HOLISTIC APPROACH FOR TECHNOLOGY ENTREPRENEURSHIP EDUCATION IN ENGINEERING

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Abstract *– This paper discusses a comprehensive strategic approach being carried out by the A. James Clark School of Engineering at the University of Maryland for facilitating technology entrepreneurship for undergraduate and graduate students as well as faculty in diverse technical disciplines. Our objectives are to foster an increasingly entrepreneurial culture that helps students and faculty understand the fundamentals and feasibility of forming technology enterprise, to help them establish and manage sustainable ventures and to accelerate commercialization of technologies developed on campus.*

Index Terms – accelerator, boot camp, business plan competition, incubator

INTRODUCTION

In recent years, the development of entrepreneurship programs for engineering students have gained considerable momentum [1,2,3,4]. During the past three years, the Clark School of Engineering at the University of Maryland has made substantial progress towards establishing a robust entrepreneurial culture pervading diverse students and faculty from all technical disciplines [5]. Our first goal is to educate, encourage and support students and faculty who are interested in starting technology enterprises, especially those arising from research. The second goal is to provide the region with technology companies that contribute to the economy and create jobs.

Our technology entrepreneurial activities fall into three general categories: culture building, self-help resources and hands-on venture formation. Culture building activities include: An undergraduate entrepreneurship residence program, technology ventures club, business plan competition and a graduate course on technology startups. The self-help resources category includes both a web portal and mentoring. Hands-on venture formation activities include: a VentureAccelerator, seed funding program and an on-campus technology incubator.

CULTURE BUILDING

A robust entrepreneurial culture is essential for encouraging and supporting students and faculty in launching technology enterprises. Students and faculty need to understand the fundamental concepts and accepted tactics associated with startup technology enterprises and believe in their ability to apply them. This requires that talented and experienced people be available to teach them, provide consultation to their evolving ventures and make connections for them.

Observing the success of peers is also a powerful source of confidence. Accordingly, our entrepreneurial culture promotes successes and provides many activities that support successful ventures. Activities currently in place are discussed below.

Hinman CEOs Program

Our primary entrepreneurship program for undergraduate students is the Hinman CEOs (Campus Entrepreneurship Opportunities) Program. Jointly founded and managed by the engineering and business schools, this program was initiated in the fall semester of 2000 for students who have a strong entrepreneurial drive [6]. The program attracts these entrepreneurial students and creates a strong sense of community and cooperation among them. The University and its academic and corporate partners provide many resources, activities, courses, technologies and services to help students learn how to start, grow, and manage successful companies.

The most important feature of the program is that students admitted to the program live together in a modern incubator-like residence hall where they can freely exchange ideas and network with their fellow CEOs. Living, studying, working and playing together, these students are provided with unique opportunities to form teams that often evolve into commercial ventures. The practical knowledge and experience these students gain from the program impacts the way the CEOs think about their careers, their destinies, and their ability to start businesses.

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The target audience is primarily juniors and seniors, along with some exceptional sophomores. The program is limited to about 100 students. Typically, about a third are engineering majors, a third are business majors, and the remaining third come from many diverse departments.

The program is structured around a comprehensive group of activities and facilities designed to provide a rich and supportive environment for learning about entrepreneurship, forming teams, starting companies and sharing lessons learned. These include:

- A dynamic community environment that is centered around a residence hall where all Hinman CEOs live and interact closely
- An incubator-like technology environment with features such as wireless Internet access, videoconferencing, modern computing facilities and state-of-the-art business and technology software tools
- Weekly seminars and workshops with speakers such as investors, accountants, legal experts and successful entrepreneurs
- Participation in a Boot Camp (discussed later) at the beginning of the academic year which brings together regional experts to introduce fundamental entrepreneurial concepts to both students and faculty
- A mentoring program that matches student teams with experts from the technical, business and academic communities
- Support for product development projects to assist student teams in fabricating pre-prototypes and obtaining intellectual property protection
- Opportunities for CEOs to form companies with faculty and graduate students who have created technology-oriented intellectual property through their research
- Entrepreneurship education which consists of four courses available in the business school and one in the engineering school
- An annual business plan competition (discussed later) which gives students the opportunity to compete for prize money which can then be used to further their companies and ideas
- Possibility of obtaining space in the on-campus technology incubator that the engineering school has operated for 17 years.

Each semester students receive one-credit in engineering. Their grade is determined by the level and quality of their participation in program activities and contributions to improving the program.

While the Hinman CEOs Program provides the extensive array of activities described above exclusively for undergraduates, most of the programs and activities described below are designed to also give graduate students and faculty similar opportunities to learn about, and actually participate in, technology enterprises.

Thirty companies have been formed by undergraduate students in the Hinman CEOs Program. These range from small ventures to more substantive ones that have received investment funding. A Hinman CEOs company was awarded honorable mention in the 2001 University of Maryland Business Plan Competition, and another was awarded second place in the 2003 competition.

Technology Startup Boot Camp

Each academic year is "kicked off" with a one-day program designed to introduce technical students and faculty to fundamental concepts associated with starting and managing technology enterprises.

Typical topics include:

- Evaluating Tech Business Ideas
- Intellectual Property Basics
- Licensing from the University and the Federal Government
- Federal and State Programs to Assist Startups
- Legal Fundamentals
- Building a Team
- Obtaining Financing.

Boot Camp topics are presented by experts from law firms, accounting firms, investment banks, investment partnerships and entrepreneurs from regional technology companies. The event is concluded with a panel of successful regional entrepreneurs. Included in the panel are several University of Maryland students and faculty entrepreneurs who discuss their experiences in starting technology ventures on campus.

About 200 students and faculty attend the Boot Camp. Attendees are given notebooks containing the presentation materials and contact information of each speaker. The program is conducted in a manner that encourages and facilitates networking among the attendees and the speakers. Attendees, who generally are newcomers to entrepreneurship, come away from the Boot Camp with a basic knowledge of the fundamental concepts, a list of available resources and contact information for the speakers and other attendees.

Business Plan Competition

Each academic year concludes with a business plan competition, typically with $50,000 that is raised from sponsors representing the investment and professional services communities. Goals of the competition are to provide education and networking opportunities for students, to foster new venture ideas and to provide new opportunities

for students and recent alumni to compete for funding that will enable them to start or further existing businesses.

The competition is campus-wide and is open to graduate and undergraduate students. Eligible teams may include non-students; however, each team must have at least one member who is a current University of Maryland student or recent graduate (within five years) who plays a material role in the team. "Material role" is generally interpreted as being an officer of the corporation or having an equivalent position. A team is ineligible if it has received prior institutional funding.

The competition commences with the submission of executive summaries in the late fall. Maryland personnel and judges, representing the investment and professional services communities, narrow down all submissions in two steps to six finalists who prepare full business-plans. Finalists present their plans to the judges and a large audience at which time winners are selected by the judges. Most submissions tend to be technically oriented. Funds awarded must be used to start a business or further an existing venture. Winners are monitored for several years following the competition to ensure funds are used properly as well as to assess the success rate of competition awardees.

Technology Ventures Club

The Technology Ventures Club (TVC) is a dynamic forum for technical graduate students to learn about technology entrepreneurship, network with fellow students, as well as with investors and service providers, and obtain assistance forming a new venture. The TVC meets monthly and is open to all graduate students who are majoring in technical disciplines. Monthly meetings include seminars, workshops, and social networking events.

Seminar speakers represent the investment and professional services communities as well as the local technology community. Workshops focus on specific startup topics, including business planning, forecasting, conducting marketing research, making sales presentations, and fundraising. They are led by a mix of university staff and outside experts. Social mixers give students opportunities to network with each other with the goal of forming teams, and to meet members of the technical and business communities.

Members of the MBA Entrepreneurship Club are invited to some Technology Ventures Club meetings to build relationships among technical graduate students and MBA students.

Fundamentals of Technology Startup Ventures Course

This three-credit course is designed to take graduate students and upper-level undergraduate students, who are majoring in technical disciplines, through the fundamental aspects of organizing, funding and managing technology start-up ventures. This multi-disciplinary course draws on legal, financial, management and technical concepts. The course structure involves lectures on fundamental topics as well as insights by outside experts who speak about the practical application of these concepts.

Students in the class are required to form teams for developing business plans for starting new technology companies. As part of the process, each plan must include a financial model, a strategy for raising capital and product and competitive analyses. Teams present their plans in class to a panel of judges who ask questions and provide critiques in a manner that is similar to that which takes place when entrepreneurs present to potential investors. Since most of the students are PhD students, business plans often involve technology associated with their research.

The course is team-taught by instructors with substantial technology and business experience, and lectures are also given by highly qualified professionals and successful entrepreneurs from the region.

Topics include:

- Attributes of successful start-ups
- Launch options
- Terminology and definitions
- Assessing your idea's commercial potential
- Understanding and building a business model
- Developing a competitive and market analysis
- Developing intellectual property, prototypes and products
- Testing technology
- Safeguarding your Intellectual property
- Competitive intellectual property analysis
- Elements of effective business plans
- Accounting fundamentals for tech start-ups
- Financing the venture
- Equity and value building
- Legal fundamentals for the technology start-up
- Building your management team
- Attracting and retaining your employees
- Boards of Directors and Advisors
- Promoting your firm to investors, customers, employees and advisors
- Managing growth
- Exit strategies
- Management processes
- Lessons from entrepreneurs

Several companies in various stages of development have been started by graduate students participating in the Technology Ventures Club and the Fundamentals of Technology Startup Ventures course. One such company formed by two students who had conducted their research under the supervision of a leading mechanical engineering professor was awarded first place in the 2003 business plan competition. The lead student is Vice President of the club and was a student in the Spring 2003 course. Of the nine

teams formed in the course during the Spring 2003 semester, four have reasonable prospects of becoming viable companies, and these teams are seeking involvement with the incubator, seed funding program and the VentureAccelerator.

SELF-HELP RESOURCES

As students and faculty become familiar with fundamental concepts and tactics, they can access a great deal of information and tools via the Internet. Because searching on the Web in an unorganized way is often a daunting task, a web portal has been created to direct students and faculty to the best available information and tools for technical entrepreneurs.

The region is fortunate to have a large number of experienced professionals within the University and in the region who are willing to mentor students and faculty. Connections are provided to enable students and faculty to be mentored by these individuals.

TECHNOLOGY ENTERPRISE WEB PORTAL

The web portal contains information and tools that have been linked into one site. Types of links include:

- Template for forecasting revenues and income statements
- Business plan preparation guidance
- Intellectual property rules
- Information on funding sources
- Testimonials and case studies
- Fundamental legal resources

Over time, the web portal will evolve so that it includes information on most topics associated with starting a technology company and commercializing technology

MENTORING

Two levels of mentoring are available to students in the Hinman CEOs Program, members of the Technology Ventures Club and the students taking the Fundamentals of Technology Startup Ventures course. University staff involved in technology entrepreneurship provide "level one" mentoring. Technology faculty offer advice and consultation in their area of expertise to round out the internal source of mentoring. The support staff of the University includes many individuals with extensive experience in starting, investing in, managing and exiting technology ventures.

In addition, an extensive network of highly experienced professionals in the region is maintained consisting of entrepreneurs, service providers, investors and others who are interested in helping the University's aspiring entrepreneurs. These individuals serve as "level two" mentors and are also often called upon to provide advice to faculty who are forming startup ventures. Level two mentors provide more in-depth advice regarding fundraising, legal issues, strategy, product development plans and executive recruitment. In some instances, level-two mentors have become actively involved in ventures they mentor. This involvement includes investment, participation on boards of directors and advisors and selection of officers of the fledgling companies.

HANDS-ON VENTURE FORMATION

Technology VentureAccelerator Program

The VentureAccelerator Program provides extensive hands-on business assistance to qualified students and faculty seeking to form new ventures based on research or some other type of technical innovation. VentureAccelerator is led by an experienced entrepreneur who was recruited to the university from the business community. Services of the VentureAccelerator include executive recruitment, board development, business planning, strategic consulting, fundraising assistance, marketing analysis, and licensing negotiations. VentureAccelerator works with between five and ten companies at one time ensuring each venture a high degree of attention and support.

To apply for VentureAccelerator, entrepreneurs and/or early-stage companies submit written descriptions of core technologies and associated markets. A 30-60 day analysis including multiple question/answer sessions between VentureAccelerator and the applicant usually ensues. Once admitted, companies are expected to remain in the program until demonstrating a high potential of self-sustainability, usually evidenced by a significant institutional investment, customer engagement, and/or licensing arrangement.

VentureAccelerator is currently mentoring seven companies. These firms represent diverse research areas, stages of development, and position of the founders, as these enterprises include faculty-started, incubator, and student-initiated (undergraduate and graduate) companies in disciplines spanning enterprise software, electronics, and biotechnology. Assistance currently being provided includes long-term growth planning, recruitment of management teams and advisory board members, raising investment capital, acquiring manufacturing space, launching products,

Current, specific VentureAccelerator activities include:

- Assisting an incubator company with $2 million to implement long-term growth plan and hire complete management team
- Assisting a faculty-owned industrial technology company to recruit a CEO and raise venture capital "A" round. The company has raised $5 million in private and government funding to date

- Assisting graduate student-owned manufacturing software company to launch its first product, raise capital and recruit a marketing team (this company won first prize in the 2003 Business Plan Competition)
- Assisting a faculty member with research expertise in HVAC systems to commercialize technology through a company startup
- Assisting undergraduate student-owned niche recreational-vehicle company to raise angel investment and secure low-cost manufacturing space (this company won third prize in the 2003 Business Plan Competition and has raised $300,000 in investment capital to date)
- Assisting an information management company started by a Hinman CEOs student team to launch its initial product, recruit advisory board members, and to raise grant funding (this company won second prize in the 2003 Business Plan Competition)
- Assisting a company started by a professor in the dental school to expand its niche market.

Seed Funding Program

Since 1987, the engineering school has conducted a program that facilitates product development projects for Maryland companies. Proposals, co-authored by University of Maryland faculty and Maryland companies, are accepted twice per year. Proposals are evaluated for technical merit and commercial potential. Companies of all sizes participate, and about a third of applicant companies are startups. Projects can last up to two years. For startups, these projects are usually for prototype development or product design. Faculty owned ventures are common company applicants.

For startup companies, the University pays 90% of project costs, and the company pays 10%, with the maximum yearly amount of the University contribution capped at $70,000. Alternatively, the University can pay the full amount ($77,000) in exchange for 2% equity for each year of the project. In either case, the University contribution represents funding that the company doesn't have to raise from investors, and is in effect seed capital for product or prototype development.

At a major research university such as the University of Maryland, the expertise that startups can access through this program is substantial, and many successful projects have been executed benefiting diverse startup companies in Maryland. Since 1987, 124 startup companies have received product development assistance through this program. Ten years after receiving this assistance, over 50% of the companies are still in business.

On-Campus Technology Incubator

Since 1985, the engineering school has operated an on-campus incubator for technically-oriented startups. The incubator is housed in its own modern building providing 21,500 square feet of well-equipped office and laboratory space for startup companies. Access to many services, both business and technical, is provided. Companies in the incubator are prime candidates for the VentureAccelerator.

Applicant companies come from both inside the University; i.e., faculty-owned startups, and from outside the University. During the program's 17 years of operation, 45 companies have graduated, and most are operating in the region. The University believes that in the future, a growing proportion of applicant companies will result from the on-campus technology entrepreneurship activities discussed above. With its physical location near the engineering school, and with its technology orientation, the incubator is nearly optimum for student and faculty startups.

Another advantage of the program, and one that is important to faculty, is that conflict-of-interest issues associated with faculty-owned companies have been anticipated. As such, policies and procedures have been established and are well understood by incubator staff. This tends to minimize problems associated with faculty ventures.

Of the 45 companies that have graduated from the incubator, five years after graduation, 80% of the graduating companies are still in business. Three of the companies are listed on major stock exchanges, and two of these companies have a combined valuation of over one billion dollars. The third company merged with another company which in turn merged with Dun and Bradstreet. Twenty percent of major public biotech companies in Maryland got their start in the incubator.

Synergies of the Diverse Programs

The Clark School's diverse entrepreneurial initiatives benefit from many synergies which strengthen each program as well as the overall effort. For example:

- Student ventures arising from the Hinman CEOs Program, the TVC and the technology ventures startup course are frequent entries in the business plan competition
- Hinman CEOs undergrad students have been placed as interns within incubator companies in technical and business roles, giving these students on-the-job training in technical entrepreneurship
- Ventures emanating from the Hinman CEOs Program, the TVC and the Fundamentals of Technology Startup Ventures course often apply to the seed funding program for product development support
- The VentureAccelerator markets its services heavily to Hinman CEOs companies, TVC

students, incubator companies, and winners of the Business Plan Competition.

- External sponsors of the Business Plan Competition serve as angel investors, venture capitalists, and mentors to portfolio companies within the incubator, accelerator, TVC, and Hinman CEOs Program.

SUMMARY AND CONCLUSIONS

The Clark School of Engineering has developed a comprehensive set of programs and activities to assist students, faculty and regional entrepreneurs in creating, managing and growing technology enterprises. Students and faculty who often begin with little knowledge of how to start a technology company are provided with a wide range of substantial opportunities to learn and develop viable enterprises.

About 50 entrepreneurial undergraduate students enter the Hinman CEOs Program each year and are taken through a two-year experiential, hands-on set of activities that develops their entrepreneurial skills. Over the three years of the program, 30 companies have been formed by teams of students, and operating these companies gives the students valuable hands-on experience which adds greatly to the academic training that students normally receive.

The Technology Startup Boot Camp, Business Plan Competition, Technology Ventures Club and Fundamentals of Technology Startup Ventures Course are activities that help to develop the technology entrepreneurial culture. These activities help students to understand the technology startup process and to gain confidence in their ability to start technology enterprises. Several companies have been started by graduate students and faculty who participate in these activities.

Information on the web portal allows students and faculty to learn more on their own initiative. Mentoring by University personnel and regional experts provides answers to specific questions and guides them to the next level of enterprise development.

The VentureAccelerator is currently mentoring seven companies. These firms represent diverse technologies and stages of development. These enterprises include those started by students (undergraduate and graduate), faculty and companies in the incubator that were started by regional entrepreneurs.

The seed funding program has helped 124 startup companies to develop products and services, and over 50% of these companies are still in business ten years after receiving the assistance.

The on-campus incubator has produced three companies that are publicly traded on major stock exchanges including 20% of the publicly traded biotechnology companies in Maryland. Thirty-six successful private companies have also been developed in the incubator.

We are confident that our holistic approach to on-campus technical entrepreneurship will continue to result in viable ventures and provide insights to students and faculty that will impact their careers and destinies.

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