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Technology Entrepreneurship Promoted by Universities' Incubation Centers in Taiwan: Its Successes and Challenges

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Abstract — *Since 1996, the Small and Medium Enterprise Administration (SMEA) in Taiwan has supported various institutions to establish incubation centers (ICs) for facilitating start-ups and innovation. At present, there are 79 ICs in total and 65 (or 83%) of them are established in universities/colleges. Most ICs in the universities/colleges offering engineering education (EE) and/or engineering technology education (ETE) programs perform very well in technology entrepreneurship. Based upon literature review and the first author's practical experience of being his university's IC's former director, this paper points out its successes can be attributed as follows: (1) Employing university's core competencies, (2) Aligning with regional industry clusters (3) Focusing on emerging technologies, (4) Valuing cultivation of start-up and innovation talent, (5) Encouraging technology transfers, (6) Making collaboration and exchange between ICs. However, the ICs also face the following challenges: (1) More incentives should be offered to encourage faculty involvement; (2) Tighter links should be forged between incubation centers and venture capital firms; and (3) Technology entrepreneurship should be highly emphasized in the incubation center performance appraisal.*

Index Terms *— technology entrepreneurship, incubation center, startup, Taiwan*

College-level Entrepreneurship (E-ship) Education Programs Have Grown and Obtained Benefits

In this new century of technology, we are facing the challenge to attain full employment and economic growth. Many jobs and much wealth are created by small enterprises started by entrepreneurially minded individuals, many of whom go on to create larger enterprises. Therefore, eentrepreneurship is a driving force in pursuing full employment and economic growth. As a way to upgrade a student's abilities to succeed as an employee as well as an entrepreneur, entrepreneurship education is becoming a priority within all levels of education.

For example, Table 1 shows the five-stage lifelong entrepreneurship education model, developed by the Consortium for Entrepreneurship Education. Both Stages 3 and 4 may take place in vocational schools/programs, two-year colleges and four-year colleges and universities. Stage 3 encourages students to create a unique business idea and carry the decision-making process through a complete business plan; and, in some cases enable students to actually experience the operation of a business. The outcome of Stage 3 is for students to learn how it might be possible to become an entrepreneur and to practice the processes of business. Stage 4 assists adult learners having job experiences to put a business startup idea together. Governmental administrations concerning small business normally sponsor these training programs [1].

Entrepreneurial competencies can be learned and fostered. In the United States, entrepreneurship education programs are growing in colleges and universities. Whereas 15 years ago only a handful of schools offered courses in entrepreneurship, today more than 1,500 colleges and universities offer some form of entrepreneurship training. There are currently more than 100 active university-based entrepreneurship centers in the country and more than 270 endowed positions in entrepreneurship, an increase of 120% in just the last five years [2]. That is to say, the number of entrepreneurship programs has significantly increased since the early 1990s. A survey of 2,484 Eller College alumni from the University of Arizona (UA), 460 of whom have graduated from UA's Berger Entrepreneurship Program since its founding in 1983. There were 511 alumni, including 105 entrepreneurship graduates, completed and returned the questionnaire and the response rate was about 21%. Compared to other graduates of the UA's Eller College of Business and Public Administration, alumni of the Berger Entrepreneurship Program: (1) are three times more likely to start new businesses; (2) have annual incomes that are 27 % higher and own 62 % more assets; (3) are more satisfied with their jobs (the margin, after controlling for outside factors, was about 1%); (4) are more likely to work for high-tech companies and to be instrumental in new-product development [3] .

Job Training and Education			Job Experience	
Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**
Basics	**Competency Awareness**	**Creative Applications**	**Start-up**	**Growth**
• Gain prerequisite basic skills • Identify career option • Understand economics and free enterprise	• Discover entrepreneurship competencies • Understand problems of employers	• Learn entrepreneurship competencies • Apply specific occupational training • Learn how to create new businesses	• Become self-employed • Develop new policies and procedures for a new or existing business	• Solve business problems effectively • Expand existing business

TABLE 1
LIFELONG ENTREPRENEURSHIP EDUCATION MODEL [1]

Engineering-related Programs Are Expected to Include Technology Entrepreneurship

College-level entrepreneurship programs are becoming more common in non-business disciplines, such as engineering and the arts [4]. Technology entrepreneurship, whether in a start-up or established company, is "a style of business leadership based on the process of identifying high-potential, technology-intensive business opportunities, gathering resources such as talent and cash, and managing rapid growth using principled, real-time decision-making skills" [5]. A technology entrepreneur, who is expected to demonstrate leadership in bringing technology to the market, is normally to solve a problem that exists in the market, to build long-term value, and is to have freedom [6].

It should be noted that engineering entrepreneurship and technology entrepreneurship have similar ends and means. For example, the College of Engineering at Penn State University (PSU) received a two-year grant from General Electric (GE) to launch Engineering Entrepreneurship Minor, designed to enhance the skills, knowledge, and attitudes necessary for students desiring to become entrepreneurs [7]. Kisenwether at PSU argued that the Minor aimed to move students with entrepreneurial mindsets to become technology entrepreneurs [8].

Decent engineering education (EE) programs and engineering technology education (ETE) programs are anticipated to include technology entrepreneurship education. For example, Emery and Feland argued that engineers may demonstrate the following competencies when they learn entrepreneurship: (1) Design and development of technology-based products, (2) Technical leadership of engineering departments, (3) Marketing and product management of technology-based products, (4) Sales and customer support for high-technology products, (5) Leading technology-based companies, and (6) Founding high technology businesses [9]. ABET (Accreditation Board for Engineering and Technology) criteria are often mentioned to support the rationale to offer technology entrepreneurship education in both fields of EE and ETE.

University's Incubation Centers in Taiwan Have Actively Promoted Technology Entrepreneurship

In Taiwan, in the manufacturing, construction and mining and quarrying sectors, small and medium enterprises (SMEs) are defined as those enterprises with less than 200 regular employees; for other sectors they are defined as those enterprises with less than 50 employees. The SMEA has substantially assisted SMEs to become more competitive.

In May 2002, the government of Taiwan launched a six-year national development plan (2002-2007) called "Challenge 2008", which vision is to develop Taiwan into a "green silicon island" that balances the needs of environmental protection and economic development. The aim of "Challenge 2008", which will cost an estimated US$75 billion, is to foster the creativity and talent that Taiwan needs to achieve this vision. As a part of Challenge 2008, a "Two Trillion and Twin Star" program is promoted. This is four-year project to drive the production value of semiconductor and flat-panel display (TFT-LCD in particular) industries to NT$1 trillion (US$29.6 billion) each, and build the digital content and biotechnology sectors into star industries, all by 2006. The National Si-Soft Project was also launched to upgrade Taiwan's integrated circuits (IC) industry [10] . These emerging technologies inspire many technology entrepreneurs.

In Challenge 2008, "Developing Taiwan into an Asia-Pacific Entrepreneurship Center" is a sub-program to establish powerful mechanisms for innovation and business start-up, thereby facilitating the growth of innovative new enterprises. Intended to be a virtual center, the Entrepreneurship Center is anticipated to utilize Taiwan's existing SME incubation centers as its main platform, forging links between domestic industries and funding sources, forming alliances with overseas incubation centers, as well as offering joint entrepreneurship with leading foreign universities [11].

Since 1996, the SMEA has financially and administratively supported various institutions to establish incubation centers (ICs) for facilitating start-ups and innovation. At present, there are 79 ICs in total and 65 (or 83%) of them are established in colleges and universities. Most ICs in the colleges and universities offering EE and/or ETE programs perform very well in

technology entrepreneurship. The university's ICs can collaborate with leading program design and providing educational activities to support start-ups and innovation. The students involved include ordinary university students, graduate students, would-be entrepreneurs and entrepreneurs in starting up their business, mainly operated within an incubation center. Every project gains consultations from experts, and supported by the university and IC staff, who are responsible for assisting the commercialization of the technologies developed within the university's laboratories. Trade fairs can be used to bring companies, venture capital firms and SME development companies together. The government provides assistance in terms of personnel cultivation, funding and revision of the legal framework [12].

The Successes of Technology Entrepreneurship Relies on Interlocking Mechanism

The Innovation Incubation Center at National Taiwan University (NTUIIC) categorizes its incubation industries into the following six domains: electronic technology, information technology, telecommunication technology, internet technology, machinery automation and bio-technology. In the past eight years, 22 SMEs are incubated yearly on average. It has accumulated to 28 graduated SMEs. The incubatees' businesses grow rapidly. Until 2003, total capital of incubatees in NTUIIC had increased over NT$800 million (approximately, US$1 = NT$31.4 now), the government fund received by the incubatees was NT$45.4 million, and 800 job opportunities were created [13].

Technology entrepreneurship faces high risk and uncertain outcomes. It needs more quantitative data to determine the extent of success that the technology entrepreneurship incubated in universities attain. However, the growth of the technology entrepreneurship incubated in universities is on the right track because the university's ICs supported by the SMEA generally operate the following measures which assemble an interlocking mechanism:

1. Employing university's core competencies

An individual/organization's core competency is the one thing that it can do better than its competitors. For example, the core competency of Taiwan's ACER is building cutting edge personal computers faster and cheaper than the competitors [14]. The university's ICs in Taiwan keenly consider university's core competencies to screen/recruit entrepreneurs and potential entrepreneurs who intend to join ICs.

2. Aligning with regional industry clusters

An industry cluster is a geographic concentration of competing, complementary or interdependent industrial firms with a common need for talent, technology, infrastructure, and so on [15]. For example, one of best-known hi-tech industry clusters in the USA is located along Route 128 in Boston. In Taiwan, science-based industrial parks have promoted industry clustering to make it easier for hi-tech firms to secure technology from other companies and from academic institutions [12] . The university's ICs in Taiwan align with industry cluster effects.

3. Focusing on emerging technologies

As mentioned earlier, semiconductor, flat-panel display, digital content and biotechnology are four areas of emerging technologies in Taiwan. Many start-ups focus on these emerging technologies. For example, many entrepreneurs in the Incubation Center, National Taiwan Normal University, have cooperated with faculty in developing digit content, such as electronic game and e-learning software.

4. Valuing cultivation of start-up and innovation talent

Technology is changing but human capital remains an organization's most important asset. University's ICs have often independently or jointly organized training programs for current and potential technology entrepreneurs, some of whom are EE/ETE students.

5. Encouraging technology transfers

University's technology transfer has multiple ways such as educating students and publishing research results. Most university's ICs have encouraged technology transfer of faculty-generated inventions in developing into useful products in the commercial marketplace for public use.

6. Making collaboration and exchange between ICs

Synergy is a combined entity which has a value greater than the sum of its parts, or arrangements which are mutually beneficial for all those involved [16]. In order to gain synergy, many collaborations and exchange, such as joint entrepreneurship expositions and forums, have been made between university's ICs.

The Challenges of Technology Entrepreneurship Should Be Addressed

There are at least the following challenges should be addressed:

1. More incentives should be offered to encourage faculty involvement

The faculty members in public colleges and universities have seen as a kind of public servants for long. The regulations applicable to public servants restrict faculty to start up a business or obtain a rich profit when he/she transfers his/her

technological know-how to the incubatees. Therefore, more incentives should be offered to encourage faculty involvement.

2. Tighter links should be forged between incubation centers and venture capital firms

In the past few years, many venture capital firms have been switching their attention to the USA or mainland China, and this has had a negative impact on the development of Taiwan's hi-tech sector [11]. If tighter links can be forged between incubation centers and venture capital firms, a win-win situation may be created for both parties.

3. Technology entrepreneurship should be highly emphasized in the incubation center performance appraisal

The university's ICs receiving funding from the SMEA are appraised yearly. The performance appraisal results are used to be a basis for the allocation of subsidies in the succeeding fiscal year and the awards to outstanding ICs and outstanding IC managers. In order to effectively promote technology entrepreneurship, technology entrepreneurship should be highly emphasized in the incubation center performance appraisal.

To sum up, technology entrepreneurship is not easy. An entrepreneur needs high creativity and innovation as well as high general management skills, business know-how and networks (see Figure 1). As a technology entrepreneur, he/she has to effectively respond to the following questions: (1) What is technology entrepreneurship? (2) What is the difference between an idea and a business opportunity? (3) Why do ventures require dynamic leaders who understand vision, strategy, risk, and tactics? (4) How does context (e.g., economic and political climate) play a role in high-tech entrepreneurship? (5) What is market positioning? (6) Why are partnership strategies important? (7) What is the purpose of the business plan? (8) Why is cash flow so vital? (9) What are the different sources of capital for high-tech ventures? (10) What are the essentials of the venture finance process from both the investor's and founder's perspectives? (11) Why is technology entrepreneurship a team sport? (12) How can reward systems and company culture inspire innovation? (13) Why are appropriate sales and business development skills so valuable? (14) What is the role of ethics in technology entrepreneurship? [5]

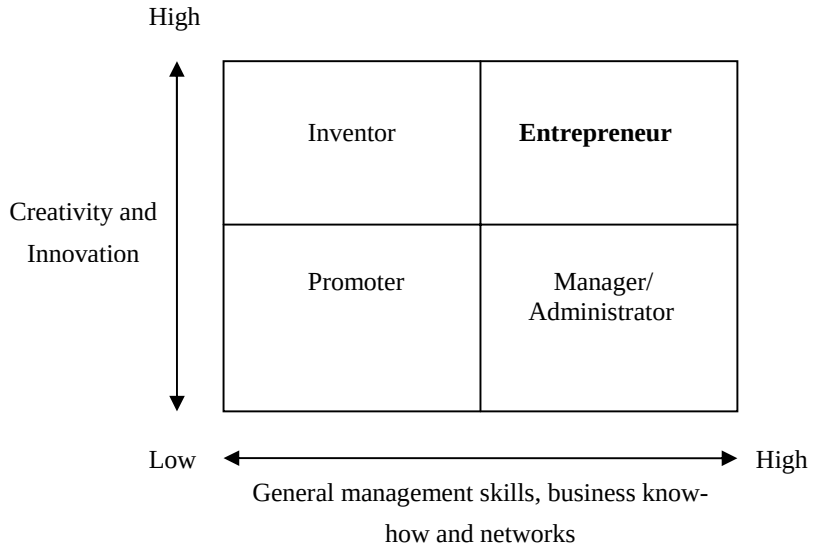

FIGURE 1
A CURSORY POSITING OF ENTREPRENEUR [17]

To become effective promoters, the university's ICs in Taiwan, working with the SMEA, have created a better environment for technological star-ups and innovation: a sound regulation system, better financial and management support and more efficient bridging services offered to their stakeholders. However, the challenges ahead should be continuously and effectively identified and solved.

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