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Essay

How a Chinese University Trains Engineers to Meet with Challenges Today and Tomorrow

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This article provides background about education reforms currently happening in China's higher education system. Particular reference in these reforms is placed on integrating theory to applied skill learning, and theory to practical learning, with an aim to train students to gain lifelong ability to meet the needs of our modern society. A three-year 'Pilot Class' program at the University of Science and Technology, Beijing has changed our conventional education pattern from classroom and library-based work, to an active and multi-faceted academic community. The students in the Pilot Class, focus on integrating theory with practice, and spend much time participating in the real world, in factories, in design, and in international exchange programs to broaden their perspectives (Asia-Pacific Journal of Cooperative Education, 2006, 7(1), 1 - 6).

Keywords: Engineering; education reform; international exchange; China.

The use of instant communication systems such as e-mail and access of information from the Internet greatly affect how people live nowadays. The fast development of these new technologies and the rapid globalization of the world economy have created high demand for engineers with computer, communication and other related occupation skills that are often acquired at universities and other centers of higher education.

In addition, employers increasingly are seeking graduates who have gained critical-thinking and problem-solving skills, seen as necessary to adapt changing economic conditions (Hodges & Burchell, 2003; Kato, 2005; Zegwaard & Hodges, 2003a, 2003b). According to many authors a university should strive to develop students' creativity, insight and analytical skill (see, e.g., Kato, 2005; Göhringer, 2002; Srisa-an, 2003) and to provide necessary training for individuals wishing to enter professional careers. By acquainting students with complex ideas in an intellectually stimulating environment, a university can thus provide unique opportunities for personal enrichment while also preparing students for their future careers.

To fit in with fast updating technology, a university should aim to cultivate students' with knowledgeable and flexibility and the general population, with multi-faceted abilities, so that graduates possess not only advanced knowledge, but also the ability to deal with practical issues and cooperation relationships in real society. Other skills required in a modern society include general knowledge, thinking, analysis, reflection, critical ability, and skills to deal with the issues in their future careers and life (Dressler & Keeling, 2004).

The purpose of a university in China, and arguably many other similar developing nations (Taylor, 2004), is not only to transmit knowledge, but also to encourage students to create and explore the new global society through synthesizing the heritage from their ancestors with abilities to form and sustain new relationships construct on cooperating relations. Computers and Internet technology increase the speed of knowledge access in our lives, as well as increasing our access to updated scientific information. It is, for example, now possible to research many scientific materials on the Internet at anytime, from anywhere in the world. This poses a significant challenge for traditional education, and educational institutions since historically centuries of education has been established on the premise of the elder generation teaching the younger generation (Coll & Eames, 2000; Srisa-an, 2002).

There is then a danger that some students may neglect the fundamental knowledge accumulated through generations, which cannot be easily mastered or accessed through a computer; such knowledge takes time to learn and even longer to master. What is the best way for our younger students to learn? What is the best classroom and best curriculum for our students in school? We must acknowledge the real needs, and to give students the necessary skills to survive in the rapidly evolving technological society. However, we cannot neglect the fundamental wisdom of the past in a thorough educational program. How can we change our educational methods to address both these needs is an interesting question and a common concern for all of us today.

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TABLE 1
Class organization for the 'Pilot Class' (NB=60)

Year		1996	1997	1998
Sex	Male	23	21	25
	Female	7	9	5
Area	Large city	8	6	7
	Medium city	6	10	4
	Town	6	3	6
	Rural	10	11	13

Meeting the Educational Requirements of Modern Chinese Society

As much greater numbers of Chinese people have enrolled in universities since the end of last century, what was traditional education for the gifted, higher education has gradually become popular education, that is, education for the broader populace; this is then a powerful social economic force.

These differences between modern and traditional education needs are something of a modern perception, and there is popular belief in China that students need the ability to distinguish between and oppose traditional 'truth', which may conflict with a need to protect, reserve and cherish important cultural traditions including those in education. Modern educational approaches to education, for example, rely on innovation, to rebuild and development is based on the principle of reflection and comprehension, which contrasts somewhat with the traditional view of respect for a teacher and following his or her instruction faithfully.

University then is a place to give students the ability to summarize conventional knowledge and at the same time the 'key' to open a door towards their future careers and lives; to build up a spirit to innovate and create a new future for themselves and their society. Hence, in a modern context, universities in China are no longer a place only to study or get knowledge from teachers, mostly as a result on increased freedoms associated with China's Open Door and Reform Policies introduced in 1978.

The Open Door and Reform Policy[1,2] changes have defeated thousands of years of traditional ideology. The Chinese scholar Confucius said: "Wisdom controls labor, laborers are controlled by the educated". China society also has an idiom: "Gentlemen use the mouse, but not the hand". However, in the minds of some in Chinese society, students should 'keep their noses in their books' and refrain from interfering in social affairs. Others in contrast, believe students should go outside of the university's 'ivory tower' and involve themselves in active society from the beginning of their period of university education. According to this view, students should be encouraged to participate in a diversified market economy and innovation in China's factories' as Chinese industry strives to maintain its global competitiveness.

Of relevance to this discussion is the fact that unlike in the past, the Chinese government no longer distributes jobs to people or dictates the location of their employment; nor does it provide things such as medical insurance and social welfare, offer a house or arrange a job for their staff, after they obtain their degrees (i.e., since the reform policies). Chinese people now can choose whatever they like to do employment-wise, and as a consequence Chinese people now have many more options in front of them. Once many students were not willing to accept the job arranged by their government, but now many students expect their government to arrange jobs for them because of intense competition in the career market. But this is impossible in China in the current economic and social climate. This competition has gradually penetrated into every student's mind from the time they enter the university. University campuses are no longer quiet places only to obtain knowledge, but a place of 'warming up' for lifelong challenges; a place to learn survival skills for their future.

The University of Science and Technology Beijing (here after referred as USTB) has launched a special class for training students to meet the requirements of China's rapidly changing society, today and tomorrow, for the aforementioned reasons. This special class is one of the reformation programs in the USTB and is termed a 'Pilot Class' specifically aimed at 'Materials for Restructuring Engineering Education'. Mastering theoretical knowledge, and writing a thesis could previously fill all of a student's life in the university. An important challenge for this program then is to shift away from traditional passive study, in which theory is divorced from practice.

Now, it is a commonly held view in China that a university should nurture students with ability to involve themselves in society soon after completing their university studies; in other words to be 'work-ready' upon graduation. Our purpose in organizing this class then, is to provide our students with lifetime working abilities, not merely to have the knowledge to solve problems in specific fields, but also to have an aptitude for self-study, and a cooperative and creative ability in their future.

Study Integrated with Practice

The conventional educational system of China paid more attention to writing ability, and theoretical research ability, but not practical ability based in real industry. Many of our students obtained a degree from university but took several years of practice to become familiar with industry. The conventional education system thus produced students relatively weak in practical application. From elementary school until graduating with the completion of a research degree involving a thesis, Chinese students experience numerous examinations. These various examinations are, however, only focusing on things such as writing, and our education systems essentially requires our students to place emphasis on memorizing material form their textbooks and lectures and other notes in the classroom. Only occasionally is there even a quick visit to some factories, and students seldom have enough time to work in a multi-faceted academic community or practical field. The result of conventional education system thus produces students with little ability in the practical application of scientific or engineering knowledge. Therefore, a key feature of the USTB organizing Pilot Class is a stress on how theory integrates with practice to meet the needs of China's fast developing and changeable society.

Producing Students with Flexible and Diversified Abilities

Training students with abilities to keep pace in a fast changing society, today and tomorrow, is now an important mission of Chinese universities. According to national statistics, about one third of Chinese students who graduate from universities will do jobs not closely related to what they studied in the university, and some never use what they have learnt in university in their employment (Luo Fuwu, 1990). Such students perhaps come to university just to obtain a 'credential' degree seeing this as the means of obtaining a career. Hence, a part of the Pilot Class aim is to see how a university can help our students spend more time involved in practical work including the workforce during their university time in order to help young students see that they have more options and gain practical societal experiences, so that they can readjust their life targets in time. Coll (1996) mentions this as a key outcome of cooperative education, in which co-op students gain what he calls 'career clarification (see also Dressler & Keeling, 2004).

Spirit of Teamwork and Cooperative Ability

Advanced technology requires development of strong peer relationship, as students need to be able to cooperate with colleagues and work together with specialists from the engineering, liberal arts, and science fields. The modern industry and the information revolution have changed self-reliant small-scale workshops to large chain enterprises. In such circumstances cross-field technology and cutting-edge subjects have bound advanced technicians and technologies together in order to meet with the requirements of modern science research. Engineers thus commonly no longer only work for one factory or one section, and cooperation and teamwork is necessary for our students today.

Independence, Confidence and Creative Ability

Conventional education paid more attention to gaining good examination results, but typically neglected creative ability. Due to China's traditional education system, students were closely instructed and followed and obeyed teachers' guidance closely, passively memorizing content from textbooks. Such a conventional education system limited students active minds, meaning that they believe and venerate lecturers, without developing critical-thinking skills in their own minds. This may then gradually weaken students' creative ability and undermine their self-confidence. Students may firmly rely on instructors' opinions and textbook for getting a good examination score in order to obtain a credential degree. It is important for inspiring student' creative enthusiasm in the university period helps student gain a concrete fundamental knowledge for their future careers.

Responsibility

The aforementioned suggests that conventional education may nurture students, but this means that they also may lose sight of their responsibilities and simply rely on their teachers and others in and out of school. They may operate only in a limited area or field, and not consider related environments and other necessity needs.

The Pilot Class "Material Science for Restructuring of Engineering Education" (hereafter referred to as Pilot Class) started in 1996. The class was chosen by lot from the entrance examination record sequence, choosing one student from each three number sequence, not only selecting the best students from the fresh recruited group. That means this class constructed used class organization as a means of choice and ensured the class was representative of this level of students.

Curriculum Arrangements

Engineering students in China's engineering programs typically require 1800-1900 hours of study across four years study, and have to complete 182 credits. In 1996, when the first Pilot Class started, the teaching curriculum at USTB was adjusted in order to meet with the needs of practical application as detailed above. This meant we had to cut classroom time, but not the credits.

In 1997, we used advanced teaching targets to revise the new teaching schedule, and this revision mainly focused on solving multi-faceted issues. In 1998, again, we revised the curriculum, and related several courses, and also introduced cross-field study and cutting-edge subjects in science and engineering. We reduced the class time and allowed the students more self study time and to spend more time in library and practical work. The appointed instructor was available to answer student's questions at any time. The following framework was the revised curriculum that evolved over the three-year timeframe of the Pilot Class.

Foreign Language and Social Science

The foreign language class did place not emphasis on examinations (i.e., language examination scores), but rather on practical hearing, speaking, listening and writing skills. Although most Chinese students have had 10 years language study, many cannot express their meaning and even cannot clearly write a statement. Actually, most students waste a lot of time studying English ineffectively. How can we increase the student's English usage skill is our target. The English examination has also changed to better reflect our emphasis on the practical usage of language.

Likewise the Humanities and Social Science class was divided into two parts; the first synthesized history, philosophy and political courses together, which mainly focused on history review and methodology usage. The second class integrated economics, social science, international relations, environment and some related sciences. We paid more attention to the integrated cross-field study courses to help our students theorize comprehensive technology concepts and improve the students' comprehension ability. We encouraged students to study art and liberal sciences by themselves, not in the classroom.

Mathematic and Natural Sciences

In mathematics teaching, we practiced applied educational psychology pedagogy, the 'target pedagogy'. We considered nurturing students with creative and self-study ability as an important renovation target. The reorganized mathematics curriculum also had reduced class time, leaving more time for solving issues by self-studying, preparing presentations and summarizing their work.

Independent thinking, teamwork discussion and questioning enhanced our students' study directly with respect to analyses and comparison.

Physics Curriculum

In 1997, we combined the physics and chemistry courses into one course, to help foster a multi-disciplinary approach to studying the physical sciences.

Engineering Fundamental Series Curriculum

The newly established Engineering Fundamentals courses are closely related engineering curricula that cover systems, materials science, energy resources and information in a total of four courses: Integrated Engineering Drawing, Engineering Mechanics, Mechanical Design, and Computer courses. This was intended to be a comprehensive training program for the second school year, requiring students to spend more time in the laboratory, to practice field and team work cooperation.

Experiments and Engineering Training

The close relation we developed between the textbook, class time and experiments, sought to widely expand students' subject vision and to develop students' ability to observe, analyze, summarize and design.

Engineering Design

Three groups, each lasting four years, participate in our experimental practical course. We divided the course into the periods: the production process, design and thesis.

Production Process

First, a restructured sample production was enacted, such as the manufacture of an automobile or a bicycle. We asked the students to restructure a bicycle or an automobile by themselves using a very limited financial budget, and getting them to choose and analyze material character and conduct marketing price comparability studies. From this it was intended that the student would come to understand and learn all the processes involved in manufacture, and improve their ability through studying production costs, social demands, as well as related law and humanity issues, the most important of which is to understand material usage.

Design

Second, we changed the traditional design curriculum to reality production design and integrated mechanical design with electronic circuit design. We found that this enhanced students' application, summary, research and comprehensive analysis ability.

Thesis

Third, during the thesis period the students spend a certain amount of time involved in a research project in factories, obtaining experience from integrated enterprises, and acquiring ability in workshop practice. After a series of reality practice and deep thinking design sessions, the students are equipped both with theory and enough practical experience to write a thesis. We found these activities stimulated students' enthusiasm for study, various related activities, raised their sense of responsibility and the quality of their theses.

The main purpose of the aforementioned Pilot Class curriculum is to better serve the needs of our society by stimulating students to explore their potential and developing social responsibility.

International Exchange and Communication

International exchange is a current hot topic all over the world (see Reeve, 2004). International exchange and cooperation is both frequent and popular nowadays. Most of our students at USTB are enthusiastic about being involved in exchanges programs. The issue is how can we organized and arrange these programs well?

This kind of exchange program gives the students more opportunities to understand diversity of culture, technology, production and design concepts. Because of such exchange arrangements, more and more students are now able to study foreign languages than before. Along with language practice in the exchange program, the students improve their confidence and realized their language ability (see Coll & Pinyonathagarn, 2004).

Additionally, some foreign engineering students come to China for one or two months internships. Naturally, they chose factories or companies related their subject major. This kind of exchange programs has greatly effectively improved students' probation result and increased in the globalization of knowledge.

Education Target

Our education target is based on the notion that a university is a place to train qualified citizens for serving society. As noted above, conventional education in China resulted in the partial training of students for production since upon graduation they still needed a significant amount of time for probation in factories and companies owing to practice being divorced from theoretical study. In fact our view now is that practical education, integrated with society and based on the reality of industry, helps our students to be involved in real-learning life and recognize their own practical ability and helps them to understand the importance of linking theory with real society needs during their university time. The target of the Pilot Class then is to train students not only in solving immediate problems, but also have

comprehensive understanding of the situation around us, for example, being able to consider effective value of production and social influence of production, as well as establishing lifelong habits of self-study.

To meet with our designed educational target, we divided our students into groups of five, with each group having their own study with and emphasis on subjects such as: market investment, material performance, mechanical performance, price extension, and production result. Using the example we employed during the first year of the Pilot Class (i.e., when the students were asked to reconstruct a bicycle choosing suitable materials, analyzing and pricing materials until installation within a limited financial budget, time and shape design) the students had to spend time checking material resources in the market, comparing the prices and quality in the market. Hence, before they bought the materials they had to learn to analyze the material's quality, and at same time research together with factories, go to the library to check technical data, and visit relevant experts and professors in order to bring their work to a successful conclusion. Therefore, the Pilot Class pushed our engineering students into the practical side of industry, in order to gain a better result, since the students had to carefully consider the price, and the quality at each phase of the manufacturing process. The students discussed what they had done and what kind of problems they encountered with their teachers, and the teachers students and tutors worked together to analyze issues and find a way to solve problems.

The Result of Pilot Class

The evaluation report for the Pilot Class suggest that students exhibited mature ability to integrate theory with industrial reality; that they were more capable in teamwork, independent work and were able to more easily join and participate in real industry after their university study. They were able to construct at a certain level of technology and gained useful experience on how factories work, how markets work and to work through many necessary processes involved in manufacturing. The students were not passively waiting for deadlines, but showed initiative in consulting and discussing issues with experts, specialists and visiting libraries and relevant sources of information, to explore and solve the issues.

At the beginning of this Pilot Class, there were naturally differences of opinion about its likely success. The Pilot Class represented a major challenge for the education system in China. The result of the Pilot Class has, however, been endorsed by the Chinese higher education authorities, and supported by education specialists in China.

According to USTB statistics one-third of the students from the Pilot Class directly signed contracts with factories or companies in the place they once studied or worked before they obtained a degree. Employers found these students exhibited strong practical ability in their occupations. Additionally, one-third of the Pilot Class were accepted by institutes and universities for further masters-level study. The Pilot Class students are reported to be better and faster at learning than traditional university students. Those going into employment are reported to be more practical and not need the intern period in order to become familiar with industry needs. They also exhibited strong ability in cooperation, problem-solving, and were more independent and mature than their traditional counterparts. Remarkably, only about 2% of the Pilot Class failed to complete their studies.

Students' Views of the Pilot Class

Student views of the value of the Pilot Class were sought. A student from 1996 wrote:

> It was easy to understand the class, and also easy to forget everything after the class. But we will never forget what we have done by our own hand after the practice, which was closely connected with our textbook, or when we solved the problem by ourselves.

Another student said:

> We used to learn from the classroom and textbook, now we learn not only from textbook but also from society and practice reality. We have learnt to cooperate with others and society, improved our social relationships, our problem-solving ability, and better statement ability.

Teachers' Views of the Pilot Class

Likewise teacher's views of the Pilot Class were sought.

One wrote:

> Our students have improved a lot through self-study and reality practice, and explore multi-dimensional study sight. The result is the students from Pilot Class studied much more than the conventional class because their curriculum was mixed with social science and science technology. Besides which they have studied fundamental knowledge, practical skill and coordinate ability, self study ability, efficient use of library and time.

The Pilot Class has pushed forward educational reform on the USTB campus to a new phase because many faculties were involved in the program. Faculties from Applied Science, Engineering Applied Science and Social Science joined together to operate the program and broadened their vision outside or related with other subjects. It may be still too early to make definite conclusions about the success of the Pilot Class. However, it seems we have made first important step for education reform in China's higher education system. We have tried to nurture qualified students and produce mature citizens to well serve our society.

Conclusions

A university should create a challenging environment which is both open and flexible. It should provide opportunities for students to engage in enterprises both inside and outside the campus. It should enable them to discover and explore their potential and develop their academic knowledge, life-long study skills and interpersonal relationships. The Internet age has created a global village, and it seems

technology develops faster year by year. How can we train qualified students to rise to these challenges and capitalize on the unique opportunities they provide? Universities have the responsibility to inculcate in students the ability to understand the relationship between theories and practice so that after university they can devote themselves to applying the knowledge they have acquired in the service of our fast developing society. A university should spare no efforts in serving the needs of society.

Notes

[1] Education Reform Report, 1996, by Prof. Ke Jun University of Science and Technology Beijing, China.

[2] Case, B.J. (2005, September). The age of accountability. Keynote address from the 2005 China-US conference on aligning assessment with instruction. Beijing, People's republic of China.

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