Session 2660

Collaborating With Chinese Universities on Engineering and Technology Education: Potentials and Issues From a Curriculum Perspective

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Abstract

The globalization of our economy has stimulated international collaborations on collegiate education. As a predominant manufacturing base and an emerging mass market, China has become an important base for engineering and technology (E&T) in the past decade. It is apparent that collaboration with Chinese universities on E&T education will help further our understandings of the needs and the developing trends for engineering and technology professionals.

This article explores the potentials and issues of collaborating with Chinese universities for E&T education from a curriculum perspective. By analyzing the TAC of ABET accredited ECET curriculum at Western Carolina University and that from a representative Chinese university, East China University of Science and Technology, the authors found that there are great potentials to collaborate with Chinese universities in E&T education. Though issues exist during the process of establishing such collaborations, they can be resolved through a thorough understanding of Chinese engineering curricula and careful planning.

Introduction

The globalization of our economy has stimulated international collaborations on collegiate education. Previous research and successful practices demonstrated that these collaborations have provided valuable experience for our faculty and students to better understand the needs and the developing trends for engineering professionals from a global perspective[1,2]. As a predominant manufacturing base and a vast market itself, China has attracted a majority of engineering and manufacturing firms from America in the past decade. It is apparent that collaboration with Chinese universities on E&T education will help further our understandings of the different requirements for engineering professionals from these two very different parts of the world.

For a variety reasons, collaboration with Chinese universities in E&T education is not an easy task. These reasons can include differences between cultures, administrative structures, educational goals, and languages. This paper explores potentials and issues of collaborating with Chinese engineering schools from a curriculum perspective. By comparing and contrasting the curriculum of our electrical and computer engineering technology program (TAC of ABET accredited) at Western Carolina University with that from a representative Chinese university, the following findings are presented in the paper:

1) Because of the administrative structure in China's higher education system, the engineering curricula are centrally controlled to certain extent by China's Ministry of Higher Education. Therefore, analysis of an engineering curriculum from one representative university can be generalized to other universities.

2) Calculation of credit hours is different than that required by EAC or TAC. In general, a four-year Chinese engineering school requires students to take 160 - 200 credit hours to graduate with a Bachelor of Engineering (B.Eng.) degree. This credit system could cause some difficulties when planning to offer potential joint degree programs.

3) "Course series" (will be explained more in detail in the paper) structure is different than what we offer here. The curriculum from a representative Chinese university indicates that the focus of coursework is on the following aspects ("series"): political science and professional education, foreign languages (normally English), computer applications, science and mathematics, electronics, and general engineering. Some issues could arise in terms of EAC or TAC requirements for engineering graduates.

4) Engineering and Engineering Technology programs are not differentiated in Chinese engineering curriculum[3]. Practical experience is a major part of the curriculum versus being less emphasized in some American engineering curricula. Because "practical series" (somewhat like internship here in the States, but it is required for every student and organized by the university.) is carried out through industry-university collaborations in China, it may provide valuable experience for our students to better understand the engineering and manufacturing processes in China through a joint degree program.

Chinese Higher Education: A Historical Perspective

Even though Chinese higher education history is not what this paper intends to address, however, because of its uniqueness, it is imperative to review its brief history in order to better understand it curriculum. Through this brief review, one can better appreciate the history of Chinese higher education and the importance of engineering education in China.

China has a long and extraordinary history of higher education. Though disconnected to certain extent by the cultural revolution, however, once resumed in 1978, Chinese higher education has bloomed during the past two decades to meet the high demand of intellectuals for China's blooming economy. Nowadays, the number of universities in China has grown from a very limited number (a couple of hundreds) to thousands in the past twenty some years, ranging from government administered universities, to those administered by provincial and municipal governments, to private universities. Program growth in Chinese universities is equally impressive comparing with the growth in numbers. In recent years, most universities have expanded from their undergraduate-centric programs to a great diversity of post-graduate programs including master's and Ph.D. programs. More and more Chinese universities have gained excellent reputation internationally through their high-quality teaching and outstanding research.

E&T education in China has always been regarded as ”elite education” among all higher education majors. Despite the growth of university admission rate from 4% in the early eighties to more than 50% nowadays, there is only a mere 20% or less of those admitted by a university can enter into various E&T disciplines. In general, as evidenced by those who came to the United States for higher education, engineering students in China possess strong mathematical and analytical capabilities. This is due to the fact that Chinese have always emphasized on the solid foundation of building an academic ”pyrimad” in science, engineering, and technology disciplines. Consequently, the E&T curricula design reflects this philosophy in E&T education.

Another aspect crucial to gain a good understanding of Chinese E&T education is that university curricula have been historically administered by the Ministry of Education. Individual university had limited freedom to change its curriculum. The centralization provides a uniformly distributed basic requirements for E&T schools across the country to ensure education quality. Even though the trend of decentralization has been observed due to the emergence of local governments and privately administered universities, however, the baseline requirements set by the Chinese Ministry of Education are used as curricula guidelines. Consequently, the results obtained from analyzing one representative E&T curriculum can be reasonably generalized to other universities in China.

A Representative Chinese E&T Curriculum

As one of the well-known universities in China, East China University of Science and Technology (ECUST) is a comprehensive university with its emphasis on engineering and technology education. The university consists of 16 colleges covering different fields of arts and sciences, engineering, and technology. The university offers Bachelor's, Master's, and Ph.D. programs. More than 40 degree programs are offered to undergraduate students. The university has over 4,200 teaching and administrative staff, among whom 1000 are professors and associate professors, one academician of the Chinese Academy of Science, and one academician of the Chinese Academy of Engineering. The university has more than 26,000 students, among whom more than 12,000 are undergraduates.

School of information Science and Engineering consists of automatic control, computer science and engineering, electronics and communications departments. The school also has multiple research centers, including a computing technology research center, an industrial automation national engineering research center, and an electronic and information experiment center. Control theory and engineering (former industrial automation) is the first doctoral degree awarding program in the country. Currently, the school has 1 post-doc station, 2 PhD programs, 7 master of science programs, 3 master of engineering programs, and 4 bachelors programs. Its undergraduate curriculum is considered as representative of its kind in China.

The four-year undergraduate course plans are shown in tables 1-4[4].

Table 1. Freshmen Course Plan

Course Series	*Fall Semester*	*Spring Semester*
Perspectives	Introduction to Deng's Thoughts Ethics and Morality Physical Education	Introduction to Mao's Thoughts Basics of Law Physical Education
Foreign Language	English Level I	English Level II
Computer	Computer Literature	C Programming
Math and Sciences	Advanced Mathematics I	Advanced Mathematics II College Physics Linear Algebra
electronics	None	None
General Engineering	Engineering Drafting	Engineering Drafting
Practical series	None	None

Table 2. Sophomore Course Plan

Course Series	*Fall Semester*	*Spring Semester*
Perspectives	Marxist Theory of Political Economy	Theory of Esthetics Military Theory Physical Education
Foreign Language	English Level III	English Level IV
Computer	Basics of Computer Software	Basics of Computer Software
Math and Sciences	College Physics Complex Variable Theory	Statistics and Stochastic Processes
electronics	AC & DC Circuits	Electronics Electrical Motors
General Engineering	None	None
Practical series	College Physics Labs Mechanical Engineering Practice	College Physics labs Electrical Practice Electronics Practice

Table 3. Junior Course Plan

Course Series	*Fall Semester*	*Spring Semester*
Perspectives	Marxist Philosophy Political Economy	Professional Ethics Military Education Physical Education
Foreign Language	English for Science and Technology	English for Science and Technology Catalog Search Techniques
Computer	None	Microcomputers Computer Applications
Math and Sciences	Applications of Math & Physics	Applications of Math & Physics
electronics	None	Applications of Electronics
General Engineering	General Chemical Engineering Automatic Control Theory Process Control Instrumentation	Process Control Engineering Electrical Automatic Control Systems Modern Control theory PLC theory
Practical series	Chemical Engineering Labs Instrumentation Labs Apprentice Practice	Micro-computers labs Process Control Labs PLC Theory Labs

Table 4. Senior Course Plan

Course Series	*Fall Semester*	*Spring Semester*
Perspectives	Pre-Professional Education	Pre-Professional Education Pre-professional Business Management
Foreign Language	Catalog Search Techniques Technical Translation	Catalog Search Techniques Comprehensive References Senior Project Proposal
Computer	Computer Application in Senior Design Projects	Computer Applications in Senior Design Projects
Math and Sciences	Applications of Math & Sciences in Senior Projects	Applications of Math & Sciences in Senior Projects
electronics	Applications of Electronics in Senior Design Projects	Applications of Electronics in Senior Design Projects
General Engineering	Lumped & Distributed Systems System Simulation Network Communications Situational Bus Control technology	Techniques of Career Development Seminar Frontier in Profession Seminar
Practical series	Lumped & Distributed system Labs System Simulation Labs Network Communications Labs	Senior Project Pre-graduation Practice

From these tables, one can easily find some very interesting aspects that are unique to this curriculum:

1) The perspectives courses focus on political science and socialist humanities. All students, engineering and technology students and student from other disciplines, are required to take these courses. These requirements signify the centralization of Chinese higher education.

2) The courses are divided into and categorized as "series" courses. These categories indicate important focus areas in China's higher education. The categories include foreign language, computer applications, math and sciences applications, major courses, general engineering concepts and practices, which cover a very broad spectrum of knowledge. The emphasis on broader knowledge base shows that foundation and fundamentals are essential in Chinese undergraduate education.

3) It is evident that math and science groundwork is deemed very important in engineering and technology undergraduate curriculum. Requirements in math are generally higher than those in American undergraduate studies for engineering and technology students. For instance, "Advanced mathematics" generally include Calculus I, II, III and differential equations. Strong mathematical capabilities have been demonstrated by Chinese engineering students studying in the united States.

4) Practical experience is crucial in Chinese engineering education. Chinese engineering students are required to expose themselves to a wide realm of engineering disciplines and skills regardless of their areas of concentration. This can be shown from the intensive lab sessions and its "practice series" courses. In China's engineering schools, "practice series" are generally conducted at the manufacturing facilities affiliated with the universities, or in collaboration with industrial partners. All the activities are organized by the universities and are mandatory for the students to participate. Unlike the internship in the United States which is optional, Chinese engineering students are provided opportunities to gain real-world experience before their graduation. Activities range from operating a lathe to cut a hammer to working on the production lines in a factory. Hands-on experience is a must for engineering students in China. This practice indicates that Chinese engineering schools do not distinctively differentiate engineering and technology. Theoretical backgrounds and hands-on experiences are treated equally important. This may has to do with the fact that China as a huge manufacturing base, engineers are required to get involved in both design and manufacturing processes.

ECET Curriculum from Western Carolina University

In recent years, the department of engineering and technology at Western Carolina University (WCU) has experienced tremendous growth. Its ABET accredited ECET program is a representative 4-year undergraduate program of its kind in the nation. Students who successfully completed this program are awarded Bachelor of Science degrees. WCU's ECET curriculum is summarized in tables 5 through 8[5].

Table 5. Freshmen Course Plan

Fall Semester	*Hours*	*Spring Semester*	*Hours*
ENGL 101 English Composition I	3	ENGL 102 Composition II	3
Perspective	3	CMCH 201 Communications	3
Wellness	3	MATH 145 Trigonometry	3
First Year Seminar	3	Perspective	3
Perspective	3	Perspective	3

Table 6. Sophomore Course Plan

Fall Semester	*Hours*	*Spring Semester*	*Hours*
ECET 231 Circuit Analysis I	4	ECET 290 Computer Engineering Fundamentals	3
MATH 146 Algebra & Analytical Geometry	3	ECET 242 Electronic Circuits	4
PHYS 130 Physics	4	Perspective	3
CS 150 Computer Programming I	4	PHSY 131 Physics	4
		MATH 170 Statistics	3

Table 7. Junior Course Plan

Fall Semester	*Hours*	*Spring Semester*	*Hours*
ECET 331 Digital Integrated Circuits	4	ECET 332 Microcontrollers	3
ECET 321 Circuit Analysis II	4	Elective	3
TEL 345 Introduction to LANs	4	MATH 255 Calculus II	4
MATH 153 Calculus I	4	ECET 341 Advanced Circuit Analysis	3
		Elective	3

Table 8. Senior Course Plan

Fall Semester	*Hours*	*Spring Semester*	*Hours*
ECET 431 Microprocessor Interfacing	4	ECET 461 Digital Signal Processing	4
ECET 452 Control Systems	4	ECET 464 Instrumentation	4
ECET 478 Senior Project Proposal	1	ECET 479 Senior Project	3
Technical Elective	2	Perspective	3
Elective	3	Technical Elective	3
Elective	3		

Some general conclusions can be reached by examining this curriculum:

1) The curriculum also emphasizes a broader knowledge base for its students. Students have

more flexibility of choosing perspective courses to better fit their interests. In fact, students have the freedom to choose from a variety of courses ranging from psychology, philosophy, religion, to geography, history, and music.

2) The curriculum does not show rigorous math requirements. This is because of the differentiation between engineering and technology majors. Experiential knowledge accounts for an important part of the technology curriculum. Most hands-on experience are gained through laboratory experiments associated with most of the courses. Availability of contemporary lab equipment has made it possible for students to gain hands-on experience from lab settings. While some high-end test equipment is steadily available in our labs, these test instruments are considered as luxuries in Chinese engineering schools.

3) The curriculum shows the incorporation of modern technologies. For example, because networking technology has become predominant in information collection and transfer, students are required to gain knowledge of Local Area Networks (LANs). In addition, modern software packages widely used in the industry, such as Max+Plus II for VHDL design, Matlab for data analysis and system simulation, and LabView for data collection and virtual instrumentation, are incorporated in various courses. This is because of the affordability of these software packages to American universities, as well as various trainers associated with the software such as UP2 for VHDL and NI ELVIS for LabView have made training of using these software packages relatively easy.

Overall, each curriculum has its strengths and weaknesses. Further investigation and comparison will better reveal the benefits and constraints of collaborating with Chinese universities.

Further Comparison of the Two Curricula

The most efficient and straightforward way of comparing these two curricula is to divide the courses into different categories, and compare credit hour requirements and percentage weight of each category in the overall curriculum.

We divide the courses into the following general categories: core courses and perspectives, foundation courses (science and math), technical foundations, major requirements, and practice courses. The credit hours and percentage weights are shown in tables 9 and 10. From these tables, one can find some significant differences between the two curricula:

(1) The Number of Credit Hours Required

The Chinese curriculum requires 178 total hours, while the American university requires 128 hours. In Chinese education system, this is made possible because of centralization. Students are admitted to a declared major and the courses are specifically offered to that major. The same group of students take the same classes from 8:00am to 4:00pm everyday. Semesters are 20 weeks in length in general. Some practice courses, including senior internship, are conducted during summer break. In addition, senior project is counted for 24 hours versus 4 hours in

American curriculum. This alone causes 20 hours difference in total credit hour requirements.

Table 9. Credit Hour Requirements and Weight at ECUST

Course Category	*Credit Hours*	*Percentage Weight*
CORE COURSES & PERSPECTIVES	**56**	**31.5%**
Humanities & Social sciences	18	
Business Administration & Military Education	3	
Elective Perspectives	3	
Physical Education	4	
Foreign Language	15	
Computer Foundations	13	
FOUNDATIONS COURSES	**30**	**16.9%**
TECHNICAL FOUNDATIONS COURSES	35.5	**19.9%**
Electrical Engineering Foundations	18	
General Engineering Foundations	17.5	
MAJOR REQUIREMENTS	**25**	**14.0%**
Major Required Courses	13	
Major Electives	12	
PRACTICE SERIES	**31.5**	**17.7%**
Various Practice Courses	5	
Senior Project	24	
Military Training	2.5	
Total	**178**	**100%**

Table 10. Credit Hour Requirements and Weight at WCU

Course Category	*Credit Hours*	*Percentage Weight*
CORE COURSES & PERSPECTIVES	**42**	**32.8%**
Writing	6	
Communications & Wellness	6	
Social Sciences	6	
History, Humanities, Fine Arts & World Cultures	12	
General Electives	9	
First-year Seminar	3	
FOUNDATIONS COURSES	**24**	**18.8%**
Math	15	
Physics	6	
Other Science	3	
MAJOR REQUIREMENTS	**58**	**45.3%**
Major Required Courses	53	
Major Electives	5	
Senior Project	**4**	**3.1%**
Total	**128**	**100%**

(2) Foundation Courses Requirements

The Chinese curriculum consists of 30 hours of foundation courses while the American curriculum has 24 hours. The major difference is the math requirements. As discussed above, Chinese E&T schools normally require higher mathematical requirements.

(3) Technical Foundation Courses Requirements

Another significant difference between the two curricula is the requirements for technical foundation. There are 35.5 credit hours requirements for technical foundation courses including electrical engineering courses (circuits, electronics, etc.) which are counted as major courses in American curriculum. General engineering foundations include courses such as engineering drafting and mechanical engineering practice. This may give us a good suggestion in terms of curriculum improvement - today's product-oriented trend calls for professionals with versatile skill sets. Therefore, diversity of engineering knowledge is a must for today's engineers and technologists. For example, an electronic engineer needs to know how to read a mechanical drawings of a product and to incorporate mechanical design into his electronic design.

(4) Major Requirements

The percentage weights in Chinese and American curricula account for 14.0% and 45.3%, respectively. This is because electrical engineering foundation courses such as AC/DC circuits, Circuit Analysis, Electronics are listed under technical foundations. If we count technical foundations into major requirements, the percentage is increased from 14.0% to around 24.0%.

(5) Practice series

As pointed out in the previous section, practice courses represent an important part of the Chinese curriculum. These courses account for 17.7% of the curriculum. The practice courses typically comprise mechanical engineering practice, apprentice practice, and pre-graduation practice. Mechanical engineering practice involves students in basic machine operation and prototype making activities. Apprentice practice aimed at introducing students to real world engineering practices. Normally students are required to work with factory workers and engineers in a manufacturing facility to understand real-world engineering and production processes. Pre-graduation practice emphasize on the real-world experience related to the student's senior project. Generally, students are required to find an engineering firm making products similar to their senior projects, and work with the engineering team to learn the design and project cycles. Cumulatively, these practice courses take 8 to 10 weeks to complete. In addition to these mandatory practice courses, some students also involve in summer intern and co-op jobs related to their senior projects.

Collaboration: Potentials and Issues

The comparison of the two curricula has shed some light on the potentials of collaborating with Chinese universities in E&T education. It is foreseeable that collaboration will help enhance each other's strengths and overcome respective weaknesses. Collaboration potentials and benefits can be summarized from the following perspectives:

1) Chinese E&T education lays emphasis on its students' engineering foundations, especially math foundation. However, most E&T students enter into manufacturing or application oriented engineering firms when they graduate. While they are good at applying what they learn from E&T schools, however, the creativity and discovery capabilities are limited because of lack of exposure to contemporary technologies. Collaborating with American universities can help them apply their knowledge at a higher level by stimulating their creative thinking, which has been emphasized in American curriculum.

2) At the same time, Chinese students are not the only beneficiaries. American students can definitely benefit from working with their Chinese counterparts in terms of reinforcing their theoretical knowledge and better apply the knowledge in theoretical research, applied research, and engineering practices.

3) While Chinese students normally have solid fundamentals, however, their exposure to high-tech environment is very limited. By collaborating with American universities, Chinese students are provided the opportunities of putting themselves in a high-tech environment, utilizing state-of-the-art equipment and contemporary research tools, and more importantly, attaining current technology updates, and getting trained with modern information resources.

4) On the other hand, collaboration provides American students great prospects of gaining real-world experience through the world's largest manufacturing and engineering base. In the past decade, most American E&T professionals have been sent to China as management executives, technical advisors, or technical experts. Almost unanimously, they feel the cultural shock, disparity in engineering practices and processes, and to some extent, difference in mentality towards engineering. Emphasis in practice in Chinese curriculum offers American students great opportunities to get involved in China's practical engineering activities at the early stage of their E&T career. By engaging themselves early in the game, American students can better appreciate the culture, the mindset in E&T, and the processes in E&T. In turn, it will make the students be more competent in their later stage of career development in this global economy as E&T professionals.

In spite of huge potentials of collaboration between Chinese and American universities, practical issues do exist to slow down the process. Two major concerns are raised purely from a curriculum perspective:

1) The credit-hour systems are different between the universities. This may cause difficulties when attempt to offer join degree programs. Credit hours should be equated so that the requirements are met, not only from both universities, but from accreditation organization such as TAC of ABET and China's Ministry of Higher Education. Meeting these requirements are essential to guarantee the quality of E&T education.

2) Even though English is the required second language in Chinese universities, and students must pass Level IV English exam administered by the Ministry of Higher Education, however, students' English proficiency is not sufficient for normal and technical communications. Most students need to take intensive English training before they can achieve certain level language proficiency gauged by the Test of English as a Foreign Language (TOEFL) administered by Educational Testing Services (ETS). The fact that all courses are taught in Chinese may raise the issue to American students who want to take some coursework at Chinese universities.

Conclusions and Suggestions

In this article, we compared E&T curricula from ECUST and WCU. The comparison results reveal great potentials and issues related to possible collaborations between Chinese and American universities in general. Through our analysis, we found that collaboration will positively help strengthen the strengths and overcome weaknesses of universities from both countries. However, collaboration experience (such as with European countries) can not be directly applied to this case because of the uniqueness of Chinese universities such as big cultural differences and language barriers.

A step-by-step approach will help ensure the success of collaborating with Chinese universities. Collaborative research of educational issues at the faculty level helps both sides understand each other better, and leadership of collaboration can be established. Subsequently, small-scale exchange at graduate student level may be initiated to further explore and understand potential problems that may emerge during the collaboration process. Through thorough investigation and trial run practice, a good planning will eventually lead to s successful collaboration.

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