

# **A Multi-Stakeholder, Multi-National Partnership to Enhance Engineering Education in China**

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## **Abstract**

Engineering education renovation is one of China's major initiatives in support of the country's economic and innovation development. The challenges posed to engineering schools are enormous: from seeking international accreditation, engaging in curriculum innovation and enhancing the learning experience to internationalization of engineering education and mandatory industry experience for engineering faculty. With the support and contribution of MathWorks and Hewlett-Packard (HP), the Chinese Society for Engineering Education (CSEE) and Tsinghua University (THU) and its Center for Engineering Education (CEE) and Institute of Education (IOE) have partnered for the last two years with the International Institute for Developing Engineering Academics (IIDEA) to provide leadership and capacity building to about two hundred (200) engineering professors, deans and leaders through workshops and discussions in various engineering education areas including learning environments to bridge the gap between how we teach and the practice of engineering, problem-based learning, building and nurturing industry-university collaboration and accreditation. The members of this panel will share the motivation, outcomes, experiences and future plans that this unique multi-stakeholder, multi-national partnership is engaged with to catalyze change. This partnership model is being adapted by others (e.g., Mexico, India) and could be of interest as a model for best practices to those attending the session.

## **Introduction**

Highly focused and efficient teams are very hard to put together, yet the multi-stakeholder, multi-national partnership described herein to address the innovation needs of Chinese engineering education institutions can be looked at as a model for others to follow. It brings together two technology companies known for their interest and support in engineering education, MathWorks and HP, to partner with CEES, THU's leadership in leading change in China through its CEE and IOE, and IIDEA, a spin-off initiative of IFEES, the International Federation of Engineering Education Societies. While each partner has its own mission and strategies, they all have one thing in common: the need to develop the talent to lead and address the innovation and challenges of engineering and technology in the future. This paper shares the outcomes achieved so far and each of the partners' motivation, role and responsibilities. Finally, the paper shares thoughts on what can be the next steps.

## **Disruptive and Challenging Times for Higher Education**

No one can dispute that these are very disruptive and challenging times for the world. Higher education is also affected by current political, financial and societal changes. This section describes what the authors believe are some disruptions affecting higher education.

### **1. There's a gap between existing curricula and the needs of employers**

A recent McKinsey report (Education to Employment: Designing a System that Works)<sup>1</sup> describes the status of education and employment around the world: high levels of youth unemployment and a shortage of qualified job seekers with critical skills. How can a country successfully move its young people from education to employment? The report cites the following statistics:

- Seventy-five million youth are unemployed
- Half of youth are not sure that their postsecondary education has improved their chances of finding a job
- Almost 40 percent of employers say a lack of skills is the main reason for entry-level vacancies

### **2. Engineering accreditation systems now moving to outcomes based**

Engineering programs accreditation systems are shifting to outcomes based accreditation, similar to the US ABET.<sup>2</sup> This means that engineering education programs must define the students' learning outcomes listening to the employers and other stakeholders, measure those outcomes and continuously improve their programs. In order prepare graduates for future careers, engineering programs must deliver an educational experience that emphasizes conceptual knowledge and reasoning, as well as professional skills development (among others, problem-solving skills, teamwork and lifelong learning; business and environment awareness among others).

### **3. MOOCs**

Massive Open Online Courses (MOOCs) have recently evolved providing learners with a low cost way of learning providing accessibility and diversity to higher education learners worldwide. Some universities are offering MOOCs for credit as part of a bachelor's degree program; others are starting with multinational offerings.<sup>3</sup>

The high cost of higher education has itself become a barrier for students, possibly preventing necessary human capital from getting training in engineering and other key fields.<sup>4</sup>

Understanding how to deliver high-quality training that meets the needs of industry at a level that is affordable for a high number of diverse students is a challenge faced by many countries. The pressing need for improving engineering training brought our multiple partners together to provide capacity building opportunities for engineering educators.

### **The urgent need to integrate education and innovation**

Innovation is a key driver of economic growth and jobs, as is talent and human resources in S&T which are closely related. The first does not occur without the second. There's a wide range of skills required for innovation, ranging from technical to "soft" to the ability to learn. These skills need to be integrated and developed through learning experiences across the

curriculum and the workplace. According to the OECD, *“Innovation holds the key to ongoing improvements in living standards, as well as to solving pressing social challenges. Skilled people play a crucial role in innovation through the new knowledge they generate, how they adopt and develop existing ideas, and through their ability to learn new competencies and adapt to a changing environment.”*<sup>5</sup>

Regions are an appropriate level for stimulating innovation: Many regional governments have important competences and budgets in the field of innovation. Their geographical proximity facilitates the acquisition, accumulation and use of knowledge. Regions innovation's performance depends not only on that of enterprises and research institutes but also on interactions between different stakeholders, enterprises and organizations, whose knowledge and know-how build up over time. EU innovation policy has placed a strong emphasis on networks which link the business to the surrounding environment (other firms, universities, research institutes, etc.) and are active mostly at regional level, e.g. in the field of cluster initiatives.<sup>6</sup>

#### **4. The Need for Engineering and IT jobs**

Except for a few places around the globe (one of the authors' country), the need for engineering and IT jobs is growing worldwide. In the US, the National Science Foundation (NSF) Directorates for Education and Human Resources, Engineering, and Computer and Information Science and Engineering announced recently a cooperative activity between NSF and members of the President's Council on Jobs and Competitiveness (Jobs Council) to stimulate comprehensive action at universities and colleges to help increase the annual number of new B.S. graduates in engineering and computer science by 10,000.<sup>7</sup> According to a CBS News e-newsletter, 8 out of the 15 are in IT and Engineering.<sup>8</sup>

These and other challenges (for example, dwindling budgets) are affecting how higher education 'does business' and will translate to reforms in their education and operation processes.

#### **China's Quest to Innovate Engineering Education**

There is an expanded scope of Engineering Education in China. In 2011, the number of engineering students at universities has reached 4.276 million which accounted for 31.7% of all the undergraduate students in China, of which 30% are engineering programs. This poses grand challenges in quality insurance and improvement in engineering education. This multi-stakeholder collaboration will be a driving force to promote the reform of engineering education.

In 2006, China launched the engineering education program accreditation for six programs in architecture and civil engineering which is expanding to more fields and began to establish the accreditation system which emphasizes the substantial equivalence with international accreditation systems, the third party accreditation organization, outcome-based review, rigorous standard and normative process. At present, the Chinese Engineering Education Accreditation Association (CEEAA), a non-profit organization affiliated with China Association for Science and Technology (CAST) consisting of over 30 national professional

associations, institutes and federations covering most of the engineering and technology fields in the country is gradually increasing its membership.

In 2010, China launched its pilot program called “*the Plan for Educating and Training Outstanding Engineers (PETOE)*”, aimed to enhance engineering education interface with industry, the world and the future. The plan included actions for the undergraduate, master’s and doctoral levels, and involved various types of universities, industrial enterprises, industrial associations, the National Academy of Engineering, government ministries and commissions. Today, about 200 universities with more than 700 programs have adopted this plan and new types university-industry partnerships have been established, including selecting excellent engineers from enterprises to engage engineering teaching in universities and supporting engineering student to practice in real industry environments.

Today Chinese universities, industries, governments (state/local) and other stakeholders have realized that China’s engineering education should merge into the global community. In order to bridge the gap between learning and teaching, between universities and industries, between China and the outside world, the kind of partnerships we have developed with the multi-stakeholders within multi-nations and multi-organizations is playing a very more important role in engineering education in China.

### **The Partnership to Enhance Engineering Education in China**

The idea of partnership to address the China’s engineering education innovation started around 2010 when Dr. Shouwen YU, former Vice President of Tsinghua University and IFEES approached IIDEA to discuss the offering of a 2-day workshop in Beijing to engineering professors and deans. With more than 80 professors, deans and government



Figure 1 Professors Morell, Lamancusa, DeGraaff and Kolmos, May 2011

officials from various provinces in China, the first IIDEA workshop was held in Beijing May 30-31<sup>st</sup> 2011. The event was organized by THU and its CEE and IOE and the CSEE. The workshop was made possible by support and sponsorship of MathWorks, a multinational engineering and mathematics software company and the participation of a workshop leader from HP Labs.

The event covered two topics of interest to the Chinese engineering education community: “Learning Environments: Bridging the Gap between How We

Teach and the Practice of Engineering,” offered by John S. Lamancusa and Lueny Morell, and “Project and Problem Based Learning,” offered by Erik DeGraaff and Anette Kolmos. Through presentations and active learning exercises, participants learned about the challenges of engineering education of the 21<sup>st</sup> century, and the need to reach out to industry and enterprises to better respond to their needs. They also learned the basics of curriculum innovation, the importance of considering various learning and teaching styles, and the advantages and disadvantages of problem/project based learning.

Throughout the two days, participants were actively engaged in the sessions and activities, and most importantly, had the opportunity to voice their questions and concerns about transforming engineering education in China. Professor YU encouraged the attendees, emphasizing that education philosophy in China must be transformed, and that educators must ask, “What is ‘the university’? [In today’s context,] what does the university do?”

A brainstorming meeting was held the day after the workshop to discuss future collaborative and partnership opportunities to support China’s quest to reform engineering education to support their economic development. This dialogue resulted in the signature of a memorandum of understanding (MOU) between TU and IIDEA to pursue similar activities in the future. The MOU was readily and duly signed on October 11, 2011.



Figure 2 Professor YU addressing attendees, May 2011

The second event of the partnership was held the Summer of 2012. With more than 100 professors, deans and government officials from over 40 universities in various provinces in China, the second IIDEA workshop was held in Beijing July 14-15<sup>th</sup> 2012. The event was organized by TU Center for Engineering Education and its Institute of Education (IOE), and CSEE. The event was made possible by support and sponsorship of MathWorks, a multinational engineering and mathematics software company with the support of HP Labs. This time, both HP and MathWorks speakers were included in the agenda, participating and contributing to the discussion.

The welcome session of the 2 day event included, Vice President of Tsinghua University, XieWeihe, IFEES President, Krishna Vedula, HP Labs and former Co-Director of IIDEA, Lueny Morell, and Vice President of CSEE, Professor Yu Shouwen. The workshop focused on two main themes: Engineering Education for the 21<sup>st</sup> Century: The role of Industry-University Partnerships and Accreditation. The list of international speakers included: Jim Tung, MathWorks Fellow; Eng Soon Chan, Dean of Engineering at National University of Singapore, Wonjong Joo, professor at Seoul Tech, Vice President of ABEEK, Erik de Graaff, PBL Educational Consultant at Delft University of Technology and guest professor at Aalborg University in Denmark, and Lueny Morell, HP Labs Strategy and Innovation Office.

The workshop format included presentations, interactions and active learning exercises with participants. The speakers promoted an environment of camaraderie open to questions and concerns of attendees. Singapore, Europe, US and South Korea’s experiences in building and nurturing a strong industry-university relations as well as engage in engineering accreditation as means to achieve excellence and be recognized worldwide. The last session of the workshop included words from Prof. Yu on the urgent need for China Engineering Schools to innovate, build industry-university collaboration, obtain the Washington Accord provisional status, and provide time to plan and learn from the experiences of others.



A brainstorming and discussion meeting was held after the workshops. IFEES president Krishna Vedula, the workshop session co-organizers, IIDEA workshop leaders Lueny, Erik, Eng Soon and Wonjong, Tsinghua CEE (Prof. Yu, Wang and Lin and the event sponsor MathWorks, Mr. Jim Tung and David Chen, explored next year’s workshop themes. Three main topics were selected for the 2013 workshop of : 1) Faculty Development – how to plan, design and manage an Effective Teaching Center; how to train faculty in teaching skills and educational technology; best

practices in teaching engineering, evaluation of faculty performance; faculty career paths; research impact on education; 2) Accreditation Deep Dive – more on accreditation criteria and process; how to train program evaluators, etc.; and 3) Developing and Enhancing Industry-University Relations.

Attendees have evaluated both workshop sessions (2011 and 2012) very positively. With the exception of two items in the workshop assessment criteria (previous knowledge of workshop topics and appropriateness of workshop length) attendees’ level of satisfaction has been high or very high. Attendees’ comments and recommendations have also been very valuable for partnership leaders, who have shared these with their stakeholders:

*“Inspirational”*

*“This session let me know lots about international engineering education reform. I have learned many good methods to improve my teaching quality.”*

*“Hope the workshop can be longer...”*

### **Points of View of Partnership Members**

This paper would fail to describe the makings and progress of this partnership if the opinions of individual organizations involved would not be included. Here’s why they are involved and some of their respective benefits, challenges and expectations.

### **CSEE- THU-IOE**

As a large community, China’s advances in engineering education would not only contribute to its local prosperity but to the global development. Chinese universities, industries and governments undoubtedly need to establish an effective channel to share with the academic achievements and the best practices in engineering education. This multi-stakeholders and multi-national partnership will benefit to attain this goal.

THU is one of the top universities worldwide, well-known by its excellence especially in engineering education. THU promotes the educational development in China with open

minds. Playing an important role in this partnership, the CEE and IOE at THU connect faculties, deans of Chinese engineering universities, schools and other stakeholders with international peers. The CEE is one of the most influential research institutes and a national think tank in engineering education in China. The CSEE has expanded substantially and now has about 200 participating members including universities, colleges, continuing education institutes, division of industries for research and academic exchanging in the engineering education. The CSEE and CEE/IOE at Tsinghua University have closely linked to domestic and international academic institutes which make it possible to bridge between local and global community.

Some of the outcomes of this two year partnership that have been important for the Chinese partners are:

- Sharing engineering education experiences with the local and international communities.
- Identifying the mutual and comprehensive needs how to improve the engineering education in China;
- Establishing a strategic partnership through the MOU to hold IIDEA workshop sessions at THU Tsinghua to promote engineering institutes' reform.

We have learned many things during the last two years. Looking forward, we would like to see more research and evidence that point and describe how the outcomes of these academic events are effectively transferred or adopted by participant institutes. In other words, how the various plans written by attendees are put into practice at their respective institutions. As the impact and scope of the partnership increases, another challenge we see is the need for more financial resources to support the workshop sessions as well as its deep, continuous development.

To enhance the quality of the workshops' experience, the China side of the partnership plans to request the opinion and advice of the attendees of the workshops the past two years in order to better address their needs in organizing 2013 events. We will also try to find more effective paths and possibilities to accomplish the strategic goals of the MOU.

## **IIDEA**

IIDEA, or the International Institute for Developing Engineering Academics, is a global leadership training institute focused on establishing a global network of engineering faculty development programs to disseminate learning about the transformation of engineering education worldwide. This goal is achieved through the offering of a menu of development, capacity building and training activities to engineering and related disciplines professors, administrators, graduate students and other interested individuals. Established in 2011 as an IFEES (International Federation of Engineering Education Societies) initiative responding to its members' needs, its vision is "Educating the Ideal Engineering Professor".

IIDEA's leadership believe that providing administrators and faculty with the tools, experiences, and knowledge of best practices and programs outside of their country can help

to inform and empower individuals to improve their teaching and learning of engineering. The Institute's role in this partnership has been to connect with the broader IFEES community to understand what the community's capacity building needs are and to identify experts within the community who may be able to offer interactive workshops to address these needs. IIDEA positions itself as the "capacity building arm of IFEES". IIDEA's Director (co-author of this paper) helps to both oversee the organization of these activities and to strategically connect them to the international engineering space and initiatives and advances throughout our global community.

Besides the training of over 200 engineering professors and deans in China, one of the most important outcomes thus far has been the creation and signature of a Memorandum of Understanding between the organizations, detailing the regularity of our work together. This serves as a foundation on which our sustained collaboration will be built. In addition, the sustained focus on certain topics (e.g., industry-university collaboration) as well as the addition of relevant new topics (e.g., the formation of teaching centers) has allowed the partnership to build on past successes and to grow in the directions most fitting to the needs of Chinese instructors and students. The IIDEA collaboration here can grow and change as China's engineering education needs grow and change, but it is assured of being in place as a support. In addition, the collaboration here can inform IIDEA collaborations elsewhere, spreading sustainable best practices throughout the IIDEA network.

As the IIDEA activities for this collaboration are complex and multidimensional, it is sometimes challenging to organize, implement, and then follow-through logistically. The complexity and multiple stakeholders involved are what makes this collaboration unique, and each year we learn from the previous year and can facilitate this activity better.

At present IIDEA is beginning the preparations for this 2013 set of workshops, the third consecutive year of the partnership. This will be the second year during which we will explicitly follow up on the Memorandum of Understanding between our organizations, an exciting fulfillment of our mutual, sustained promise to support the ongoing development of engineering education in China.

The TU/CSEE/IIDEA/MathWorks/HP collaboration is a prime example of industry-academia-organizational partnership to address an identified need and create a sustainable forum for connecting these partners and creating concrete solutions. The structure and content of this partnership may not be the exact format and topics that are needed elsewhere, but the process could and should be adapted to fit the environment and the stakeholders.

### **MathWorks**

MathWorks is the leading developer of mathematical computing software for engineers and scientists. Our MATLAB and Simulink products are used throughout the automotive, aerospace, communications, electronics, industrial automation, medical, and other industries as fundamental tools for research and development. More than 5000 colleges and universities around the world use MATLAB and Simulink for teaching and research in a broad range of technical disciplines. We maintain a strong collaborative relationship with the academic

community to create a wide range of products, resources, and programs that enhance learning, teaching, and research.

Enhancing and reforming engineering education is incredibly complex, especially given the number and variety of China's engineering schools. Moving the needle requires a combination of approaches, from countrywide initiatives to individual course development. A key outcome for MathWorks of the THU/CSEE/IIDEA/MathWorks/HP collaboration so far has been engaging with each member to get their perspective and best practices to apply to that shared challenge. Each team member's expertise is complemented by an interest and ability to consider the range of diverse aspects – including, but not limited to, program accreditation, industry-university collaboration, instructor skills development, and project-based learning approaches – in a practical and pragmatic manner.

The collaboration has also enabled us to engage with a large number of Chinese educators in a relatively small number of events, with plenty of time to discuss ways to help students gain knowledge of fundamental theories and their engineering applications while becoming skilled in tools that are widely used in industry.

One challenge we've faced is how to maintain continuity and coordination with the partnership, since our participation involves MathWorks staff based at our Massachusetts headquarters and based in China. We have sought to limit the number of people to engage in the collaboration, since so much of the success of the collaboration is based on interpersonal rapport and interaction.

For MathWorks, some next steps are to see how we can better leverage in China the resources and activities that we provide elsewhere, such as:

- online teaching resources including contributed course materials and self-paced video tutorials.
- software and training for design competitions that challenge students to solve the same problems faced by engineers and scientists

in the context of accreditation, industry-university collaboration, and other focus areas of the consortium.

## **HP**

As the largest IT company in the world, HP has a long history of supporting engineering education. Support and collaboration takes place in many dimensions, from research and development; to recruiting talent, providing students and faculty with opportunities for internships and experiences in the company; to philanthropic grants to assist education in incorporating novel use of technology to enhance learning, influencing science, math and engineering innovation policy for win-win outcomes as well as education sales opportunities for products and services.<sup>9 10 11 12</sup>

At HP we believe that it is our corporate duty to engage in the dialogue that will promote science and engineering for the greater good. It is because of the company's unique

combination of size, scale and global presence that HP can pioneer new markets, make technology accessible and affordable, and invest in the research required to enable the next round of technological breakthroughs. HP is member and serves in several engineering education associations as well as science and technology bodies, including ASEE, GEDC, IFEES and SEFI, where, for example, HP has supported the establishment of the Engineering Deans Council in Latin America and Europe. Through its HP Labs and HP Institute program, HP is an active sponsor and participant in this multi-national, multi-stakeholder partnership which results in win-win-win outcomes for all those involved. For universities, innovating the curricula to better respond to their stakeholders and country's needs, educating the engineering and IT professors in new learning paradigms, using technologies, and having access to state of the art technologies and lab experiences is of primary concern. For students, they are able to learn from their professors more effectively, gaining the critical, validated IT skills and practical experience with the business context employers need. For HP, it has resulted in strengthening the ties with the research and talent development in China and identifying potential collaborators. For the HP Institute (an HP Division sponsoring the partnership workshops in 2013), the program aims to further develop the ecosystem of education, government, IT associations, businesses, and HP's vast network of customers and partners to build and support the pool of quality IT talent for economic growth and opportunities globally.

Working with education allows HP to broaden the talent pool of experts and meet HP customer and partner needs for hiring, outsourcing, and acquiring expertise through service providers. By providing valuable learning experiences through business context awareness, end-to-end technology expertise and hands-on experience, HP and academic institutions can create a continuous funnel of graduates able to supply the industry with the attributes that business and IT leaders are looking for in order to close the IT expertise gap.

Given its interest in the engineering/IT education, the HP Institute will be sponsoring the partnership activities in 2013. The Institute hopes to engage with Chinese universities to inject business relevance and practical experience into education, ensuring that graduates entering the workforce will be ready for the emerging IT environment. The key benefit of the HP Institute program, and accompanying HP ATA (Accredited Technical Associate) certifications, is employability by providing the practical experience that will enable a graduate to set up a complete, end-to-end IT solution in an SME (Small to Medium-sized Enterprise) environment. The program focuses on creating a solution skill set that is valuable regardless of whose products the student's ultimate employer is using. By providing this new skills profile that HPs customers and partners are looking to hire, academic institutions can differentiate themselves through placement of employable graduates, allowing institutions to quickly meet their recruitment goals. In addition to HP Institute graduates having increase job prospects, they also have a higher earning potential. The US Bureau of Labor Statistics has indicated that industry certification holders earn 115% more than those that did not.<sup>13</sup>

## **Next Steps**

Partnership members anticipate continuing to collaborate to achieve individual and collective goals. We hope to share this collaboration model with other engineering education leaders around the world as an example of a multi-stakeholder, multi-national partnership focused on development of the global engineering the world needs.

## Conclusion

A win-win-win partnership, the THU/CSEE/IIDEA/MathWorks/HP collaboration is a prime example of industry-academia-organizational partnership to address an identified need and create a sustainable forum for connecting these partners and creating concrete solutions. The structure and content of this partnership may not be the exact format and topics that are needed elsewhere, but the process could and should be adapted to fit the environment and the stakeholders.

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