

ENGINEERING EDUCATION FOR THE 21ST CENTURY IN CHINA: A PILOT SCHEME FOR UNDERGRADUATES

The pilot scheme for technological education in the University of Science and Technology Beijing (USTB), formerly the Beijing University of Iron and Technology (BUIT), which has the earliest contact and cooperation with U. Penn in the USA, and TH. Aachen in Germany at the beginning of China's open policy, began its pilot scheme technological education reform for undergraduate level in 1996 consecutively for three years, in a joint effort by over sixty professors and other senior members of faculty, under the patronage of the Ministry of Education. Thirty students a year for three consecutive years were taken from 90 freshmen, one in every three according to matriculatory marks. All but one were graduated with a B. Eng degree between 2000-2002. Over one-third had their Bachelor theses completed and then were accepted for MSc or PhD study by noted universities and the Chinese Academy of Sciences Research Laboratories in physics, metal, ceramics, electron microscopy after their bachelor dissertations in advanced materials and steel making, a few also in microelectronics, semiconductors, environmental protection, archaeometric studies. Among the supervisors are seven Academician Members of the Chinese Academy of Sciences or of Engineering.

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The guidelines for their undergraduate training were:

- ◆ A change from narrow training in a narrow discipline to an integrated education in intellectual (classroom, laboratory and extra-curricular research activities), cardinal virtues (fortitude, temperance prudence, etc), and moral conducts, now often looked after by different executive groups in the universities.
- ◆ A change from simple narrow technical training to engineering-conscious education and basic education in fundamental and engineering sciences with basic knowledge in social sciences and management, sufficient for and capable of further study and research by self-education; a change from technically narrow and narrowly technical education to a broad engineering education.
- ◆ Emphasis is given to the solution of real engineering problems in production, designing and research in teams from the early stage of the higher education to build up self-confidence and independent self-education, creativity and interest in the materials and any other disciplines, it is also invaluable in acquiring team spirit and capability of team-work, leadership and organizing capability, also subserviency when occasion arises.
- ◆ Change of the roles played by the teachers from that of masters to that of guides, and the students from that of passive listeners to that of initiative learners, thinkers or masters of the learning, so as to change the passive swotting to initiative learning.
- ◆ To improve the students' foreign language ability, English textbooks of best choice are used partly or wholly, if available, even at the cost of reducing the lecture hours, content even the course subjects not absolutely necessary.



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To achieve these goals, it is necessary to reduce the lecture hours from the present curriculum, over 2700-3000, to 2000, including 120 hours course work in athletic training, leaving students sufficient time for self-study, free reading and preparation for discussions and presentation of some of the main contents in the class with the help of faculty members.

During 7 terms of 15-16 weeks each, the courses were grouped into 5 modules:

Humanities, social sciences and management	10 %
Foreign languages	10 %
Physical sports	7 %
Mathematics, Computing and natural sciences	25 %
Engineering basics	16 %
Laboratory works and engineering design	16 %
Disciplinary subjects	13 %
Electives	

The students in the three pilot classes (1996-1998): 30 students each, drawn randomly one from every three freshmen, worked in the first or second summer vacations of 8 weeks in the steel making shop of the Baoshan Steel Works, the largest and the most modern steel works in China, joining the steel mill research teams to work on

company's or national research projects in groups of five or six. The third summer vacation was spent in one of the national laboratories on their respective projects. Most of them extended the subjects into their final BEng dissertations, some even into their graduate study with the same supervisors. The early participation of research played a very important part in their education, it gives the students self-confidence in their own abilities, in their roles in the national reconstruction, and in their sense of responsibility. It also greatly improves their interest in the subject and the field in which they are working. Similar results were obtained in some other universities, e.g. in the Faculty of Arts, Fudan University, Shanghai**.

The last term of the pilot class students was spent on dissertation projects. To test the students' adaptability and ability in self-studying on an unfamiliar subject, normally in an entirely different discipline, the research topics have covered a large variety of disciplines, in different locations. The subjects covered included super-strength low carbon steels, semiconductors, electron microstructures of new quasicrystals, high Tc superconductors, rare earth permanent magnets, ceramics, artificial diamond film, titanium alloys foundry technology, mechanical forming of aluminum foil, archaeometric analysis of artifacts, environmental engineering study in a chemical works, etc. About one quarter to one third of the students have been accepted to continue their post-graduate studies in the Chinese Academy of Sciences: such as the Institutes of Physics, of Metal Research, of Ceramics; and prestigious university

departments, including Tsinghua University (on Microelectronics) and Peking University (Electron Microscopy of advanced materials). The others were employed by a wide range of industries all over China from electronic to car manufacturers.

From the results of partial feedbacks from the graduates, some now are completing their Msc. study and research, and from their supervisors, it may be preliminarily suggested that the students from the pilot classes, compared with their collegians in the normal classes, have much higher interest and confidence in studies and their future careers, stronger sense of responsibility, stronger team spirit, higher and even much higher ability and adaptability to any subject or profession other than what they were supposed to be, i.e. materials engineering, that of self-studying, and greater courage to accept undesirable duties and responsibilities. The early participation of research in national and plant research played a very important part in their education; it has given the students self-confidence in their own abilities, in his or her role in the national reconstruction and the sense of responsibilities.

Based on this outcome, the reform seems at least partly successful, although five to ten years may be needed to make a full evaluation from the future development and the successes or failure of the students in their career, academic, engineering, administrative or otherwise.



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For the effort to be effective and successful, it is essential that:

- ◆ A fundamental change or adjustment of the concept and aims of education among the teaching faculty, students, and their families and administrative staff, that the basic function of a university is education and research, which is also a carrier of education, not just teaching and book reading for a specific career or occupation; that means, a change from a school technically narrow and narrowly technical to a school for educating and cultivating worthy members of a modern civilized society well prepared for life long service to a progressing society and mankind. That is, the curricula, the contents taught and learned, the deed and practices in education must meet the need of a developing society, the personnel market and the future of students, not those assumed or extrapolated from the past.
- ◆ To comprehend that in a market economy as well as in human nature, student is the taskmaster as well as the patron or client for his learning; the teaching faculty is only the guide as well as a supervisor by exemplary deeds.
- ◆ A devoted professorial member, experienced in teaching and research, theoretical, experimental or practical, keen in the principles for educational reform, preferably from a basic course in science or engineering, chosen or volunteer to be a master-teacher for the class, to help the students to organize themselves for studying and research groups, seminars, social

activities, etc. plays a very important and indispensable part for the success of the reform. Similar results have been achieved in the pilot classes organized in the same period under the same project sponsored by the Ministry of education, by the Materials Engineering Departments of Tianjin University, the Beijing Aeronautics and Aerospace Technology, and the Mid-South Technical University in Changsha. The project received a First Class National Higher Education Award from the State Council and the Ministry of Education in December 2001. ■

Thanks are due to more than sixty members of the USTB faculty and administration as well as the 90 students, who participated in the project for the results, we are deeply grateful to the staff of 14 CAS and ministerial research institutes, universities, steel works, etc., who supported the project by providing research directions supervisors and research facilities, without which the experience outlined would not be possible.

Notes

**This is in great contrast to a different story. A talented girl of 15 was admitted into a juvenile class, and then into the Architecture Department of a famous Chinese university, completed her training in 3 years, further earned her PhD in Architecture in a well known American University, and is now serving the industry. She deplored, however, that she is fed up with the profession (a decision made by her parents and the University), a hopeful genius ruined. In contrast, many brilliant students from physics departments of first class Chinese universities and PhDs from known American universities are happily and brightly serving in the New York stock market.