Inspiration of CDIO for Professional Master Training in China

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ABSTRACT

In this paper, we reviewed the CDIO Initiative from the perspective of Professional Master Training; conceived the training objectives of Professional Master based on the understanding of CDIO's core idea; designed Master's curriculum system and teaching methods to meet the new international requirements for professionals of high-tech development constructed graduate practice platform with the support of the practical results of Material Engineering graduates in BIT during the past three years to verify that they have reached the required training objectives.

KEYWORDS

Professional Master; Engineering Master; The CDIO approach; Cultivating objectives; Training program; curriculum system.

INTRODUCTION

Professional Degree is a qualification equivalent to the Academic Degree, with the course curriculum concentrated on a particular industry. Professional Master's Degree aims to train applied talents who have a solid theoretical foundation and could adapt to a specific trade or occupation. Based on the world's trend of graduate education and the reality of China's graduate education development, the professional education will become a priority and will be strongly supported and actively guided by the government in the coming years.

China introduced the system of professional graduate education since 1991. However, the program was only carried out in few subjects, and was based on part-time study. In 2009, in order to meet the urgent demands of national economic growth and social development for high-level professionals, the Ministry of Education decided to offer in large scale, a full-time master education program to professional postgraduates. In 2010, based on the existing 19 Professional Master's Degrees, the State Council Academic Degrees Committee considered and adopted another 19 subjects, and enlarge our Professional Master's Degree portfolio to 38, covering economy, management, education, engineering, agriculture, forestry, medicine and other fields. The Master of Engineering is the most important subject among all the Professional

Master’s Degrees. According to the most recent statistics, the proportion of full-time professional postgraduate enrollment has reached 24.67% of the total postgraduate enrollment. This indicates that the development of professional graduate education in our country is accelerating and the structural adjustment of professional training is intensifying. Along with this trend, the structure of the graduate education, the education program of the Professional Master's Degree and its management system will also have significant changes and adjustments.

Compared to the academic education, professional education needs to have breakthrough innovations in the following areas: faculty team, teaching content & methods, research & professional skills training, laboratory establishment, evaluation criteria and methods, etc. The management system reform should also be considered. How to adapt to these changes and the new situation? The CDIO (Conceive-Design-Implement-Operate) Initiative for engineering education conducted by MIT and 3 other universities provide a valuable reference and experience to us.

In fact, since 2005, some colleges and universities in China have already started to learn and explore the idea & approach of the CDIO Initiative, with the support of the Ministry of Education: 39 institutions were approved by the Ministry of Education as pilots. However, the pilot program was only conducted for junior college students and undergraduate students and graduate engineering training was ignored in the program.

We believe that the CDIO Initiative is also highly valuable for the Professional Engineering Master’s training, because the CDIO framework and approach to engineering education created by world leading engineering universities is a set of training model which meets the characteristics and regular growth pattern of engineering talent. It meets the needs of engineering professionals at different levels through a variety of teaching methods and aims to train innovative engineering professionals to achieve comprehensive development. We believe that talented people is hierarchical. Therefore, the concept of engineering professionals should also include a complete talent level system, i.e. not only a large number of professionals with expertise and skills in a particular field but also some top-notch experts with leadership quality and authority in the engineering field. The CDIO Initiative could be applied in the professional training for skilled workers and technicians in the undergraduate education for engineers, as well as in Professional Master’s education for higher level engineers and experts. Therefore, it could be a very useful reference to domestic universities carrying out Master’s of Engineering.

THE UNDERSTANDING AND INSPIRATION OF CDIO

CDIO (Conceive-Design-Implement-Operate) is actually the abbreviation of the whole process of modern industrial products, and represents an education reform model initiated by

MIT and three other universities of engineering and technology. The core content of CDIO model includes a training objective, a syllabus and a set of standards. Training objectives is to set up a goal for the training, the syllabus is the specific rules of "how to train persons", and the 12 standards is the test of the entire training process. Engineers trained by this model would be professionals that meet the needs of companies and the society. CDIO educational model inherits and develops from the European and American engineering education reform ideas during the past 20 years. More importantly, the core content of CDIO model and the relevant review criteria are proposed according to the requirements of some famous enterprises of the international industrial sector and the American engineering education certification standard. The implementation of syllabus, lesson plans and curriculum through each course, each module, every teaching link, will make sure the requirements on talents from enterprises will be the included into the whole process. As a result, the CDIO model is very practical.

From professional postgraduate training perspective, we think the CDIO education model could inspire us from the 4 following aspects:

1. Whatever kind of talents should always have clear and precise cultivating objectives. For example the CDIO Initiative is to train engineers with four core abilities, which are: technical knowledge and reasoning ability; professional skills and moral qualities; interpersonal skills including teamwork and communication; conceiving, designing, implementing and operating systems in the enterprise and societal context.
2. Whatever kind of personnel training should focus on the process of education and the context. CDIO advocates student "completing the education process of conception, design, implementation and operation in enterprises and social environment".
3. Different personnel need to be fostered by different ways following different rules. Engineering professional postgraduate should develop their comprehensive engineering ability through engineering project practice.
4. We must pay special attention to “conceive” and “design” training, in order to bring up engineering and technical talent with the original innovation capability in the High-Tech field.

REFORM PROFESSIONAL MASTER TRAINING ACCORDING TO CDIO

Beijing Institute of Technology (BIT) is a key university of science and engineering in China, shouldering the mission of cultivating fundamental scientific researchers for nation and institution. At the same time, it is also responsible for cultivating engineers of technology and engineering for the society and enterprises. BIT begins postgraduate education since 1955, and became one of the first batches of Chinese doctoral degree awarded organizations in 1981. After more than 50 years of development, BIT has supplied the society with hundreds of thousands of scientific and technical talents at different levels in different fields. In recent years, China adjusted the structure of postgraduate education, carried out a full-time master education program to professional postgraduates in large scale. BIT is one of the pilot universities, this group of students will graduate in July 2011, which means the reformation has gained preliminary achievement.

1. Conceive the Cultivating Objectives and Plan the Scheme for Professional Master

The cultivating objectives influence directly the college's cultivating quality of talents and the quality of a training program plays a fundamental role. In order to ensure the quality of Professional Master, our school referred to the Professional Master's cultivating plans of more than ten domestic famous universities as well as the ideas of engineering education in foreign colleges, proposed the guidance which is used to establish Professional Master's training program: establish the "student-centered" concept of modern education, set up international and leading consciousnesses, adapt to the needs of social development actively, locate the objectives and characteristics of different subjects scientifically. Professional Master's cultivating objectives should have international perspective; should be clear and accurate; ; should be practical, , measurable, and achievable; and it is required to embed cultivating objectives into training program's all links, especially the curriculum system part. For example, the professional master's cultivating objectives of "Material Engineering "in our school expressed as: This discipline cultivates engineering and technical talents in Materials science and engineering field who are high-level, professional, and suitable for new international requirements. Degree's winners should have a solid theoretical foundation in materials science and engineering, understand the development trend of the discipline, has the ability in engineering design and undertaking technical work independently, master the material synthesis and preparation techniques, material properties testing and analysis methods, and necessary calculated and experimental skills, have capabilities to develop new materials, new products, new processes, new equipment, meet the high-tech industry needs for high-level materials engineering personnel. Be able to use English skillfully to read specialized literature and to communicate with international peers. Have rigorous and realistic scientific attitude and innovative spirit, professional ethics.

2. Design Curriculum System for Professional Master's Degree

Teaching is the main way to acquire knowledge and is the basis for capacity-building. When designing the curriculum system for Professional Master's Degree, we focus on offering graduate students the ability to obtain professional knowledge, practical application, research creatively, and organization & communication skills. Based on the research of graduate courses of domestic and foreign universities, courses are classified as 4 types: basic knowledge in this field, engineering technology, the field frontier and interdisciplinary. Among them, basic knowledge courses in the field including science foundation knowledge & engineering foundation knowledge are mainly the basics of the discipline to supplement & update knowledge on the undergraduate level and improve graduates' theories level; engineering technology courses are professional knowledge what will help improve the practical skills , focusing on students' systematic thinking and ability to solve practical problems; frontier courses reflect the latest research achievements and development trends in order to strengthen students' understanding for frontiers, broaden their knowledge and enhance their technological innovative capacity; interdisciplinary courses required for the project are mainly knowledge of related areas, focusing on management, law, culture, humanities etc., in order to improve the overall quality and capacity. Courses are also classified as required and elective, each containing a corresponding course (see Figure 1).

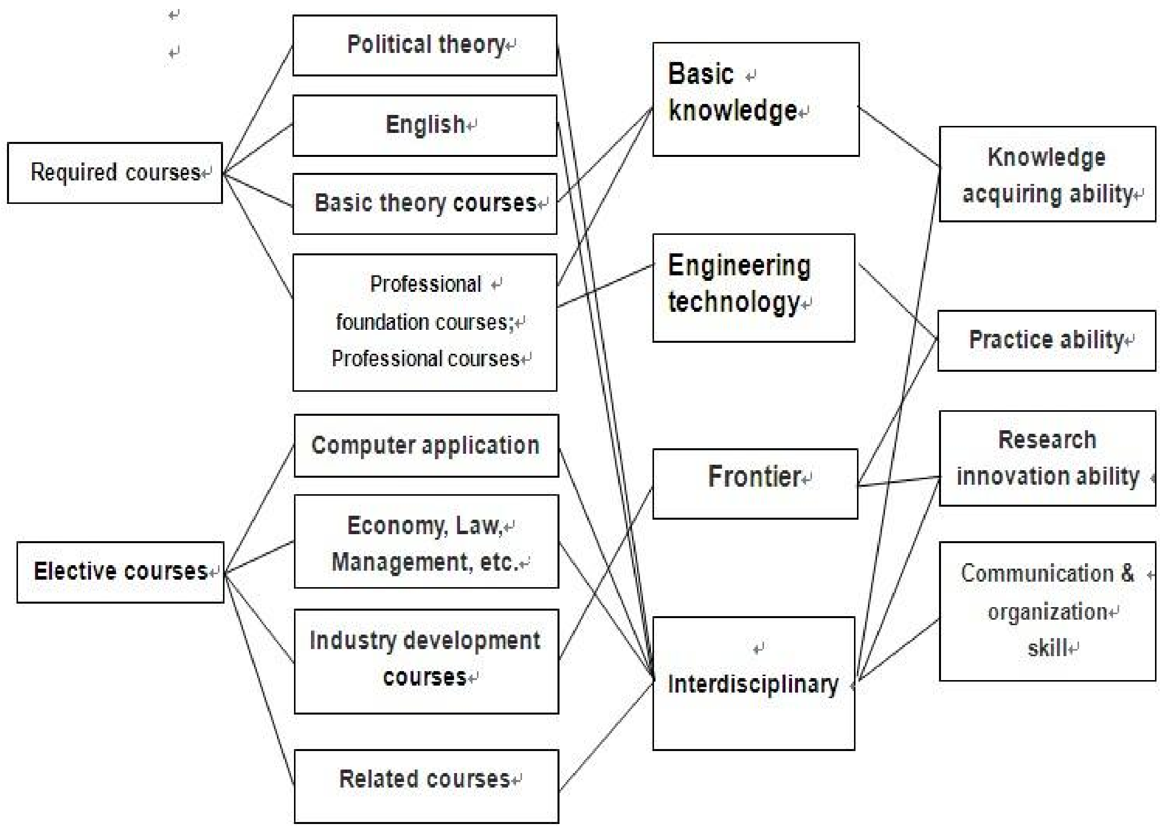

Figure1. Professional postgraduate course classification and ability relationship chart

Through the different categories of courses, we target to train graduate students to master the four abilities mentioned above. Required courses reflect the master-level core content in the subjective field, and the subject's characteristics of our school; elective courses fully reflect individual research needs of different research directions and different employment directions, also consider the needs of interdisciplinary or equivalent educational graduate for knowledge-docking. Total credits required are 34, in which required courses represents 14 credits, 41% of the total; elective courses represents 16 credits, 47% of the total and supplementary courses do not have credit; Practice counts 4 credits, 12% of the total. (See Table 1)

Table1: Materials Engineering Curriculum for Professional Master’s Degree

SN	Category	Course name	Credits	Notes
1	Field basic courses	Numerical analysis	2	Required
2		Materials science foundation	0	Supplementary
3		Modern material analysis testing techniques	3	Required
4		Solid State Physics	3	At least take 8 credits
5		Solid Chemistry	3	
6		Rubbery polymers physics	3	
7		Polymers synthetic chemistry	3	
8	Technology application courses	Advanced Organic Chemistry	3	
9		solid-state phase changes	3	
10		inorganic nonmetallic materials	3	
11		Material processing theory	3	
12		Elastic-Plastic Mechanics	3	
13		Electrolyte physics and electrolyte materials	3	At least take 8 credits
14		Functional Materials	3	
15		Resin Matrix Composite	3	
16		Combustion material science	3	
17		Material modifying and surface engineering	2	
18		Mold design theory and method	2	
19		thermodynamics of alloys	3	
20		Defect diffusion and sintering	2	
21		Plasma chemical and technology	3	
22	Field frontier courses	Materials interface science	3	
23		thin film technology	3	
24		Nano materials and physics	2	
25		Progress in Materials Science	2	
26	Interdisciplinary courses	Material science Computer Numerical Simulation	3	
27		Intellectual Property Law	1	
28		Material processing computer simulation and applications	2	
29		Review of literature retrieval	2	Required
30		Dialectics of nature and science and technology revolution	2	Required
31		Scientific socialism and the economy	1	Required
32		The first foreign language (English)	3	Required
33		Professional Foreign Language	1	Required

3. Build Platform for Practice, Train Professional Master's Conceiving and Designing Abilities

Restructuring of graduate education system further complicates the exiting diversified master's level graduate education, especially for the just started professional graduate education. We are actively exploring the potential environment which will be more favorable to their independent study and the development of their innovation abilities. Undoubtedly the background created by social, business and school together is the best environment for cultivating graduate's engineering comprehensive ability and innovative ability. In the process of building this environment, we tried to use the current available resources in our school as much as possible, we managed to break the restraints from the past concept of laboratory construction, utilization and management. We organically combined the advanced experimental equipments and software scattered at each lab through net and used the national lab rewarded by Education Ministry as the main body. In such a way, we created the open-share-lab, where each lab can run independently and can run in union. At present, some labs have already achieved the basic functions of remote experiment and have already gained certain achievements, such as the graduates open lab of intelligent control and decision of complex system based on net; the graduates open lab of digital information processing; the graduates open lab of design, simulation and test of spacecraft; the simulation lab of explosion science of technique, the graduates open lab of collection, transmission and processing of electronic information, the graduates open lab of design of new concept vehicle; the lab of environment engineering and science; the graduates open lab of management, decision and innovation; the graduates open lab of interaction art of digit and media; the graduates open lab of simulation and emulation of material; the virtual platform of real-time emersion of the process and flow of metallurgy.

Take Materials Simulation Laboratory of School of Material for example, it is mainly to train and increase the postgraduate's capacity in engineering, especially in terms of research for high-precision material processing simulation. Simulation platform is mainly composed of a local area network including server and terminals, and equipped with advanced software, such as material processing molding simulation software, material data calculation software, thermodynamic database, multiple phase diagram calculation software etc. Automatic security management systems are also installed for managing and controlling the use of computers. In materials simulation laboratory, graduate students research and develop new materials and research the control of microstructure and properties of materials in accordance with the material usage requirements, using knowledge of physics, chemistry, and materials science, computer simulation software and materials database. Reproducing complex material processing conditions through simulation on the computer at anytime, can help students get abundant data information for problem analysis and design optimization and avoid a lot of blind experiments. The laboratory has attracted a lot of graduates here to practice and learn autonomously, where they applied and tested their professional knowledge, practiced engineering operations, learned using powerful software to analyze and solve practical problems. Laboratory staff provides students with various services including detailed answers to questions, so that each participant is able to use the laboratory skillfully. In recent years, students have successfully completed a lot of researches here, many of which are national projects or cooperative projects with famous enterprises. More importantly, a large number of talents were trained here to master advanced science and technology and meet the demand of enterprises and the society.

For example, a Fresh professional master graduates of materials engineering, completed the courses excellently, selected solar cells material as research topic under the guidance of the instructor, researched the transformation efficiency of new materials using the advanced technology of the laboratory and found method significantly improving the efficiency of the new material through repeated simulation, analysis, demonstration in just two years. As a result, he signed a contract with a well-known enterprise before graduation. This is just one of many training cases of professional graduates. Many examples illustrate that students should start research projects as soon as possible. By a combination of instructor's guidance and a laboratory platform equipped with advanced technology, they would grow rapidly through the CDIO practice.

Meanwhile, we also strived to create a soft environment for students' development, including arranging a series of lectures; encouraging students to attend academic conferences; inviting domestic and foreign celebrities, the elite in famous enterprises, world-renowned scholars to do special reports on international political, military and economic tops, technological frontier and the latest trends. The purpose is to extend graduate students' international perspective. In addition, we arranged a series of activities such as quantitative reading, group discussions, oral reports in the training session, to train graduate students' critical thinking which is an important part for them. Some graduating students said: "In the days of getting my Professional Master's degree in BIT, I feel the monthly subject reports benefit me mostly, a lot of reading and the debates in seminars also benefited me deeply."

CONCLUSIONS

In 2009，Engineering Master Plan Enrollment of BIT is 310, covering 10 majors. This group of students that will graduate in July 2011 have overall achieved the training program's objectives. About 20% of them prepare to study for PhD in China or abroad, the other 80% of them prepare to start a career, and the signing rate achieved the average level of academic Master in previous years.

Based on the CDIO's idea and our understanding & practice, BIT formed a detailed training program for Professional Master, having the training objectives as a guide, the curriculum as core, including the process of training and evaluation requirements.

This article mainly focuses on BIT's practice to establish professional master's training program according to the CDIO's idea. However, because the cultivation of Professional Master is just beginning and have inevitable inertia with Academic Master Program, there are still lots of questions to be answered surrounding the cultivation of professional master, such as school-enterprise cooperation, the social practice, faculty construction, which will explore and research in the future.

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