectual Property, Venture Funding, etc., are also provided on campus.

- **Project and Problem-Based Learning**

A key pedagogical element of the environment that we are evolving is the permeation of Project and Problem-Based Learning (PBL) through the curriculum. This is a means to foster many of the attributes listed above that are needed for a more entrepreneurial career environment as well as being recognized as a means to improve learning outcomes. PBL encourages self-reliance and innovative thinking and also can contribute significantly to enhancing team skills.

Initial implementation in the core curriculum has been in the freshman year Mechanics of Solids course and in sophomore Probability and Statistics. It has found wide implementation in concentration courses, with for example, more than 50% of the required Mechanical Engineering courses being taught by PBL.

Support for implementing Technogenesis in the undergraduate curriculum, including support of faculty to develop PBL, has in part come through a $1.3M grant from the New Jersey Commission on Higher Education (NJCHE), under its Workforce Excellence Program. The other major component, funded by the NJCHE grant, is the Innovation Center discussed below.

- **Engagement in Research with an Entrepreneurial Orientation**

Students are encouraged to engage in faculty research projects that have the potential to generate intellectual property in addition to the traditional goal of publication of new knowledge.

One route to encourage this has been through the *Undergraduate Technogenesis Summer Scholarships* that were established by the TG Task Force as mentioned above. As example, more than 65 students applied for these high-qualification, project-based summer study scholarships in 2001; 23 students were approved for this first series of awards, disbursed for that summer. Scholarship projects included work in the fields of computer cryptography, arsenic removal from drinking water, wireless networking, and non-thermal plasma technology. A number of the awards were to students who worked with start-up

ventures created by faculty in the Stevens Technology Ventures Incubator. In 2002 an additional 25 students were funded.

In addition to Stevens-funded summer scholarships, the *National Science Foundation CSEMS Program* has funded approximately 40 academic year scholarships per year in the last two years. This program is intended to help mostly financially disadvantaged students to complete technical degree programs. At Stevens this program is coupled to Technogenesis to encourage participation in the latter as an enabler of graduation and career success.

- **Product Innovation Center**

The NJDHE grant mentioned above has also helped support creation of the *Product Innovation and Realization Center*. The Center is intended to facilitate students to move from the conceptual phase of their projects through to prototype. This is a key step on the path to potential commercialization. The further development of commercially attractive ideas can take place through the student-friendly Stevens Technology Ventures Incubator mentioned above.

The Product Innovation Center comprises an open plan, high-bay approx. 4000sq. ft area containing rapid prototyping via CNC machines, 3-D printing directly from graphics software and also electronic prototyping to create circuit boards. The Center also has a range of mechanical and electronic test equipment. Industrial size CNC, electro-discharge machining and an injection molder are hosted in the facility. The Center is supported by technicians with machining and electronics expertise and is under the management of a faculty member. Software tools for mechanical (SolidWorks, Pro-Engineer) and electronic design (Protel) also are available in support of prototype design.
The impact on the undergraduate curriculum is illustrated in Fig.1

Concluding Summary

Stevens Institute has made good progress on a strategic orientation of the university's culture towards one that is entrepreneurial on many levels and facets of the academic enterprise, including faculty research and both undergraduate and graduate education.

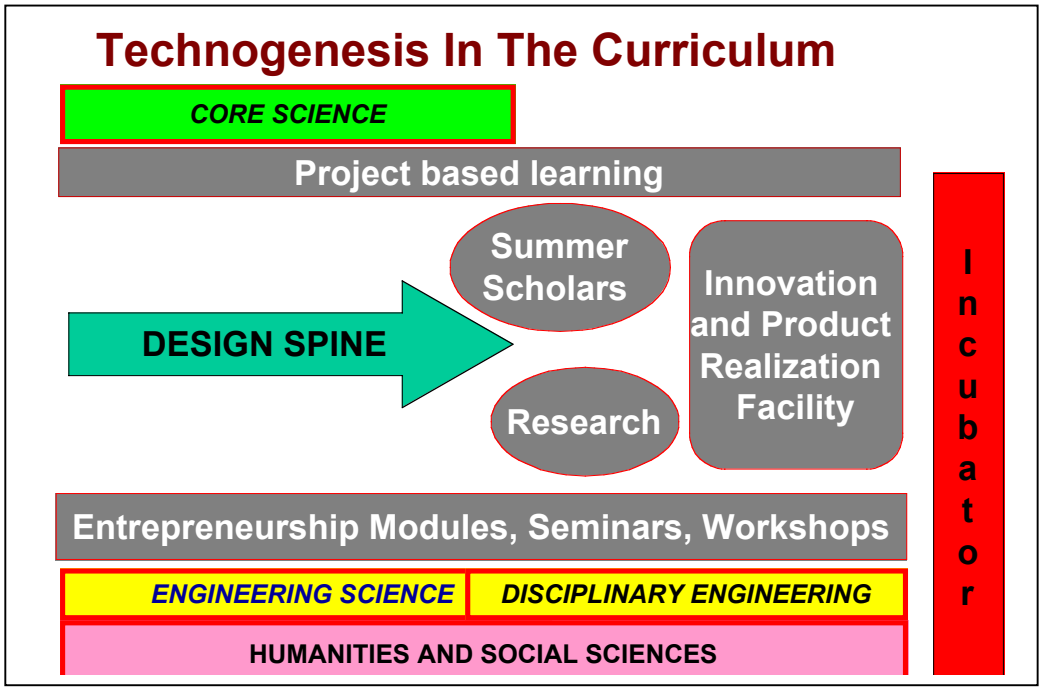

Figure 1 Entrepreneurship elements of the undergraduate engineering curriculum