

University Innovation & Entrepreneurship Ecosystem for Engineering Education: A Multi-case Study of Entrepreneurship Education in China

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University Innovation & Entrepreneurship Ecosystem for Engineering

Education: A Multi-Case Study of Entrepreneurship Education in China

Abstract: As an active response to the national policy “public entrepreneurship and innovation,” the university entrepreneurial ecosystem for engineering education provides a new model for developing theories and practices of entrepreneurship education in China’s most advanced universities. This study contributes in several ways to engineering education and entrepreneurship education. First, as one of the key strategies for global competition in human resources, university entrepreneurial ecosystem highlights the importance of questions like “how to disseminate entrepreneurial education in universities” and “how to cultivate college students’ entrepreneurial awareness, entrepreneurial thinking, and creativity.” Second, in spite of the rich theoretical and practical accomplishments in the fields of engineering education and entrepreneurial ecosystem theory, few studies have attempted to combine the insights from both fields of study. This paper makes a novel contribution by bringing together literatures in engineering education and entrepreneurial ecosystem.

This paper begins with clearly defining and delineating entrepreneurship education and its objectives in Chinese universities, identifying three major models of entrepreneurship education: 1) specialized education model; 2) program-driven model; and 3) whole process engagement model. Next, using semi-structured interview and structured case study methods, this paper dynamically traces and conducts quantitative analysis of the design, construction, and operation of entrepreneurial ecosystems in Zhejiang University and Xi’an Jiaotong University. In conclusion, this paper offers suggestions for improving university entrepreneurial ecosystem in China in five aspects: founding entrepreneurial schools; building supply chains of entrepreneurial service for engineering education; establishing Technology Transfer Office; faculty development in entrepreneurial education; and creating voluntary entrepreneurship organizations among university communities, alumni, and students.

Key words: Engineering Education, Entrepreneurship Education, Innovation and Entrepreneurship Ecosystem (I&E Ecosystem)

1 Background: Entrepreneurship Education of Colleges and Universities in

China

Innovation and entrepreneurship is considered one of the most powerful driving forces for economic and social progresses in our era. As a result, building a unique entrepreneurial ecosystem and transforming into an “Entrepreneurial University” have become goals for many colleges and universities. Since UNESCO granted entrepreneurship education the same importance as academic and vocational education in 1989, entrepreneurship education has gradually become one of the main focuses of governments around the world. Inspired by decisions made at the 17th National Congress of the Communist Party of China, the Chinese Government has paid intensive attention to strengthening entrepreneurial education in colleges and universities. This emphasis is echoed in multiple policy documents, such as the Chinese Ministry of Education (MOE)’s “Opinions on Vigorously Promoting entrepreneurial Education in Universities and Start-ups by College Students”^[1](2010) and “Opinions on Comprehensively Improving the Quality of Higher Education”^[2](2012). The Chinese State Council’s annual “Report on the Work of the Government” in 2015 further clinches governmental support for entrepreneurial by encouraging people to “start their own businesses and to make innovations” as a way to create jobs and increase their income. In May 2015, the State Council General Office provided a blueprint for implementing this national strategy in higher education through its “Opinions on Deepening the Reform of entrepreneurial Education in Colleges and Universities,” a policy document that articulates the importance of entrepreneurial Education in four areas: 1) the nation’s innovation-driven development strategy; 2) upgrading national economy; 3) comprehensive reform in higher education; and 4) employment of college graduates.^[3] In June 2016, the MOE proposed to “institutionalize reform in entrepreneurial education” (MOE, 2016).^[4] These policies and actions by the MOE indicate that entrepreneurial education in Chinese universities and colleges has entered a new era of comprehensive implementation. Based on this situation, constructing a unique entrepreneurship education model and building entrepreneurial ecosystem according to their own conditions and environment are fundamental for colleges and universities on their road towards “Entrepreneurial University”.

2 Defining Key Terms

2.1 Objectives and Characteristics of Entrepreneurship Education

Colin Bohl (1988) proposed that entrepreneurship education should cultivate in students the necessary knowledge, ability, and psychological qualities required for undertaking entrepreneurial activities. Gerald E. Hills (1988) proposed that the most important objective for entrepreneurship education is to increase students’ awareness and understanding of the process of initiating and managing a new business enterprise.^[5] In 1998, UNESCO defined entrepreneurship education as the cultivation of individuals with initiatives. *Entrepreneurship Education* refers to an educational system that equips the learners with entrepreneurial abilities via the development of entrepreneurial awareness, entrepreneurial thinking, and entrepreneurial skillsets, of which the objective is to make students in colleges and universities behave like entrepreneurs and to equip them with the knowledge, skills, and personalities needed for their future careers through cultivating entrepreneurial mind, attaining entrepreneurial knowledge, and experiencing the entrepreneurial process (Zhang, 2007; Liu,

2008).^{[6][7]} Bae et al (2014) & Tingey et al. (2016) argue that entrepreneurship education is about developing entrepreneurial attitudes and skills, with the purpose of increasing motivation for under-resourced groups to complete formal education, promoting vocational and social skills, and enabling youth to contribute to their community's economic development.^{[8][9]}

Table 1 Objectives and Characteristics of Entrepreneurship Education

Bohl (1988)	Cultivating the knowledge, abilities, and psychological qualities required for undertaking entrepreneurial practice
Gerald (1988)	Increasing awareness and understanding of the process involving in initiating and managing a new business enterprise
UNESCO (1998)	Encouraging initiatives among individuals
Zhang (2007)	Educational systems that develop learners' entrepreneurial abilities
Liu (2008)	Making students in colleges and universities behave like entrepreneurs and equipped themselves with the knowledge, skills and personalities needed for their future careers
Bae et al. (2014)	Developing entrepreneurial attitudes and skills
Tingey L, et al. (2016)	Increasing motivation for under-resourced groups to complete formal education, promoting vocational and social skills, and enabling youth to contribute to their community's economic development

In this paper, we argue that entrepreneurship education is an “action-induced learning model” that seeks to cultivate entrepreneurial thinking. That is, the essence and primary objective of entrepreneurship education are not entrepreneurial behaviors but education. Teaching “entrepreneurial skills,” as important as it is, should not be the fundamental, let alone the only, objective of entrepreneurship education. Instead, we argue that the most important objective is the cultivation of entrepreneurial culture and innovative thinking, and this objective is most effectively met by curriculum and practical projects that adapt to the unique culture and local conditions of individual educational institutions.

2.2 Main Models and Characteristics of Entrepreneurship Education

The model of entrepreneurial education is essential for achieving the objectives of entrepreneurial education. Traditional education model, however, is inadequate for preparing entrepreneurs to deal with the complexities of running and creating innovating business opportunities (David Higgins, et al., 2013).^[10] As a matter of fact, it is urging to develop innovative thinking and educational models to improve entrepreneurial education. Indeed, colleges and universities will decide different models of entrepreneurship education based on their own conditions and environment. A few major entrepreneurship education models and their core characteristics in the US and China are shown in Table 2.

Table 2 Entrepreneurship Education Model and Characteristics in US and China

	Model	Characteristics	Representative
US	Focused model	Instructional activities running specifically in Business School and Management School	Harvard University
	Radiant model	Instructional activities spreading all over the campus	Cornell University
	Magnet model	Entrepreneurship Education Center taking charge of planning and running the whole program using resources from Business School and Management School	MIT
China	Specialized education model	Focusing on entrepreneurial training and competency development	Zhejiang University

Program-driven model	Characterized by research and teaching integration and practices	Xi'an Jiaotong University
Whole process engagement model	Stressing on multi-subjects and whole process engagement	Tsinghua University

As the role model of entrepreneurship education in the world, the US exhibits three main models for entrepreneurship education. First, the focused model. In this model, instructional activities run specifically in Business School and Management School to develop specialized entrepreneurial talents. For example, in Harvard University, it is the applicant's personalities that matters. Students' entrepreneurial skills are developed through programs and activities (National Agency for Enterprise and Construction, 2004).^[11] Business School and Management School are in charge of the faculty, expenditure and programs needed in entrepreneurship education. This purity helps entrepreneurial education develop in system, and as a result, there is a large probability that graduates will start their own business in the future. Second, the radiant model. Different from the focused model, in radiant model, instructional activities spread all over the campus to develop students' entrepreneurial spirit and mind for their future careers. Taking Cornell University as an example, it insists that "every student with entrepreneurial skills and knowledge can make great value in any working conditions". The Committee of the Entrepreneurship and Personal Enterprise Program has been established to coordinate and guide entrepreneurial activities at Cornell. Students can choose their programs across schools and majors, which will break the border of different disciplines and maximize the use of resources (University-wide Entrepreneurship @ Cornell, 2004).^[12] Last, the magnet model. MIT is an important representative of this model. Its Entrepreneurship Center has a mission to "stimulate, train and direct the new generation of entrepreneurs from all different departments in MIT". In this model, all programs are developed through the capital, faculty and alumni from Business School and Management School, and Entrepreneurship Education Center takes charge of planning and running the whole program (Mei, 2008).^[13] Similarly, presently three models of entrepreneurship education are widely practiced in China's colleges and universities: First, the model of specialized entrepreneurship education focusing on entrepreneurial practice and the cultivation of entrepreneurial capacities. This model is often implemented through curricular and extracurricular activities, such as disciplinary competition, entrepreneurial training, university incubators for start-up companies, practice-based entrepreneurship education, business plan competition, and intensive classes on entrepreneurial. Major universities like ZJU, Shanghai Jiaotong University, and Central South University have followed the specialized education model. Second, the program-driven model emphasizing research and teaching integration and business practice. This model focuses on providing students with services including program practice, policy consultation, entrepreneurship guidance, resources support, etc. to develop and practice their abilities of innovation, entrepreneurship and employment, and is dedicated to establishing an entity platform for project incubation. Such kind of model is exemplified by Xi'an Jiaotong University, Nankai University and Wenzhou University. The third model—multi-agent whole-process participation—seeks to integrate "creativity, innovation, and entrepreneurship." Exemplars of this model, such as Tsinghua University and Wuhan University of Technology, have attempted to facilitate creativity through special interest groups, to support innovation through Maker Spaces, and to assist entrepreneurship by creating institutions like X-lab (Zhang et al., 2016).^[14]

As Table 2 indicates, entrepreneurship education in the US tends to develop students' entrepreneurial mind through instructional activities. In China, in contrast, entrepreneurship

education tends to encourage students to participate in entrepreneurial activities and to experience the whole process of entrepreneurship. In the whole, entrepreneurship education in the US is in integration of “top-down” and “bottom-up”, while in China, entrepreneurship education has a tendency to be “top-down”, which means the senior management of the university is responsible for entrepreneurship education.

Particularly, we want to call attention to the ecosystem of entrepreneurship education. In essence, the concept of ecosystem allows us to view entrepreneurship education as a holistic educational system that interconnects with the teaching, research, service, and international partnership of a university as well as the innovation systems in local and regional communities. This ecosystem mobilizes multiple actors and heterogeneous resources to stimulate innovative and entrepreneurial thinking and to support valuable entrepreneurial activities. In the follow section, we provide a clear definition of the entrepreneurship education ecosystem.

2.3 Components and Definitions of Entrepreneurship Education Ecosystem

MIT and Kauffman Foundation define an entrepreneurship education ecosystem as all kinds of programs concerned with the development of entrepreneurs and the commercialization of technology or intellectual property issues in universities. Isenberg (2014) suggests that an entrepreneurship education ecosystem consists of six general domains: a conducive culture, enabling policies and leadership, availability of appropriate finance, quality human capital, venture-friendly markets for products, and a range of institutional and infrastructural supports.^[15] Emphasizing the engaging subjects in entrepreneurial activities, Diaconu and Dutu (2015) suggest that individuals, organizations, institutions are significant factors that can influence successful entrepreneurial behavior.^[16] Liu (2012) explains that the interacting and interdependent unity between the entrepreneurship education and other actors in the ecology is sustained by information flow, incentive structures, and mechanisms for mutual reinforcement.^[17] Li (2015) extends the ecosystem to include relevant activities throughout the teaching and research of a university and community activities that aim at developing entrepreneurial thinking and supporting entrepreneurial practice.^[18] According to Li, this ecosystem is an “organic” unity of strategies, infrastructure, teaching and learning, and outreach activities. Zhao et al. (2015) and Mack (2016) accept the concept of an entrepreneurship education ecosystem as an “organic unity” and further articulate the characteristics of this complex unity. For Zhao et al. and Mack, an entrepreneurship education ecosystem is a university-led entity with social and governmental support. Through cash flow, practice docking, technology transfer, and culture building, this ecosystem enables the circulation of “currents” such as talent, information, and capital among universities, governments, and society in ways that impact and constrain the effects of entrepreneurship education. And through these interacting components, new firm formation and associated regional entrepreneurial activities are fostered.^{[19][20]}

Table 3 Components and Definitions of Entrepreneurship Education Ecosystem

MIT and Kauffman Foundation (2009)	University programs that focus on the development of entrepreneurs and/or the commercialization of technology and intellectual property issues
Liu (2012)	Unity between entrepreneurship education and the surrounding ecology
Isenberg(2014)	6 general domains: a conducive culture, enabling policies and leadership, availability of appropriate finance, quality human capital, venture-friendly markets for products, and a range of institutional and infrastructural supports
Mihaela Diaconu, et	Composed of individuals, organizations, institutions that can influence successful

al.(2015)	entrepreneurial behavior
Li (2015)	An organic unity formed by the interaction among various actors in the process of developing entrepreneurial thinking and practice
Zhao and Zhang (2015)	An organic unity that impacts and constrains the effects of entrepreneurship education through the circulation of talent, information, and capital among universities, governments and society
Elizabeth Mack(2016)	Consisting of interacting components, which foster new firm formation and associated regional entrepreneurial activities

To sum up, we suggest an entrepreneurship education ecosystem is an organic unity of strategies, infrastructure, teaching and learning, and outreach activities. Led by universities and supported by governments and society, this system enables the circulation of talent, information, and capital to develop entrepreneurial thinking and support entrepreneurial practice.

3 Entrepreneurial Ecosystem for Engineering Education: A Multi-Case Study of Universities in China

This paper selects two typical representatives from East China and West China, the former of which is Zhejiang University (the best engineering university in the east) and the latter is Xi'an Jiaotong University (the best engineering university in the west). Through structured case studies, this paper tends to develop entrepreneurial ecosystems for engineering education.

3.1 Case Study of Zhejiang University (ZJU)

Located in the historical and cultural center Hangzhou, ZJU is a distinct and internationally renowned comprehensive research university. Ranking 141 in ESI's latest data in March 9, 2017, ZJU ranked 102 in 2017 Research Ranking of Global Universities (RRGU) and 3 in mainland China. After decades of educational reform, experimentation, and practice, ZJU has established an entrepreneurial ecosystem with specialized education model that highlights interdisciplinarity, professional and "public innovation and entrepreneurship".

3.1.1 An Interdisciplinary Model for Engineering Education Innovation

The interdisciplinary model for engineering education in ZJU is reflected in ACEE (Advanced Honor Class of Engineering Education). Through integrating interdisciplinary general education, professional education, and comprehensive innovation education, ACEE prepares professionally competent engineering leaders who are capable of organizing and leading projects in key areas of engineering and technological innovations, and has been recognized as a national "Experimental Zone for Paradigm Innovation in Educating Comprehensive Engineering Talents." ACEE emphasizes on "fundamentals, design, and creation," aiming to educate comprehensive engineering talents who are solidly grounded in the natural sciences, have strong ethical principles, and display command of engineering design thinking and methods as well as design capacity. ACEE implements a specially designed DTIL Plan that features Design, Training, oversea Internship, and Leadership; the plan focuses on enhancing students' hands-on experience, open-ended design, and comprehensive innovation by reinforcing their comprehensive qualities with training in basic theories, hands-on practice, innovative design, and engineering problem solving. The ACEE curriculum, consisting of four modules (see Table 3), includes some core courses from different engineering majors as well as

ACEE exclusive courses. In addition, ACEE regularly invites famous experts to give seminars that introduce research in important engineering and scientific areas, especially topics on complex and large-scale engineering projects.

Table 4 Modules and Contents of ACEE Curriculum

Engineering Fundamentals	Mathematical Modeling, Introduction to Engineering, Systems Science and Engineering, Principles of Engineering
Engineering Design	Computer Graphics and Basic Data Structure
Engineering Management	Management, etc.
Engineering Practice	Wheeled Robot Technology, etc.

3.1.2 A Professional Model for Engineering Education Innovation

Zhejiang Polytechnic Institute benefits from ZJU’s traditional strengths in multiple disciplines, engineering research and education, a well-developed framework for government-industry-university cooperation, as well as a mature network for international collaboration. In response to national and regional innovation-driven development strategies such as “Made in China 2025” while educating more high-end engineering and scientific talents, the Polytechnic Institute was created by ZJU in 2016. Focusing primarily on graduate engineering education and training for corporate engineers, the Institute follows a “high-end, high-quality, international” philosophy of education and actively explores an educational system for cultivating applied, sophisticated, and innovative science and engineering talents. Education in the Institute emphasizes practical training in engineering, industry-university cooperation, and international collaboration. The Institute encourages the pairing of academic and corporate advisors and is actively engaged in creating mechanisms for cooperative education between university and corporations. The contents of education seek to integrate courses, engineering practice, international exchange and internship, as well as real world R&D experience. The Institute has formed partnership with world famous engineering institutions such as École Polytechnique, Technical University of Berlin, and Eindhoven University of Technology. The Polytechnic Institute also owns a world-class center for engineering innovation and training, which provides platforms for engineering experimentation and innovation in a number of areas, such as high-efficiency low-carbon clean energy, information and microelectronics, robotics and advanced manufacturing, and electrical and equipment technologies.

Table 5 Characteristics of the Polytechnic Institute, ZJU

Engineering Practice and Training	Campus training + corporate practice
International Exchange	Cooperation with universities overseas, short-term training and practice at well-known corporations
Technology R&D Innovation	R&D, design innovation, and completing theses based on industrial needs or the reality of enterprises
Dual-qualified Staff	Appointing full-time and part-time advisors who have experiences in university teaching and in industry
Catalyst of Educational Reform	Promoting reform at graduate level engineering education

3.1.3 A “Public Innovation and Entrepreneurship” Model for Engineering Education Innovation

The entrepreneurial ecosystem at ZJU is committed to “public innovation and entrepreneurship”. This commitment is exemplified in the Zijin Town for public innovation and entrepreneurship, a

university-led and publicly accessible incubator for entrepreneurial. The Zijin Town for Public Innovation and Entrepreneurship integrates multiple actors in university-industry cooperation, such as scientific research institutes, industrial research institutes, innovation parks, and national university parks for science and technology. Supported by the multiple campuses of the ZJU as well as its extensive network of collaboration with domestic and international universities, Zijin Town for Public Innovation and Entrepreneurship has established appropriate marketing mechanisms and a professional team to support technology transfer and project incubation. Creators of the Zijin Town envision it to become a unique incubator that actualizes ideas of “green and smart city.” The structure of the Zijin Town is illustrated in Figure 1. Zijin Town is committed to promoting academic entrepreneurship and encouraging faculty and students in ZJU to participate in entrepreneurship activities and the establishment of commercial enterprises in the forms such as industry-university cooperation, university-based venture capital funds, university-based incubator business, startups set up by scholars, and researchers with dual identity in enterprises and academic departments, in order to make their own research results commercialized and transform and apply into practice. Zijin Town is mainly responsible for the introduction of technical personnel, industry-university collaborative innovation, industrial technology R&D, project incubation transformation and entrepreneurial education training, and meanwhile for the establishment of the Institute of Scientific Research Achievement Transformation Committee and its institutions and the promotion of scientific research results incubation, transformation and industrialization. Through the integration of strength on and off campus, Zjin Town has established the Industrial Technology Transformation Institute and introduced market-oriented mechanism to build a first-class exhibition area of government-industry-university-research collaboration and faculty-and-students co-entrepreneurship.

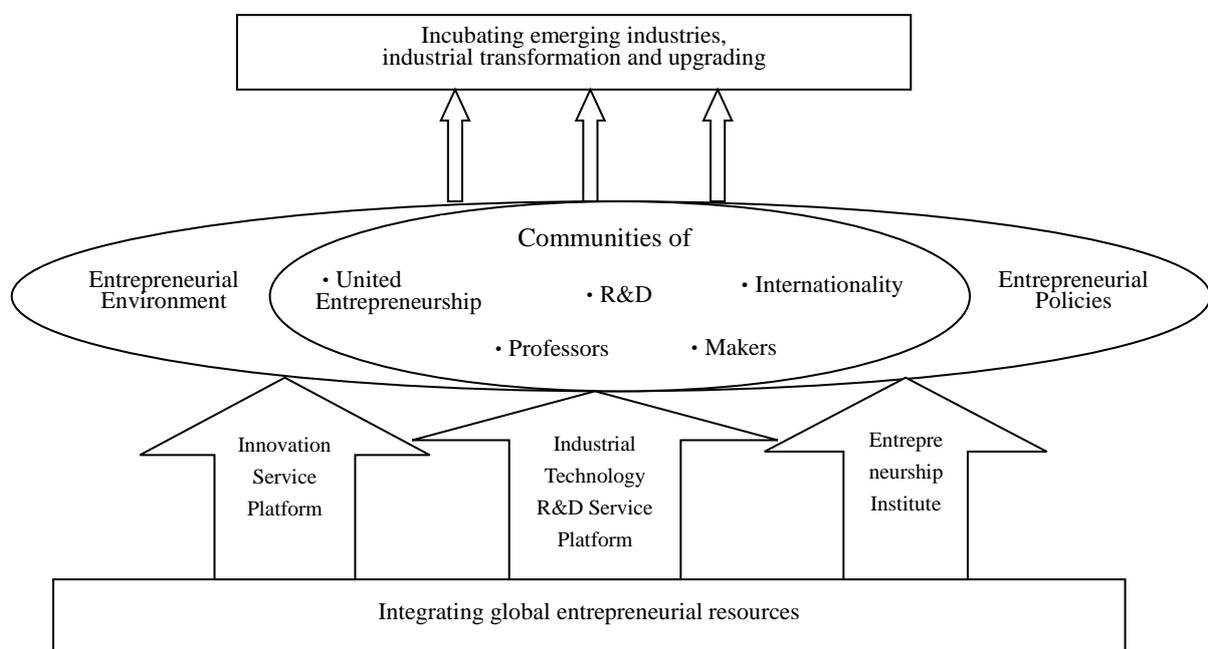


Figure 1 Structure of Zijin Town for public innovation and entrepreneurship, ZJU

By the end of 2015, graduates from ZJU have founded more than 100 public companies. ZJU's

graduates also account for 80% of owners of science and technology business in the city of Hangzhou. Since 2012, graduates from ZJU have founded over 1,700 science and technology companies in the National High-tech Industry Development District in Hangzhou. As a result, graduates from ZJU have been recognized as one of four major entrepreneurial forces in the Province (the other three are the “Alibaba” corporate group, “Zhejiang merchants,” and “Entrepreneurs Returning from Oversea”).

3.2 Case Study of Xi’an Jiaotong University (XJTU)

Located in Xi’an, Shaanxi Province, Xi’an Jiaotong University (XJTU) is a comprehensive, national key research university with traditional strengths in science and engineering. In March 2017, XJTU got the ESI ranking of 470 in the world, and 18 in mainland China. XJTU has developed an entrepreneurial ecosystems with a program-driven model, that is, a model of research-and-teaching integration and practice orientation. Aiming to develop students’ innovative and entrepreneurial awareness, capability, and engineering leadership, this entrepreneurial ecosystem is based on engineering disciplines and driven by large-scale national projects and university-industry cooperation. Over the years, this entrepreneurial ecosystem with special characteristics has carved out a unique pathway for enhancing students’ hands-on design capability; meanwhile the ecosystem helps lay a solid ground for students to understand and solve complex engineering problems.

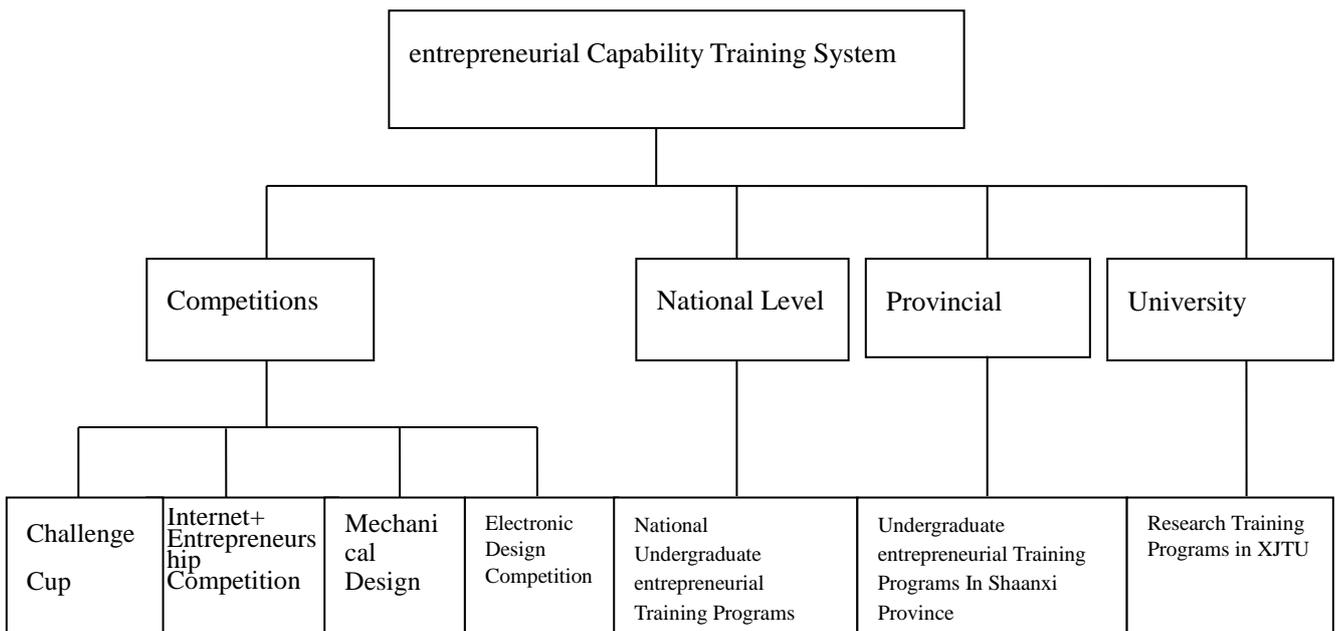


Figure 2 entrepreneurial Capability Training System in XJTU

3.2.1 A Research -and-Teaching-Integrated Model for Engineering Education Innovation

Research and teaching integration consists of two parts: entrepreneurial curriculum and collaboration with industrial partners. To begin with, XJTU creates an overall systematic plan for practical education that features a comprehensive entrepreneurial curriculum. With inputs and participation from the industry, XJTU’s plan increases the proportion of practical education in students’ credits. This is done in part by creating for-credit entrepreneurial courses. The plan also provides opportunities for industry to play a greater role in cooperative education through offering courses,

giving talks, and assigning corporate employees as students' co-advisors. The entrepreneurial curriculum focuses on contents like career planning and development, entrepreneurship and management consulting, entrepreneurship boot camp, as well as seminars that introduce state-of-the-art research. In addition to curriculum development, XJTU also creates a service team that consists of career consultants and supporting groups. With these measures, XJTU fosters an entrepreneurial ecosystem that benefits from the synergy between practical and curricular education. Meanwhile, XJTU is dedicated to collaborate with industrial partners. Using CDIO projects (Conceive, Design, Implement, Operation), XJTU has stimulated innovative practical education and promoted the combination of innovation and entrepreneurship through entrepreneurial training plans and competitions. XJTU has explored multiple forms of university-industry cooperation for entrepreneurial education, such as team-based professional practice, corporate-sponsored capstone design projects, internship, and team projects to solve real-world engineering problems supplied by the industry. The implementation of CDIO education at XJTU further reinforces self-guided learning and teamwork. From 2012 to 2015, these measures have resulted in 129 publications (including 36 SCI papers), 33 patents, and over 300 prizes in domestic and international competitions. Each year about 4000 students take part in one or more entrepreneurial education programs. In addition, the entrepreneurial ecosystem at XJTU has incubated 30 registered companies.

3.2.2 A Practice-Oriented Model for Engineering Education Innovation

There are two components of practice-orientation: innovation platforms and educational base for innovation and entrepreneurship. XJTU has developed and refined a series of platforms for interdisciplinary and university-industry innovation. To facilitate interdisciplinary innovation in engineering, XJTU built a “dreamworks studio” for college students to practice innovation. With an investment of over 60 million RMB, the 13,000 square meters Engineering Workshop provides a first-class engineering practical training base for students to practice interdisciplinary innovation in engineering science and technology. At present over 85% of XJTU students use the Engineering Workshop for practical training. The Engineering Workshop integrates multiple project teams to create an “innovation-friendly” atmosphere for students to practice new ideas and explore new solutions. The Engineering Workshop also enables and encourages interdisciplinary innovation, featuring interdisciplinary systems such as the mechatronics innovation platform, the electrical and electronics innovation platform, and the unmanned aerial vehicle innovation platform, etc. Besides encouraging interdisciplinary innovation within the university, XJTU also shares its innovation platforms with industrial partners such as Shaanxi Electric Power Company, Delixi Group, Dongfeng Motor Group, and Shenyang Machine Tool Company. To facilitate university-industry cooperative education for engineers, the university integrates 12 national centers for experimentation education, 8 interdisciplinary platforms for innovative practice, 8 national and 6 provincial off-campus practical education bases, and 220 industrial partners for internship. To ensure the quality of cooperative education, the university also forms partnership with a number of major industrial and research institutes, such as Center for Space Application Engineering and Technology of the Chinese Academy of Sciences, Beijing Qihoo Technology Co., Ltd., and Beijing Baidu Network Technology Co., Ltd. The alliance between XJTU and institutional partners recruit prominent sophomores in science and engineering majors to a three-semester co-op education program. The co-op education includes theoretical courses, innovation training plans, academic internship, production internship, team building, and awards for excellence. Besides, to build an entrepreneurial ecosystem that will

inspire innovative students, develop innovative and entrepreneurial capacity, and advance industrial development, XJTU has invested heavily in the XJTU-Xi'an High Tech District Educational Base for Innovation and Entrepreneurship. With the leadership of XJTU and the participation of companies in the Xi'an High Tech District, the Educational Base adopts a “university-government-enterprise cluster” model to facilitate deep collaboration among these actors. As Figure 3 illustrates, the Educational Base has developed “1 base and 4 centers,” all of which work synergistically to form an ecosystem that supports university-industry interaction and facilitates the fusion of innovation and entrepreneurship.

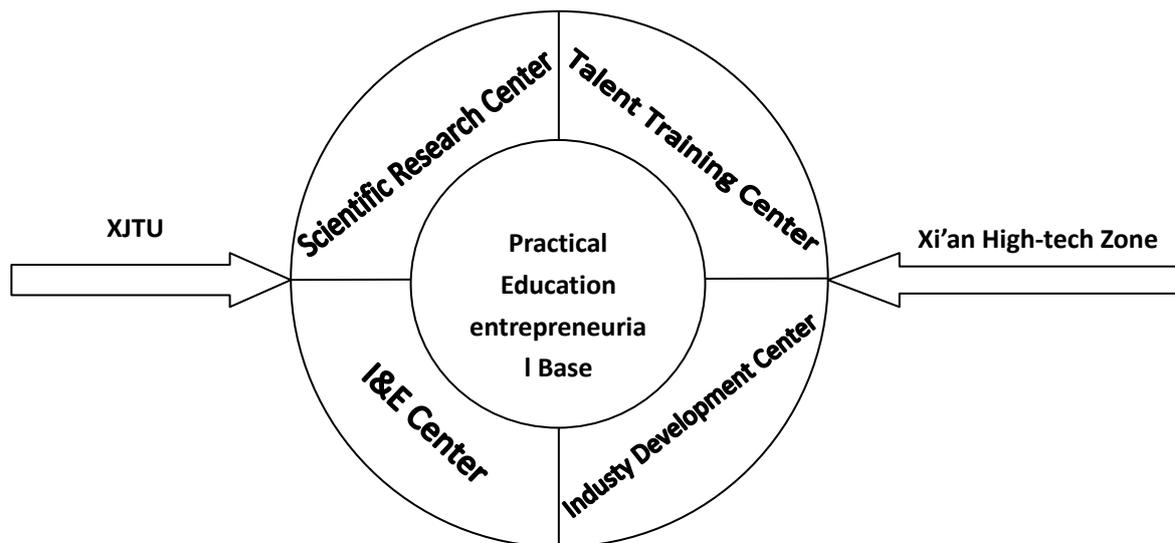


Figure 3 XJTU-Xi'an High-tech District Practical Education entrepreneurial Base

4 Five Suggestions for Improving University entrepreneurial Ecosystem for Engineering Education in China

Based on literatures in entrepreneurial education and engineering education research and our case studies of exemplars in establishing successful entrepreneurial ecosystems for engineering education, we make five recommendations for improving and further disseminating university entrepreneurial ecosystems for engineering education.

First, dedicated institutions of entrepreneurship, such as Entrepreneurship Schools, provide a promising means for educating entrepreneurial talents. Existing Entrepreneurship Schools in China have successfully educated young entrepreneurs, leaders in innovation and entrepreneurship, chief innovation officers, and senior corporate managers. Entrepreneurship Schools also provide leverages for integrating societal teaching resources (e.g., corporate entrepreneurship advisors), creating labs for entrepreneurship, and hosting international workshops and competitions on innovation and entrepreneurship.

Second, universities could play a central role in creating a supply chain for entrepreneurial service in Engineering education. To encourage engineering-led entrepreneurship, engineering colleges and departments could make labs and research facilities accessible to the entire campus, using these resources to build maker spaces that will create real-world products and service. To cultivate engineering students' entrepreneurship, curriculum developers could add courses that

emphasize engineering practical education through reengineering and optimizing the contents of practical education and eventually building state-of-the-art curriculum system for engineering practical education. University policymakers also play substantial roles in promoting university-industry cooperation and building multi-agent participation in the entrepreneurial education ecosystem by clearly articulating the roles, rights, and responsibilities of governments, industry, universities, researchers, and consumers in the educational system. University leaders can further integrate various stakeholders of engineering education to create learning communities. Finally, universities should take initiatives in co-operative education by creating centers for engineering practical education. These measures would significantly lower the cost for entrepreneurship and enhance its success rate.

Third, universities should establish Technology Transfer Offices (TTO) for academic entrepreneurship. Our analysis shows that appropriate institutional structure and incentives are essential for motivating innovation and entrepreneurship in universities. In particular, an effective Office of Technology Transfer would help translate the institutional and research strengths of mature universities into adequate protection of intellectual properties and potent drive for technical innovation and entrepreneurship. Proper incentive structures, such as equity allocation or proportional cash reward, would encourage faculty members to start their own business based on research findings or their own technical talents. Universities could also create a supporting environment for student inventors to translate their research findings or start their own business.

Fourth, faculty should become “academic-industrial double advisors” in entrepreneurial education. Through the fusion of industry and education, university faculty development and continued education should focus on improving faculty’s professional teaching as well as hands-on capabilities, and this can be achieved in part by increasing engineering faculty members’ industrial experience. Universities should attract more talents from the industry, especially top talents in the manufacturing industry. Universities could also collaborate with companies to train “academic and industrial” advisors. In addition, taking advantage of the Internet and virtual learning technologies, universities should take active steps to create virtual platforms for cooperative engineering education.

Finally, on the basis of top-down model of entrepreneurship education, universities in china should encourage self-organized, bottom-up model of entrepreneurship education driven by communities, alumni, and students. We caution against overreliance on governments and universities for the construction of university entrepreneurial ecosystems. Building such ecosystems should avoid an entirely “top-down” approach, which threatens to marginalize students, alumni, and self-driven entrepreneurial communities in the region. Instead, governments and universities should encourage faculty and students to pursue “sunshine entrepreneurship” by adopting evaluation and reward systems that emphasize industrial application, encouraging the participation of social stakeholders, channeling donation to innovation and entrepreneurship, and encouraging cooperation with corporate partners and companies founded by alumni.

5 Conclusions

Building upon existing literature, this paper dynamically traces and conducts quantitative analysis of the design, construction, and operation of entrepreneurial ecosystems in Zhejiang University and Xi’an Jiaotong University. The two case studies demonstrate two distinct models for

entrepreneurship education: a specialized education model in ZJU and a program-driven education model in XJTU. Based on the lessons generated by the case studies, this paper offers suggestions in five aspects: founding entrepreneurial schools; building supply chains of entrepreneurial service for engineering education; establishing Technology Transfer Offices; faculty development in entrepreneurial education; and creating voluntary entrepreneurship organizations among university communities, alumni, and students. This paper contributes to the theory and practice of entrepreneurship education in China through combining theories about engineering education and entrepreneurial ecosystem and through documenting the “best practices” in universities that have successfully built entrepreneurship education ecosystems.

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