A Successful Joint Venture for International Engineering Education

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Abstract

This paper describes a successful partnership in engineering education between two top universities in China and the US, Shanghai Jiao Tong University (SJTU) and University of Michigan (UM). From 2000, the partnership has evolved from a pilot program in the School of Mechanical Engineering in SJTU to a joint institute (college) within the same university that is called UM-SJTU Joint Institute (JI). The JI has a separate Mechanical Engineering program and an Electrical and Computer Engineering program offering Bachelor's, Master's, and Ph.D. degrees. Officially approved by the Ministry of Education of China in February 2006, the JI has grown from an unknown college that had difficulty recruiting sufficient undergraduate students to one that is able to attract top students in China with its reputation as a highly competitive and fully internationalized engineering program. The JI is essentially a US system within a Chinese public university. It has been regarded as the special zone and "experimental field" for China's reform in higher education. It is recognized in China for its autonomous management system, interdisciplinary curricula, internationalized programs, and faculty engagement in teaching and research. By far, a 100% of undergraduate placement for 1,531 graduates has been maintained at the institute. Over 37% of the graduates pursued higher level studies in the top 10 engineering graduate schools in the US. In 2016, both undergraduate programs of the JI acquired ABET accreditation. The goal of JI is to become a highly reputable institution for innovative global engineering education and research activities.

Background of the Partnership

Introduction of quality higher education resources from the western countries to China can be traced back to the early 20th Century. The purpose was to rapidly develop an effective model for China's higher education system to train talents that were desperately needed by the country. In the spirit of China's reform and opening policy, the Chinese central government approved a 5-year strategic plan from the Ministry of Education in 2004 that emphasized the importance of further opening the education system and encouraging international cooperation as one of the key strategies of China's educational development. One year earlier, the State Council passed the Regulations of People's Republic of China on Chinese-Foreign Cooperation in Running Schools.[1] In 2010, promoting international collaborations and introducing quality international education resources was stated in the National Long-term Education Reform and Development Plan.[2]

At the same time, in anticipation of the impact of globalization on higher education, universities in the United States have been developing various forms of educational offerings in other countries including China. Influence abroad for the country and international reputation for the institutions are the obvious benefits among others. The forms of US education abroad include branch campus, partnership with a local Chinese university, distance education, and consultation to universities and governments.[3]

It became natural for educational cooperation between universities of China and the US in various disciplinary areas. Among those areas, engineering had the priority. Figure 1 shows the number of students graduated from and admitted into engineering programs of universities in China from 2006 to 2015. The country is producing over a million engineers annually in the recent years which has doubled the number in 2006. This is supposed to be a big support for the rapid development of China and the rest of the world. However, the newly produced engineers are not necessarily prepared to meet the requirements of the market and to be able to function in the globalized industry. [4,12] Developing an effective educational model to produce engineers with a global vision and interdisciplinary mind remains a challenge.

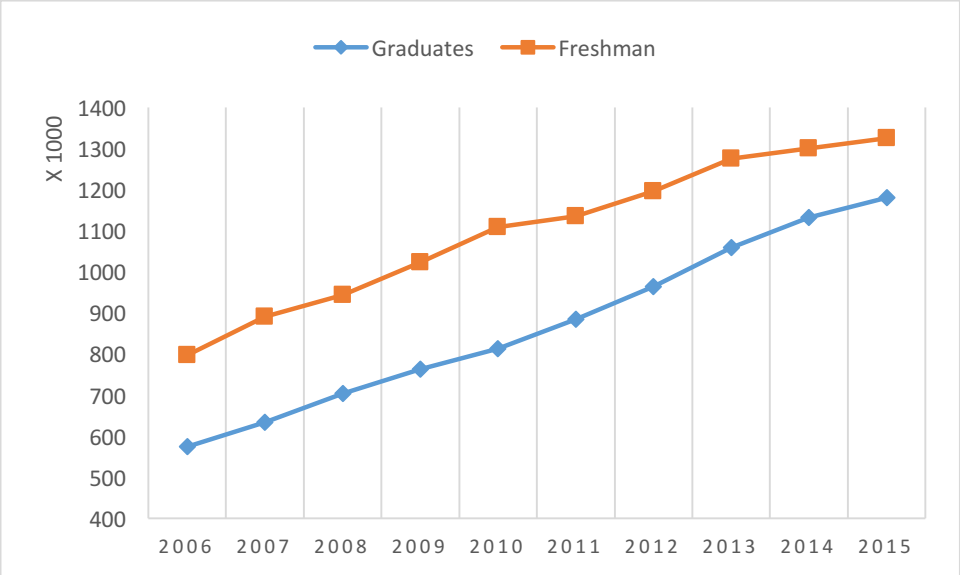

Figure 1. Statistics of Engineering Programs in China from 2006 to 2015
(*Source: Ministry of Education of China*)

Establishment of the Partnership

Under the circumstance, Shanghai Jiao Tong University (SJTU) started to collaborate with University of Michigan (UM) in engineering education in 1999. The two universities saw in each other comparable institutional characteristics that are desirable for effective cooperation. First, the two institutions are both large, comprehensive research oriented universities. Second, both universities are public/state universities that share the same institutional perspective. Third, both universities are among the prestigious elite within their country. Fourth, both universities have renowned engineering programs.[5]

From 2000 through 2005, the two universities entered into an agreement to develop the mechanical engineering discipline at SJTU and achieved remarkable results from this early pilot effort. Excited from this initial success, the two universities created a major strategic partnership agreement in 2005 to jointly establish an institute called UM-SJTU Joint Institute (JI) which is a college of SJTU located on its main campus in China. The JI offers a Mechanical Engineering (ME) program and an Electrical and Computer Engineering (ECE) program. Upon the official

approval by the Ministry of Education of China, the institute was publically launched in April 2006 in Shanghai. Its first cohort of undergraduate students entered in September 2006. At establishment of the JI, it has been designated a pilot for China's higher education reform and shouldered the task of experimenting various aspects of the US higher educational system and finding a working model(s) that can be exploited by other Chinese institutions.

Pragmatically learning from developed countries has been common in developing countries including China, which is effective sometimes but also coming with issues.[6] Many international collaborations in engineering education in China have adopted the "good" practices of the foreign education system while refused the "bad" or "not-to-work" practices. The founders of the JI, however, believed that it would be a fair judgment on "good" or "bad" practices only after they have actually been tried and proven working or not working. Therefore, the institute initially adopted almost every aspect of educational system from the University of Michigan. After one decade of experience, most adopted models are proven to work surprisingly well; some aspects, such as the mathematics courses, required significant adjustment to fit the Chinese system; some are more complicated that the institute is still struggling with, e.g. the limited undergraduate student quota. Those successful and innovative attempts now become the characteristics of the institute that include autonomous management, interdisciplinary curricula, internationalized programs, and faculty engagement in teaching and research.

Administration Model

On the one hand, JI as a part of the public Chinese university is not a legal entity. It has to comply with the basic regulations of the country and the university, such as student admission process, student quota, ideological education, financial rules, etc. On the other hand, it is financially self-sustained and has a fairly high level of autonomy in its administration, curricula, academic requirements, faculty and staff hiring and promotion, tuition, etc. From that perspective, it is like a standalone private institution.

The Dean of the JI reports to the Board of Directors which consists of top leaders of both parent universities including the President, Provost, VP for Research, Deans of three colleges of UM, and Chairperson of the University Council (General Secretary of the Party), President, Deputy Vice President, VP for Education, VP for Human Resources and International Affairs of SJTU. The Board of Directors has final decision-making authority on major issues such as mission of the institute, important developments, appointment of the Dean, tenure and promotion of faculty, etc. The decisions of the Board usually go through internal administrative process of SJTU for implementation.

The Academic Program Group (APG) was initially formed as an advisory panel for the Dean and later evolved to become a standing decision-making committee. The APG is composed of the Dean and Associate Deans of the JI and administrators and senior faculty members of the University of Michigan. The APG meets once every two weeks through video conferencing and discusses the full range of institutional decisions, challenges, and opportunities that arise at the institute. Significant emphasis is put on faculty appointments, promotion, and tenure. In this aspect, the APG functions similarly to a college level promotion and tenure committee at US

universities. The APG advises on expanded international academic cooperation to create new programs with other US universities.

The Dean appoints Associate Deans that oversees particular functions of the institute. The organization of the institute is special in that there is no department structure, which is discussed later. Administration of the institute is through faculty committees composed of mixture of faculty members of both ME and ECE programs. Faculty members on these committees are responsible for discussing and resolving issues, creating policies and procedures, making recommendations to the Deans, and having the authority of making final decisions on a number of matters. For example, the institute is accompanied by an Honor Code when it was established that outlines certain standards of ethical conduct for persons associated with the institute. The policies of the Honor Code apply to all students of the institute or taking courses at the institute, faculty members, staff members, and administrators. The Faculty Committee for Discipline (FCD) consists of faculty members and imposes sanctions on students that have been found to have violated the Honor Code. The decisions of the FCD are ordinarily final.

The JI is a US-like system within a Chinese institution and a private-like college of a public university. This unique identity creates challenges as well as opportunities for the institute to experience differences between the two educational systems and figure out a working model that is able to integrate advantages of both educational systems. For instance, unlike in many US universities where the universities decide how many freshmen to recruit every year, the Ministry of Education (MoE) allocates a specific quota for freshman recruitment to each university in China. Then the university distributes the quota to its schools and institutes. The undergraduate student admission at JI has to be part of the general recruitment effort of the Chinese university and be limited by the quota. On the other hand, this also guaranteed the quality of the freshman students which makes JI a very academically competitive and rigorous environment.

Degree and Non-Degree Programs

At establishment, the JI started off with two four-year bachelor's degree programs in Electrical and Computer Engineering (ECE) and Mechanical Engineering (ME). Both programs are ABET accredited from 2016. Additionally, the institute also offers a Dual-BS degree program that allows some students to earn two bachelor's degrees, one from each of the parent universities. Both programs offer Master's and Ph.D. degree programs.

There are two major semesters at the JI for each academic year. The fall semester typically goes from early September to mid-December; and the summer semester begins in early May and ends in early August. There is also a short spring semester from mid-February to the end of April. The spring semester resembles a short term during the summer break of a typical US university. This arrangement of the semester system is to facilitate the degree and non-degree programs involving faculty and students of the University of Michigan and other overseas universities.

The engineering programs at the JI are internationalized and English-based. Its curricula are modeled after the corresponding programs of University of Michigan. All courses except the courses required by the MoE and the Chinese university are delivered in English. All faculty

members have academic and/or industrial experiences in overseas institutions and/or companies. On top of that, the institute actively brings international faculty as adjunct instructors to teach courses. International students are invited to the institute to take courses together with the local students through short-term study programs and exchange programs. The local students are given cross-cultural experiences not only at the institute but also overseas through the dual bachelor's degree program, sequential undergraduate-graduate programs, exchange programs, and short-term winter programs in Germany, France, Spain, Canada, Australia, Japan, etc. This internationalized learning environment gives the local students opportunities to understand and appreciate the diversity of different cultures, and provides the graduates awareness of importance of the diversity in global collaboration. The goal is to have 100% of the students graduated with some international academic experiences by 2020. Figure 2 shows the statistics of local students going abroad through the short-term exchange and study abroad winter programs.

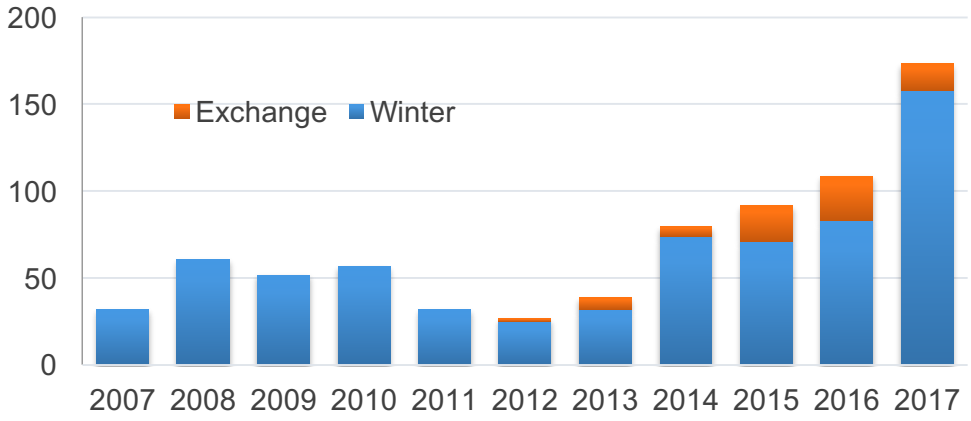

Figure 2. Statistics of Students Studying Abroad

At the onset of JI, all technical program requirements and curriculum structures were carefully designed to allow for curriculum integration between the corresponding programs of the JI and UM. This curriculum alignment allows some students of the JI to pursue dual undergraduate degrees in two different but related engineering or science disciplines at two universities, known as the dual-degree program. In the fall semester of sophomore year, students who are interested in the dual-degree program apply for transfer admission to the UM. The admitted students may choose to study in one of the engineering or science programs at UM in their junior and senior years for a bachelor's degree. At the same time, they have to complete courses required for the bachelor's degree at SJTU. It has become a very popular option among the students.

The JI also offers several sequential undergraduate-graduate study programs that will allow students to seek an undergraduate degree at the institute followed by a MS degree in an engineering or non-engineering discipline from a foreign institution. Currently, students have options in engineering, computer science, integrated system design, business and management for the graduate level study.

In every major semester, fall or summer, the JI hosts 40-70 international students coming from various countries to take courses side-by-side with the local students. The credits are typically easily recognized by and transferred back to the home universities of the students. This has

become a quite convenient arrangement for the international students, especially in the summer semester (mid-May to early August) when many students are in vacation. It has also been an economic option for the students because the tuition (if need be paid) is usually considerably lower than their home institutions. In addition to earning credits, the international students also get to learn various levels of Chinese language, experience Chinese culture through excursions and entertainment activities. For instance, there were 68 students from 15 different countries studying together at the JI in summer 2016. Exchange international students at the institute commented that it was a delightful surprise to have had opportunities to make friends with not only Chinese students but also people from all over the world. Figure 3 shows the statistics of incoming short-term international students at the joint institute.

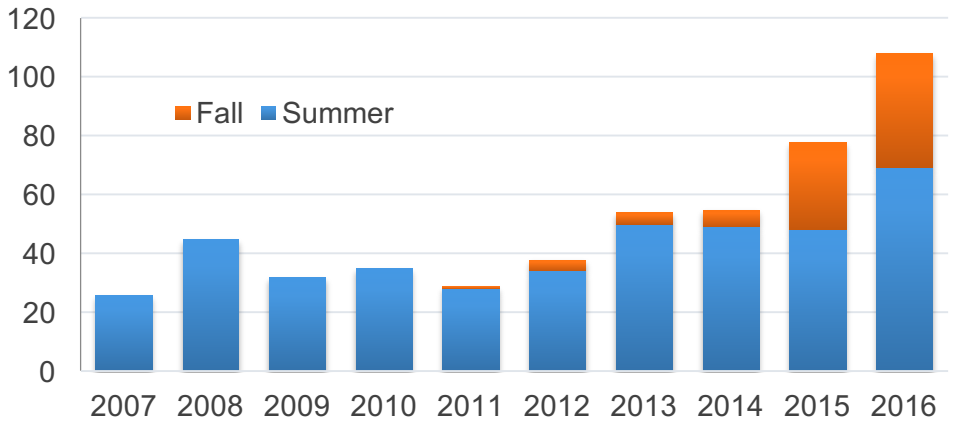

Figure 3. Statistics of Short-term International Students

Academics and Curricula

Candidates for the Bachelor's degree at the JI must satisfactorily complete 128 credits including engineering foundation courses, program subject courses, intellectual breadth courses, technical elective and free elective courses. All these courses are taught in English by the JI faculty. Using the Electrical and Computer Engineering program as an example, credit distribution of the categories is:

- Engineering foundation: 39 credits
- Probability/Statistics: 4 credits
- Intellectual Breadth (liberal arts): 16 credits
- Program Subjects: 39 credits
- Core ECE Elective: 4 credits
- Upper Level ECE Technical Electives: 7 credits
- Flexible Technical Electives: 12 credits
- General Electives: 7 credits

Additionally, compulsory courses must be completed according to requirements of the MoE and SJTU. These courses include academic writing in English, physical education, and the Chinese

ideological education such as Basic Theory of Marxism, Introduction to Mao Zedong's Thoughts & Theoretical System of Socialism with Chinese Characteristics, Military Theory, etc. International students are exempted from the Chinese ideological education courses. Other flexibilities exist in the JI curricula. For example, students may choose to test out the first level of math course (Calculus I) which most Chinese students do because of the intensive math training in the pre-college education in China. The students from English speaking countries may test out the first level of Academic Writing course. In that case, the students must choose to take a second-language course such as Chinese or German language courses offered at the joint institute.

Every student must complete a 4-credit Capstone Design course replacing the graduation thesis that is typical in traditional Chinese universities. Through carefully designed and open-ended design problems, students learn how to approach design problems in a systematic way and how to use the engineering knowledge and skills acquired from various courses to tackle engineering problems. Many "soft skills" such as oral presentation, teamwork, critical thinking, time management are re-emphasized in this course. A full project report and a formal oral presentation are required. In addition, students are exposed to discussions about professionalism, ethics, entrepreneurship, environmental sustainability, etc. Over 80% of the projects are sponsored by local or multinational companies such as GE, Siemens, HP, Intel, General Motors, Huawei, etc. Each of these projects is co-supervised by a JI faculty member and an industrial advisor from the company. The rest of the projects are proposed by JI faculty members or the students themselves. Each Capstone Design project team is composed of 4-5 students of mixed (ME and ECE) majors. The course was designed this way embracing the idea of multidisciplinary teamwork in each project just like real world industrial settings.

The growing importance of general education or liberal arts studies to engineering education has been recognized and shared among universities in the US and China.[7,13] Besides technical and science subjects, the JI also offers courses in humanities and social science areas by its liberal arts faculty to expand the intellectual breadth of students. When JI was founded, the curricula did not include the intellectual breadth category within the overall 128 credits. It was believed back then that the Chinese ideology courses may serve the purposes of liberal arts studies until 2010. The intellectual breadth requirements were added to the curricula as more humanities and social science courses started to be offered at the JI. A variety of subjects are taught at JI now, such as philosophy, political science, sociology, history, culture, economics, business, entrepreneurship, literature, writing, technical communication, etc. Additionally, professional ethics is a compulsory course in the engineering curricula to highlight the underestimated importance of the subject in China.[8,9] Those humanities and social science courses are designed for students to appreciate mutual supporting relationship between engineering and non-engineering fields. They give students a deeper understanding of the human society as well as their social responsibilities as future leaders.

The curricula have been proven effective according to the feedback of employers and alumni. By far, JI maintains a 100% undergraduate placement rate. Out of 1,531 graduates from 2010 to 2016, over 37% of the students were admitted to the top 10 engineering graduate schools in the US, close to 52% admitted to the top 20 engineering graduate schools in the US (ranking based on 2016 US News graduate school ranking); over 12% were admitted to graduate schools in

China and other countries; close to 20% of the graduates were employed in industry, shown in Table 1. Figure 4 shows the job placement and the types of industry for the Classes of 2010 to 2016 of JI.

Table 1. Statistics of Undergraduate Placement (2010-2016)

Placement Summary (2010 – 2016)		
Number of Graduates	1531	
US Graduate Schools	1040	67.9%
US Top 10 Eng. Grad. Schools	571	37.3%
US Top 20 Eng. Grad. Schools	793	51.8%
Other Int'l Graduate Schools	82	5.4%
Chinese Graduate Schools	112	7.3%
Employment	297	19.4%

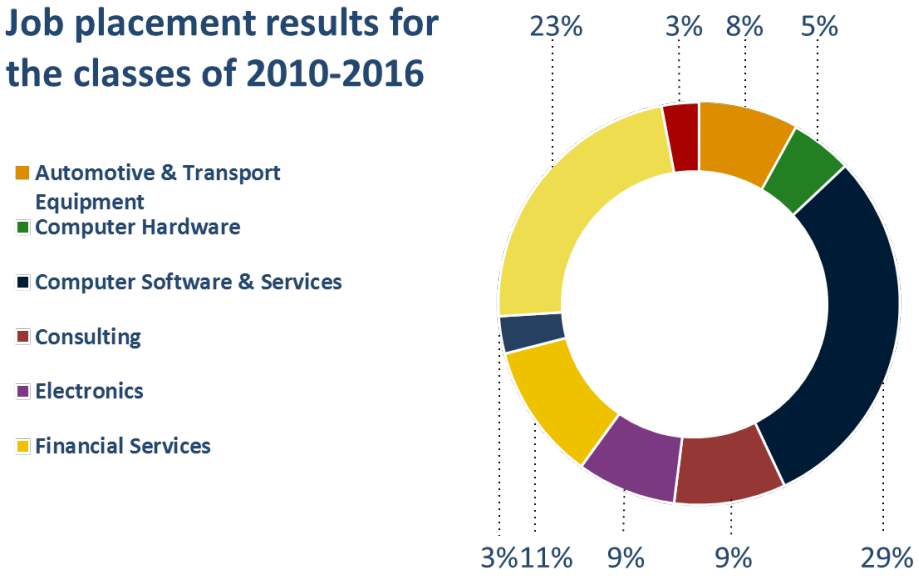

Figure 4. Job Placement of the Classes of 2010 to 2016 of the Joint Institute

Faculty

There are two types of faculty members at JI, tenured or tenure-track faculty and non-tenure-track teaching faculty. Unlike some international collaborations in China that fly faculty from the international partner university to the Chinese institution to teach courses for a short time,[10,11] all JI faculty members are full time employees of SJTU and the JI. All the core courses including

the engineering foundation courses as well as the liberal arts courses are taught by the local faculty. As the goal of the institute is to become a highly reputable institution for innovative global engineering education and research activities, a dynamic and stable faculty team is crucial. The JI has adopted the mechanisms in major research universities in the US for its faculty recruitment and retention.

Faculty Recruitment

The pool of applicants for faculty positions is from around the world with most of the primary applicants educated or currently working at leading US universities. There is no geographical restriction, however. The hiring considerations are the same as those at major US universities. Current faculty of the institute clearly expressed that they chose JI over other options (including higher rank appointments at more prestigious Chinese universities) because the institute has very good students, and gives them the research independence of a US university. The hiring review involves comprehensive evaluation of the candidate's educational background, teaching experience, publication record, motivation, reference letters, and on-campus interview. An internal search committee guides the process, but the discussion whether to extend an offer involves the entire faculty. The faculty hiring decision is of the Academic Programs Group (APG).

Tenure and Promotion

The JI adopts the concept of tenure as used in the US academic system and uses the academic ranks of Assistant Professor, Associate Professor, and Professor. The tenure and promotion system of the institute closely follows that of US universities. Tenure is viewed as a permanent employment commitment from the institute, barring serious failure to perform or acts of negligence, dishonesty, and the like. A tenure-track faculty member has the option of extending the tenure clock from a standard 6-year window to up to 8 years, recognizing the fact that the institute is still young and most of the faculty entered the institute without adequate research facility support and the recruitment of graduate students takes much longer time than that at typical US institutions. Although the time window might be extended by one to two years, the standards for promotion to a tenured faculty rank remain unchanged as compared with those commonly used in top engineering programs in the US.

To gain tenure, faculty must perform in all aspects of faculty expectations, including research, teaching, and service. In research they must publish independently, be visible within their field, show evidence their work is being used by others, mentor PhD students, attract funding as a Principal Investigator, and establish their reputation among leading academics worldwide. Faculty annual salary is highly competitive but capped by 12 months, which discourages faculty from profit-driven research projects which has been a serious problem in traditional Chinese universities for a long time. The tenure and promotion model assures faculty commitment in fundamental scientific research and teaching activities. Faculty commitment in education and teaching quality of the institute has been highly appraised in SJTU.

Non-Tenure-Track Faculty

The JI hires full-time non-tenure-track faculty members whose main responsibilities are teaching and administrative services. The recruitment of non-tenure-track faculty also goes through a rigorous evaluation and interview process. Qualified candidates must demonstrate competence in academic credential, university teaching experience, outstanding teaching performance, etc. The institute uses academic ranks of Lecturer (equivalent to Assistant Teaching Professor), Associate Teaching Professor, and Teaching Professor. The non-tenure-track faculty must also undergo a rigorous review process in order to be promoted to the next rank.

Promotion to higher rank requires evidence of professional growth, including (not necessarily all) of the followings: publications, mentoring other faculty members, leading initiatives within the institute to improve instruction quality, attendance at teaching-focused short courses or conferences, successful course development, writing about teaching, giving short courses, etc. In addition, a major criterion is excellence in teaching, as determined by student evaluations, class visitation, submitted course material etc.

Conclusion

This paper describes the operational models of the University of Michigan-Shanghai Jiao Tong University Joint Institute that is jointly sponsored by Shanghai Jiao Tong University and University of Michigan. Models and mechanisms of the US educational system were adopted and tested in a public university of the Chinese system. Some are proven working well and providing valuable experiences to the engineering educators and policy makers, while the others face great challenges and need adjustment. The JI presents a case of successful collaboration in engineering education between universities in China and the US. Student data demonstrates the achievement in undergraduate education of the institute. Many practices, such as the curriculum arrangement, academic rules, the tenure process, the Capstone Design course, the professional ethics education, the soft skill training, the Honor Code, engineering accreditation, have been adopted by Shanghai Jiao Tong University, as outcomes of this joint venture. Other universities in China were required by the Ministry of Education to learn from the experiences of the JI in faculty recruitment, administration, and education.

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