

Global Capstone Design Experience in Engineering Education

Yiming Rong^{1*}, Dan Wu², Haiyan Zhao³, William Goodwine⁴, Gretar Tryggvanson⁵

¹*Tsinghua University, Beijing, China, yrong@tsinghua.edu.cn;*

**also with Worcester Polytechnic Institute, Worcester, MA, USA, rong@wpi.edu;*

²*Tsinghua University, Beijing, China, wud@tsinghua.edu.cn;*

³*Tsinghua University, Beijing, China, hyzhao@tsinghua.edu.cn;*

⁴*University of Notre Dame, South Bend, IN, USA, billgoodwine@nd.edu;*

⁵*University of Notre Dame, South Bend, IN, USA, gretar.tryggvason.1@nd.edu*

Abstract

As the economy goes more and more global, the need for engineers with international background is glowing fast not only in quantity but also in quality with different performance measures. In order to provide the society with quality engineers in new century, engineering education has been developed more and more in three dimensions, i.e., academic, entrepreneurial, and social components of learning process. This paper describes our exploration of integrating these components in a comprehensive project practice in the senior project center in China. In addition to enhancing academic acquisition of scientific knowledge and problem solving ability, the non-technical skills have been practiced in doing real world projects sponsored by global companies. Through working in a mixed team with members from USA and China, the students have the opportunity to grow becoming better global citizens. They learn to understand the society and social responsibility of a qualified engineer. They also learn from each other from living and working together during the project period, which enriches their cultural background, high-quality human being, and cross culture understanding.

Keywords: *Engineering Education, Projects, Globalization.*

1. Introduction

As the economics goes more and more globalization, the need for quality engineers is glowing fast not only in quantity but also in different performance measures. In order to provide the society quality engineers in new century, engineering education has been developed more and more in three dimensions, i.e., academic, entrepreneurial, and social components of learning process. Three dimensional engineering education was clearly described by Dan Herman in 2007 as “engineering education is now comprised of three key axes: technical, professional and global skills” [1]. After analyzed the current situation of engineering education, James Plummer proposed the changes we should make

in order to have a mixed curriculum with other fields for students to learn many skills not in traditional engineering curriculum but very useful in their professional career [2].

Worcester Polytechnic Institute (WPI) has implemented the project based education for years. Particularly in its global program, junior students go abroad to complete intensive two-month academic projects (so called IQP: Interactive Qualifying Project) at international locations. They work in small, multidisciplinary teams with local agencies and organizations to address open-ended problems that relate technology and science to social issues and human needs [1,3,4,5]. In recent years, it has been extended to senior projects (so called MQP: Major Qualifying Project), becoming a practice on the three dimensional education.

In the China Project Center of WPI, it has been explored to integrate the three dimensional education components into a comprehensive project practice. In addition to enhancing academic acquisition of scientific knowledge and problem solving ability, non-technical skills, such as communication effectively in various contexts, understanding of professional & ethical responsibility, understanding of solution impacts and sustain/exploit benefits, project management, relationship management, quick response to changes, etc. have been practiced during doing real world projects sponsored by global companies. Through the practice of a mixed team with members from USA and China, the students have the opportunity to grow becoming better global citizens. They learn to understand the society and social responsibility of a qualified engineer in new century. They learn from each other from living and working together during the project period, which enriches their cultural background, high-quality human being, and cross culture understanding.

2. WPI's China Project Center

WPI's China Project Center was formally established with Huazhong University of Science and Technology (HUST) in 2006, partially under a grand support from National Science Foundation of USA. In order to educate students with the capability of working well in the global economy condition, we envision the necessity to provide them the an opportunity to experience global economics, engineering, research, education, and different cultures when in college through

- working/living in a multi-cultural environment;
- partnering with multi-national companies;
- identifying projects with a strong technical focus; and
- understanding cultural impacts.

Therefore the mission of establish a premier project center that provides our students with unique opportunities for simultaneously

- practicing their technical skills,
- applying their innovative ideas,
- developing their interpersonal abilities, and
- cultivating their entrepreneurial spirit in a global and innovative world

so that upon graduation, they will not only adapt to the real world more quickly, but also succeed and lead in the culturally diverse marketplace. The Center is committed to education excellence with projects focusing on:

- applying technical knowledge to solving real-world problems;
- developing capabilities to work effectively in multi-cultural teams; and
- creating new ideas and identifying new alternatives based on technology.

Every year from 2005, a number of WPI students go to China to do their MQPs with top students selected from HUST in mixed teams and work on real world projects sponsored by global companies with China operations. During the project period of time, they travel and live in China for 7 weeks. Similarly a number of exchange students from HUST go to WPI, doing their senior projects in USA for seven week. This program becomes more and more popular at WPI and Chinese universities, and keeps growing, as shown in Figure 1. Now it has been expanded to include Notre Dame University at US and a number of universities in China, such as Tsinghua University, Shanghai Jiaotong University, Beijing Jiaotong University, and Shanghai University.

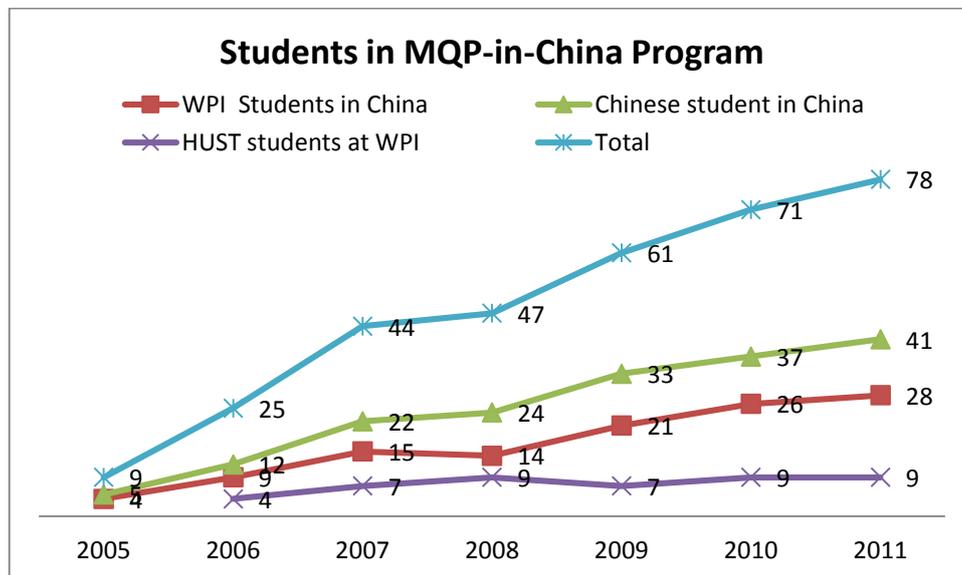


Figure 1. The numbers of students involved in the China Project Center

In order for the students to work out comprehensive project results with both academic value and application value in the companies sponsoring the projects within seven weeks, the project preparation is very important. During the term (seven weeks in WPI academic calendar) before going to China, the students work on

- communication with project partners, sponsors, and advisors, for team building,
- background study to understand the company and the problem,
- technical literature review to prepare knowledge and tools to be used in projects,
- problem definition and project planning with objectives and tasks laid out, and
- projection of expected outcomes from the projects.

In the preparation stage, the students mainly work through e-mails and with other modern IT technical means to keep as teams. When arriving in China, the WPI students with their

partners from HUST visit the companies to gain the first hand understanding of the company operations and the problem to be solved, while confirming and modifying their project plan. Then they come to HUST campus to conduct the project activities, while traveling back to the company sites to collect data, report and test project progress, and for other necessary face-to-face communications, according to the project requirements. The students own the projects and drive the project progress based on the project plan. They are required to have formal weekly meetings to report the project progress, with presentation and discussion minutes distributed to co-advisors and industrial mentors. The students often need to deal with communication obstacles and project scope changes, practicing the real world problems. In the final presentation, all student teams get together to show their project results to the audience invited from companies (sponsoring or not sponsoring projects) and universities (involving or not involving in the projects). Figure 2 shows the project cycle.

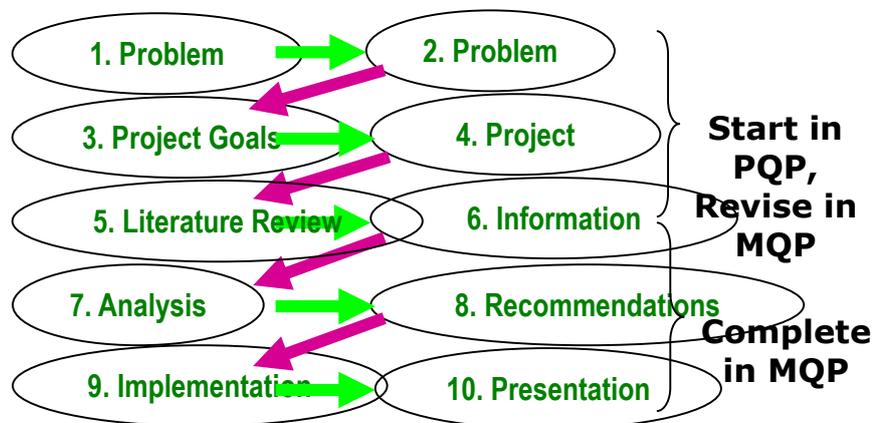


Figure 2. Project cycle with preparation and completion of projects in China Center

The projects address the industrial needs with quite broad topics with a variety of company sponsors, such as Caterpillar, Tyco International, Nypro, Saint Gobain, Amphenol TCS, CIS, Timken, Johnson Control, and Bodycote. Here is a list of 2010 projects to show the range of project topics and sponsors,

- Emergency Signal Alarm with Speaker plus Dual Color Strobe, sponsored by Tyco, with SJTU;
- Transport Cart Redesign for Production Lines, sponsored by Caterpillar, with HUST;
- Global Manufacturing Engineering & Collaborative Tools, sponsored by REM/Stanlok, with HUST;
- HexCrawler Robot: Mechanical and Control Systems, sponsored by DEPUSH, with HUST;
- Reuse, Recycle, and Reduce Wastes, sponsored by Nypro-China, with HUST;
- EDC China Implementation and Operations, sponsored by Staples-China, with HUST;
- P/M Sintering and Associated Atmospheres in China, sponsored by Air Products, with SJTU;
- Robots in Engineering Education, Sponsored by BJTU (IQP);
- Fixture System for High Force Grinder, Sponsored by Saint Gobain, with HUST;
- Process Improvement, sponsored by Amphenol TCS, with BJTU;
- Carbon Footprint Evaluation and Improvement in Production, sponsored by CIS, with BJTU; and

- Elderly and Disabled Life Assist Robot, Sponsored by SHU

Since the project process is well enforced with collaborations among all parties (students, co-advisers, and company engineers/managers) involved, most of the projects are successful ones.

3. Benefit Evaluation of the Project Center

The project center is self-sustainable with the benefits to the stakeholders. The perceived benefits include the following. First, the students gain ability and skills on

- to communicate effectively in various contexts,
- understanding of professional & ethical responsibility,
- to understand solution impacts and sustain/exploit benefits,
- project management and relationship management, and
- quick response to changes, etc.

The after-project impacts on students include,

- broad vision on global economy and culture,
- better job opportunity, and
- confidence

The opportunities for project sponsoring companies include the values created directly from the project through fresh idea, mixed team, and collaboration, and the market effects on potential employment opportunities and university relationship. Most of the companies are willing to continue sponsorship.

When projects are finished, the students are asked to comment on the most impressive experience in the MQP in China program. The WPI students expressed as follow,

- First-hand knowledge about culture, well beyond projects, including the rapid economic development, working/living environment, Chinese campuses and higher education system, people and communication in China, sight seeing (cities in coast and in land, Great Wall, Three Gorges Dam, etc.), and food/cuisine;
- Teams with HUST students/professors;
- Technical skill/learning style of HUST students; and
- Confidence of working in different cultural environment and with different kinds of people.

There are many individual stories of the impact on WPI students once they finish the senior project in China, such as,

- It is usually a hot topic in job interview;
- Alumni from the program are taking on global duties and responsibilities in companies. Some of them travel back to China with company business;
- They may receive high starting salary (highest is around \$90,000 for ME students) and fast promotion (promoted to manager position in second year);
- They may work for Chinese companies with US operations; and
- They questioned professors in China related discussions with their MQP experience.

The HUST students may experience slightly different since they are in the Chinese higher education system and this is usually their first time to work on the real world problem solving (WPI students may have had experience IQP in junior year). They concluded the most impressive experience as,

- Getting exposed to new ways of thinking;
- Working on real-world problems;
- Teamwork and leadership roles;
- Understanding project cycle/process;
- Understand of the importance of design justification;
- Learning how to work with the US students, particularly the ways of communication, understanding, and coordination; and
- “Feeling” about the life style of the US students.

Using undergraduate students to do projects directly for industrial companies is new in China. Our industrial colleagues have their comments on the successful experience. Here are two quotes.

“The two projects sponsored by Nypro China were quite successful and exceeded expectations. The students were courteous, thoughtful and very interested in their project topics and showed mature attitudes. The mixing of local Chinese students with the American students created unique challenges for the students and sponsors. The most noticeable challenges were relating to oral communication, cultural differences in methods used to communicate ideas along with a general lack of knowledge or experience in the fields. The students were able to overcome the challenges because of their relative overall maturity as individuals, support from the WPI professors and extensive guidance from their sponsor. The projects will ultimately add value to Nypro in terms of meeting Nypro’s cost savings and environmental goals along with having provided to students an experience that will be everlasting to them professionally and personally”; by Ronald Alciati, Global Supply Chain Manager at Nypro China.

“Coming into this project, I wanted to make sure that we had a win/win situation that would benefit both the engineering students as well as our company. To be honest, I felt that this would end up a training exercise for the students and would just take valuable time from our team as we are dealing with a difficult economic time in our industry. However, I was pleasantly surprised how seamless the student worked with our people as well as the overall results from the project. Creating a database to monitor and track supply chain activity seems fairly straight forward, but the work the student team did to first document our process and then create the database around it was very not trivial. It required interviewing and discussing the roles and responsibilities of numerous functional departments and then combining that information into a process flow that all involved parties agreed on. I also thought initially that I would have to "hold their hands" and help gather this information, but they jumped right in, contacted the necessary people and got the information on their own. They also did a great job coming up to speed with MS Access. Neither had experience with access before this project, but they were able to learn the software, do the modeling and mapping and create the database quite effectively. I think the only downside of the project was that there was not enough time to load data

and really test the database. We will need to do that internally and make applicable bug fixes and database upgrades”; by Eric Juntwait, Amphenol TCS .

To repeat and summarize, the success of student projects may provide the following impacts,

- technical achievement
 - valuable results from the projects, as shown in Figure 3 as examples,
 - papers presented in conference (e.g., [3])
 - patents resulted from the projects, and
 - the company satisfaction
- professional working ability and skills
 - presentation skill, as shown in Figure 4,
 - effective communication, team work, leadership, etc.
- cultural understanding and friendship
 - respect on cultural difference
 - enriched understanding of cross cultural variety
 - personal relationship management



Figure 3. LED lighting system designed and prototyped by the students in 2009



Figure 4. Student final presentation



Figure 5. WPI students touring China with their project partners

4. Summary

For nearly eight years, there have been more than three hundred students participated the senior projects in the China Center. Through the comprehensive project process, the students practice the academic study, professional training, and cultural enrichment. They have provided explorations and benefitted from the three dimensional education curriculum.

5. Acknowledgements

This research work was partially supported by National Foundation of USA, Department of Education of USA, and the China Ministry of Education's Humanities and Social Science Research Project "Study on the Training of Engineering Science and Technology Talents" under Grant no. 10JDGC002.

References

- [1] Daniel Hirleman, Eckhard A. Groll, and Dianne L. Atkinson, "The Three Axes of Engineering Education", *International Conference on Engineering Education (ICEE)*, Coimbra, Portugal, September 3 – 7, 2007.
- [2] F. Looft and Y. Rong, "The Capstone Project: An Integrated Experience", Chapter 8 in *Shaping Our World, Engineering Education for the 21st Century*, Editors, G. Tryggvason and D. Apelian, ISBN 978-0-470-92974-2, Wiley and Sons, 2011
- [3] E. Sosnovsky, B. Windsor, Y. Rong, "Comprehensive Design Process of Planar Mechanisms for Small and Medium-sized Companies", *Engineering Education: 21st Century Frontiers, ASEE Zone 1 Conference*, West Point, NJ, March 28-29, 2008
- [4] Y. Rong, A. Zeng, and L. Gao, "Integration of Innovation, Entrepreneurship, and Globalization in Engineering Senior Projects", *7th Annual ASEE Global Colloquium on Engineering Education*, Cape Town, South Africa, October 19-23, 2008
- [5] Y. Rong, "Integration and Practice of Entrepreneurship in Global Senior Projects", *Capstone Design Conference*, Boulder, CO, June 7-9, 2010.