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Characteristic Construction of Training Program against the Background of Engineering Education Professional Certification

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***Abstract*—Pharmaceutical engineering in Jilin Institute of Chemical Technology is the second in the three northeastern provinces and the first in Jilin province which has passed engineering education professional certification in China. This major conducted in-depth analysis and exploration of training program from talent training objectives, graduation requirements, course system based on the three core concepts of engineering education professional certification: "Outcome-Based Education, Student-Centered, Continuous Quality Improvement", and taken certification standards as the main line. The training program optimized and revised not only reflects the characteristics of pharmaceutical engineering, but also implements the engineering education professional certification standards into various teaching process, providing reference for the rapid improvement of quality of pharmaceutical engineering professionals.**

Keywords—engineering education professional certification; Student-Centered; Outcome-Based Education; Continuous Quality Improvement; training program

I. THE RESEARCH BACKGROUND

The cross-border movement of engineering and technical personnel has become more and more frequent in the context of global economic integration. It is imperative for engineering education internationalization, international recognition of engineer training and qualifications. Washington Accord has the highest visibility among the three international accord on engineering education certification. It has the earliest signing time and the largest number of States Parties, it is the most authoritative and influential, and it is an engineering education degree mutual recognition accord with the most complete system of four-year international undergraduate education. Its core content is that the training program of engineering major certified by each member state has substantial equivalence [1]. China officially became the 18th member of the Washington Accord on June 2, 2016. This important milestone marks the formal entry of China's engineering talent training into internationalization and standardization [2].

Engineering education professional certification is an indispensable part of "five-in-one" teaching quality evaluation system in the "Opinions on the evaluation of undergraduate teaching in ordinary colleges and universities" from the Ministry of Education of the People's Republic of China [3]. Its procedures and policies draw extensively on the practical experience of several official member states of the Washington Accord. The accreditation standards of Engineering Education in China are formulated by referring to the accreditation standards of ABET (Accreditation Board for Engineering and Technology) [4-5]. The three core concepts of engineering education professional certification are: "Student-Centered; Outcome-Based Education (OBE); Continuous Quality Improvement (CQI)"[6].

The Chinese version of "Pharmaceutical Industry 4.0" - "Made in China 2025", is not only the program of action of the Chinese Government for the first decade of implementing the strategy of manufacturing power , but also the action goal and program to guide the intelligent transformation and upgrading of China's pharmaceutical industry [7]. During the process of developing into a powerful country of manufacturing even a powerful country of creation, China needs high-quality technical engineering talents with international competitiveness as a guarantee. In order to meet the needs of the above-mentioned talent training, pharmaceutical engineering in Jilin Institute of Chemical Technology actively applied for engineering education professional certification in November 2016 , and passed the certification in January 2018. In order to improve the quality of personnel training continuously and ensure the continuous and healthy development of the major, the training program was optimized and revised.

II. REVISION OF THE TRAINING PROGRAM FOR PHARMACEUTICAL ENGINEERING

A. Establishment of Talent Training Objectives

OBE refers to the goal of teaching design and implementation is the learning outcomes that students receive after four years of undergraduate study [8]. That is to say, talent training objectives were established guiding by demands of social and industry. Then raise graduation requirements according to training objectives. Finally, build a course system to supports achievement of graduation requirements. Demands are both the starting point and the end point for implementation,

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ensuring a high level of consistency between talent training objectives and learning outcomes. The engineering education professional certification advocates OBE concept throughout the whole process of talent training [9].

Evaluating the quality of students trained in schools needs to draw on the opinions of employers and graduates. So this major revised talent training objectives not only based on convening symposium on employers, symposium on graduates and Teaching Committee(including pharmaceutical companies and industry experts)working conference aiming at the operation of training programs, but also combined the demands of innovation of science and technology, economic development and social progress in China and Jilin Province.

The talent training objectives of this major covers three levels: basic, middle and top objectives. Basic objectives: The all-round development of morality, intelligence, physique, beauty and labor, in other words, mental health, has a healthy body, good professional ethics, social responsibility, and aesthetic taste, that is to be a citizen of good quality. Middle-level objectives: Have solid theoretical foundation and ability to discover, analyze, and solve complex engineering problems in pharmaceutical process using engineering knowledge and expertise. The graduates can engaged in engineering design, product development, production operation and management, etc. in production enterprises, research institutes, design institutes and management departments in medicine and related fields, that is to become a useful person to society. Top-level objectives: Have strong practical ability, innovative spirit and entrepreneurial awareness. Have ability to adapt to an independent team work environment and adapt to career development through life-long learning. The graduates can have workplace competitiveness in pharmaceutical industry and become a modern engineers and managers facing the front line of production and management five years after graduation, that is to become the pillars of society.

B. Formulation of Graduation Requirements

This major proposed graduation requirements from the aspects of quality, knowledge and ability under the guidance of training objectives, according to the accreditation standards of engineering education, combined with features of this major and demands of social. These requirements fully cover 12 items competency requirements in the Engineering Education Professional Certification Standards, including 5 technical abilities requirements, 4 non-technical abilities requirements, 3 requirements for the fusion of technical and non-technical abilities [10].

1) Technical Abilities

a) Engineering knowledge: Ability to apply mathematics, natural sciences, engineering fundamentals and expertise to solve complex engineering problems in pharmaceutical process.

b) Using modern tools: Ability to develop, select and use appropriate technologies, resources, information technology tools and modern engineering tools to solve complex engineering problems in pharmaceutical process. Including prediction and simulation of these problems, understanding the limitations of them.

c) Design/Development Solution: Ability to design the solutions to complex engineering problems in pharmaceutical process. Designing unit equipment , technological process and control systems which meet the actual production of pharmaceuticals. Designing process can reflect the sense of innovation and consider social, healthy, safe, legal, cultural and environmental factors at the same time.

d) Problem analysis: Ability to use the basic principles of natural science, mathematics and engineering to identify and explain complex engineering problems in pharmaceutical process. Ability to obtain effective conclusions of these problems through research and analysis of Chinese and foreign literature.

e) Research: Ability to research complex engineering problems in pharmaceutical process based on scientific principles and scientific methods, including design and implementation of experiments, analysis and interpretation of experimental data and attainment of reasonable and effective conclusions based on the comprehensive information obtained.

2) Non-technical abilities

a) Communication: Ability to communicate with the public and industry peers on complex engineering problems in pharmaceutical process effectively. It includes writing reports, designing manuscripts, presenting statements, expressing and responding to instructions clearly. Have a certain international perspective, be able to communicate in a cross-cultural context.

b) Professional norms: Have humanities and social sciences accomplishment and sense of social responsibility. Be able to understand and comply with engineering ethics and norms in the engineering practice of the pharmaceutical industry.

c) Life-long learning: Be positive and initiative in self-learning and self-development, be able to learn consistently to adapt to the development of science and society.

d) Individual and team: Ability to take on the roles of individuals, team members and leaders in a multidisciplinary team.

3) Requirements for the fusion of technical and non-technical abilities

a) Engineering and Society: Ability to analyze and evaluate the impact of pharmaceutical engineering practices and solutions to complex engineering problems in pharmaceutical process on safety, health, law, society, and culture based on the background knowledge of pharmaceutical engineering reasonably. Ability to define the responsibilities to be undertaken clearly.

b) Project Management: Understand and master the principles of engineering management and economic decision-making in the pharmaceutical industry, and apply them in a multidisciplinary environment.

c) Environment and Sustainable Development: Ability to understand and evaluate the impact of engineering practices

of complex engineering problems in pharmaceutical process on sustainability of environment and society.

C. Construction of the Course System

The achievement of graduation requirements and the realization of talent training objectives must rely on the course system to support. Therefore, it is essential to build a scientific and rational course system to achieve the expected learning outcomes keeping up with the development of cutting-edge technology in the pharmaceutical industry.

1) Decomposition of graduation requirements indicator points

Graduation requirements are requirements for the learning outcomes that students should achieve when they graduate. Their description form is abstract and difficult to evaluate, so it is necessary to refine it into specific indicator points that can arrange the teaching content and measure. Based on condensing the features of this major , and combining with the requirements of the training objectives, the 12 abilities required for training were decomposed one by one, totally decomposed into 33 observable and measurable indicator points. For example, the technical ability requirement d) was decomposed into three indicator points:①Ability to apply basic concepts of mathematics and natural science to appropriate representation of complex engineering problems in pharmaceutical process; ② The best solution can be selected from the numerous solutions of a complex system by researching and analyzing relevant literature; ③A solution to an engineering problem can be described accurately in technical terms. The basic principles of engineering can be used to analyze the influencing factors of the engineering practice process and to confirm the rationality of the solution.

2) Establishment of relevance matrix between course and graduation requirements

In order to help teachers to choose content according to the purpose of teaching scientifically, and to arrange effective assessment methods to ensure that all graduates meet the graduation standards, it is necessary to establish the correspondence between graduation requirements indicator points and the course, to establish a clear mapping relationship between graduation requirements and course system, to embody it with reasonable graduation ability support matrix (as shown in Table I). Take technical ability requirement d) as the example, the corresponding course for indicator points①,②,③ are Linear Algebra, Advanced Mathematics, Probability Theory and Mathematical Statistics, Organic Chemistry; Research and Development of New Drugs, Pharmaceutical Technology, Information Retrieval; Principles of Chemical Engineering, Principles of Chemical Engineering Experiment, Pharmaceutical Separation Engineering, Graduation Design (Thesis), respectively.

TABLE I. MAPPING RELATIONSHIP BETWEEN GRADUATION REQUIREMENT AND COURSE SYSTEM

Serial Number	Name of Course	Technical Abilities							Non-technical Abilities				Requirements for the Fusion of Technical and Non-technical Abilities		
		a)	b)	c)	d)			e)	a)	b)	c)	d)	a)	b)	c)
					①	②	③								
1	course1				H										
2	course2					M									
3	course3						L								
…	…														

a. Note: Supporting strength of course to indicator points is expressed by the letters H (high), M (middle), and L (low).

b. The support intensity of each course is positively correlated with the contribution of the teaching content to the support of each indicator point.

3) Structure of the course system

Course system was structured based on taking the cultivation of application innovation ability as the main line, focusing on the formation of engineering thinking, strengthening the cultivation of engineering practice ability, cultivating the spirit of innovation. This systems consists of six courses modules: Basic Course of Humanities and Social Science, Basic Course of Mathematics and Natural Science, Basic Course of Engineering and Specialty, Specialized Course, Practice of Basic Course, Engineering Practices and Graduation Design Thesis). The theoretical and practical course structure is scientific and reasonable. Proportion of compulsory course and elective course is moderate. The course modules connected each other organically, courses docked one another seamlessly.

Each course module in the course system has a distinct role. Basic Course of Humanities and Social Science, Basic Course of Mathematics and Natural Science focus on cultivating students' humanistic literacy, scientific thinking, professional ethics, as well as skills of communication and presentation, mainly supporting engineering knowledge, individual and team, professional norms and communication in graduation requirements. Basic Course of Engineering and Specialty focuses on cultivating students' basic engineering skills and strong adaptability, mainly supports engineering knowledge, problem analysis, research in graduation requirements. Specialized Course focus on developing students' ability to solve engineering practice problems, mainly supporting engineering knowledge, using modern tools, environment and sustainable development, project management, problem analysis, design/development solution, life-long learning in graduation requirements. In addition, each practical course cultivates students' ability to research and innovation, adaptability and team work, primarily supporting research, engineering and society, communication, individual and team and life-long learning in graduation requirements.

III. CHARACTERISTICS OF THE TRAINING PROGRAM FOR PHARMACEUTICAL ENGINEERING

Pharmaceutical engineering training program optimized and revised in this paper has distinctive characteristics.

A. Constructed a Course System of "One Platform, Two Systems"

This major constructed the course system with the guidance of subject logic and technical logic, taking comprehensive quality as the platform. It not only ensures the integrity of the subject knowledge system, but also guarantees the integrity of the professional technical knowledge system. It fully embodies the guiding theory of solid basic theoretical knowledge and complete professional knowledge coverage.

B. Pay Attention to the Cultivation of Students' Engineering Practice Ability and Innovation Ability

The formation of students' engineering practice and innovation ability must be carried out throughout the training process, and the ability to innovate is cultivated in the practical teaching process. Under the guidance of the educational thought of "Strengthening Practice and Emphasizing Innovation", this major adheres to the certification concept of "Student-Centered", pays attention to the cultivation of students' scientific thinking and innovation ability, and constructs a progressive practical teaching system of "Basic Experiment → Professional Experiment → Engineering Training → Graduation Design (Thesis)". From the shallower to the deeper, this major will cultivate students' engineering practice ability, ability to solve complex engineering problems in pharmaceutical process and ability to innovate. Practice training continuous four years without interruption really.

The cultivation of ability and quality can be realized on the one hand through the course system constructed by the training program, on the other hand, it can be realized by carrying out a second classroom and creating a campus environment. First of all, give full play to the advantages of blending water and milk between schools and enterprises, and cultivate students' application ability under the model of "School-Enterprise Cooperation in Running Schools" and "Enterprise Tutorial System". For example, hiring enterprise engineers to teach theory class with strong engineering skills or bring students to the enterprise to do graduate design in engineering projects or in actual production. Secondly, guide students to participate in the second classroom project such as social practice and career development during the winter and summer vacations actively. Finally, organize scientific and technological innovation activities as much as possible. For example, encourage students with innovative potential to enter the "Master's Tutor's Research Office" in their sophomore or junior year, so as to lay a solid foundation for participating in the "Pharmaceutical Forum", "Challenge Cup National College Students Series Science and Technology Academic Competition" as well as other scientific and technological innovation activities.

C. Continuous Learning in English

Four-year uninterrupted way of maintaining English study is set in the course system to ensure that students master a foreign language and be able to read the foreign language literature related to this major. Student learn the basics of college English and strive to pass the English 4th and 6th exams from the first to fourth semester. Course of "Foreign language reading in science and technology" and professional bilingual are set up from the fifth to seventh semester. Foreign language learning is integrated into Graduation Design (Thesis) in the eighth semester.

IV. CONCLUSION

The training program plays a guiding role in improving the quality of personnel training. The pharmaceutical engineering in Jilin Institute of Chemical Technology will adhere to the certification concept of "Continuous Quality Improvement" to perfect the open and dynamic system of training programs gradually. Quality of teaching will be continuously improved under the guidance of this programmatic document. This major will cultivate internationalized modern engineers and managers facing the front line of production and management, who understand pharmacy, chemistry and engineering applications.

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