

# Research on the Educational and Training Model of Excellent Engineers for Applied Undergraduates Oriented to New Engineering

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**Abstract**—The construction of the new engineering department is an advanced direction for the development and reform of Higher Engineering Education in China. It aims to cultivate excellent engineering talents facing the industry, the world and the future. University of Jinan Quancheng College takes the construction of new engineering as its foothold and strengthens the construction of mechanical specialty in the light of industry 4.0. It focuses on the practice and exploration of the training mode, curriculum system and training scheme of the specialty. Its experience can be used as a reference for the specialty construction of Applied Undergraduate colleges.

**Keywords**—new engineering, excellent engineer, training mode, applied undergraduate

## I. INTRODUCTION

The machinery industry is a “changing world” industry, a pillar industry of the national economy, the backbone of the manufacturing industry, and a strong foundation for national economic transformation and development and the realization of “one belt and one road”. With “Made in China 2025” as the main symbol, China manufacturing powers have accelerated their progress, and eight strategic emerging industries have developed rapidly. However, the talent gap in manufacturing industry is very large. By 2020, the talent gap in the new generation of information technology industry will reach 7.5 million people, 4.1 million people in the power equipment industry, and about 3 million people in the new material industry, high-end CNC machine tool industry and robot industry, respectively [1]. The reform and development of higher engineering education must adapt to the development of national economy and major strategic decisions such as “Made in China 2025”. Since February 18, 2017, the development of Higher Engineering Education in China has gone through three parts: Fudan Consensus, Tianda Action and Beijing Guide. From Fudan Consensus, Tianda Action to Beijing Guide marks a new stage in the reform of higher engineering education with the theme of new engineering construction[2]. The development of the country has put forward new and higher requirements for the training of Engineering talents, which require the construction of new disciplines facing industry, the world and the future[3]. The proposal of the new discipline is based on the

comprehensive recognition of the times, social needs, the current situation of engineering education and the development law of Engineering discipline [4].

## II. PROBLEMS IN HIGHER ENGINEERING EDUCATION

### A. Neglect Individuality Education

In recent years, the expansion of college enrollment has solved many social hot issues, which is an undoubted advantage, but it can not deny its drawbacks. With the expansion of enrollment in colleges and universities, undergraduate training programs have changed to a certain extent. The same training program is adopted for the same major, ignoring the individual advantages of students and failing to teach students in accordance with their aptitude. Graduates under the same training mode have a solid foundation and extensive knowledge, but lack the ability of scientific research innovation and engineering practice [5]. The implementation of the training program for outstanding engineers is a bold reform and attempt in Higher Education in China. By setting up “small class” experimental class teaching, teachers can better achieve teaching monitoring and teach students in accordance with their aptitude.

### B. Emphasis on Theory and Practice

Talents training program pays attention to theory teaching, students spend most of their time in basic professional courses, and seldom touch with production practice. Their thinking and innovative activities have been limited, which hinders students' initiative to innovate and the development of the industry is not prospective enough.

Despise practical teaching links, such as “Modern Enterprise Management” as a practical course, most colleges and universities still use theoretical teaching methods. It is difficult to participate in the production management of modern enterprises, and most of them talk about soldiers on paper directly. Some practical teaching links in colleges and universities mainly focus on curriculum design, metalworking practice and enterprise visiting practice, and can not directly participate in enterprise production.

### III. CONSTRUCTION OF TALENTS TRAINING MODEL FOR NEW SUBJECTS

For the needs of industries and enterprises, we should strive to explore a new talent training mode with the core of highlighting engineering practice ability. Pay attention to the structure of learning seedlings and carry out the individualized training of small class teaching to cultivate excellent technical and excellent innovative talents. We should pay special attention to the cultivation of lifelong learning ability.

#### A. *Excellent Technical Talents*

Excellent technical talents with the practical ability of technology application and innovation have been cultivated in the mechanical industry. Proficient in basic professional knowledge, digital manufacturing, industrial robots and the use of mainstream machinery and equipment. Through professional qualification certification oriented to industry and enterprise standards, we can familiarize ourselves with and understand the basic knowledge and basic technology of machinery industry and its cross-industry.

#### B. *Excellent Innovative Talents*

Through scientific and technological innovation laboratories and various innovative science and technology competitions, such as the Challenge Cup and the University Students' Science and Technology Innovation Competition, we can further train new engineering talents facing new disciplines to master the frontier dynamics and to complete scientific research.

### IV. COURSE SYSTEM CONSTRUCTION FOR NEW ENGINEERING

With the development needs of industries and enterprises, we should build up the knowledge, ability and quality requirements of personnel training. To cultivate knowledge, practice application and technology development as the core, lifelong learning ability as the goal, and engineer professional ethics as the core. Adhering to the concept of "123" talent training, we should construct the structure of knowledge, ability and quality, that is, taking engineering practical ability as a main line, taking machinery and electricity as two supports, and taking three professional directions of machinery manufacturing and automation, electrical engineering and automation, and robot application as three modules to establish a new talent training curriculum system.

In the course system, we should strengthen the training of engineering practice ability, mainly through engineering practice training and second classroom education. Engineering practice training includes four parts: experiment, practice, training and curriculum design. Engineering practice focuses on the development of design and comprehensive engineering practice projects, and on the comprehensive training of advanced manufacturing and modern engineering; Secondary classroom education makes

full use of innovation platform to develop competition-driven innovation ability, promote learning by competition and replace examination by competition, and focus on strengthening various activities for the development needs of industries and enterprises, so as to cultivate innovation consciousness and vocational development ability.

Strengthen the joint training of schools and enterprises, keep track of the suggestions of graduates and enterprises on the training program, which takes engineering application as the main line, and construct curriculum system according to knowledge module. New technology should be added to the talent training program, and knowledge application should be emphasized. For example, the traditional "Machining Technology", "Metal Cutting Machine Tool" and "Metal Cutting Principles and Tools" are merged into "Fundamentals of Mechanical Manufacturing Technology"; Setting up new courses reflecting current manufacturing technology characteristics, such as "CATIA", "Solid works", "CAXA-ME", etc. Setting up comprehensive and applied courses, such as "CNC Technology" and combining advanced CNC professional qualification certification.

Cooperate with society, industry, enterprises and institutions to build practice and training bases, consolidate and develop existing school-enterprise cooperation and training bases, and add robotics training bases for new subjects to meet the needs of technical cooperation, post practice and curriculum development actively .

Construct four levels of basic practice teaching platform, namely "experimental teaching, practice teaching, practice teaching, curriculum design teaching" and the second classroom science and technology innovation practice platform. Among them, the experimental teaching platform consists of professional laboratories, such as hydraulic and pneumatic transmission laboratory, tolerance and technical measurement laboratory, sensing and testing laboratory, CAD/CAM laboratory, modern manufacturing technology laboratory and other 30 professional laboratories; Practice teaching platform is composed of more than 20 school-enterprise cooperation units, which can carry out post practice, production-university-research cooperation teaching; The training and teaching platform is undertaken by the school engineering training center; The teaching platform of curriculum design is composed of two parts: school and enterprise. The project-driven method is adopted to cultivate double-tutor system; The second classroom science and technology innovation practice platform is composed of science and technology innovation laboratories, focusing on the competition-driven science and technology innovation activities.

### V. TRAINING SCHEME OF "EXCELLENCE PLAN" FOR MECHANICAL SPECIALTY

The training of "Excellence Plan" adheres to the training concept of "trinity", takes imparting knowledge as the basis, cultivating ability as the core, and forming quality as the purpose, so as to build the knowledge, ability and quality structure of personnel training. It is necessary to develop

engineering knowledge, engineering ability and engineering quality in a balanced and all-round way, and optimize the knowledge system so as to improve the training quality of "Excellence Plan" in an all-round way.

Engineering knowledge: including humanities and social science knowledge, natural Science knowledge, professional basic knowledge, professional knowledge and engineering technology knowledge, to establish a systematic and solid knowledge system. Starting from the cultivation of engineering ability, we should establish a professional branch structure and increase the study of basic theory and professional theory in similar professional directions. Based on "Industry 4.0", intelligent manufacturing is realized. The knowledge structure is divided into mechanical manufacturing direction, mechanical and electronic direction, robot use and maintenance direction.

Engineering ability: including engineering practice ability, innovation ability and career development ability. Ability training is mainly through engineering practice training and second classroom education. Engineering training mainly includes three parts: experiment, practice and practical training. The development of engineering practice training should be dominated by teachers, assisted by students' participation, based on students' hands-on, assisted by teachers' guidance, focusing on the development of design and comprehensive engineering practice training, focusing on the comprehensive training of advanced manufacturing and modern engineering; Secondary classroom education makes full use of innovation platform to develop competition-driven innovation ability, promote learning by competition and replace examination by competition, and focus on strengthening various activities for the development needs of industries and enterprises, so as to cultivate innovation consciousness and vocational development ability.

Engineering quality: including ideological and political quality, professional quality. In engineering practice, the application of professional knowledge and the exertion of skills are often closely related to the physical and mental quality, sense of responsibility and moral sense of professionals.

The following characteristics are reflected in the implementation of the "Excellence Plan" for mechanical design, manufacturing and Automation Specialty in our institute.

#### A. "3+1" Training Model

The whole training stage is divided into two stages: in-school learning and enterprise learning. "3" is a three-year theoretical learning stage, and "1" is a one-year practical learning in which enterprises are deeply involved. The "3+1" training mode breaks the traditional teaching order and implements the teaching mode of "2.5+0.5+0.5+0.5". Namely: 1-5 semester (2.5) in school to learn public theoretical knowledge; The sixth semester (0.5) carries on the production practice, the practical training, the

curriculum design in the enterprise; The seventh semester (0.5) will go back to school to expand professional knowledge; The eighth semester (0.5) is to carry out project-driven graduation internship and graduation design in enterprises.

#### B. "Double Certificate" Training Model

For the needs of employment and industry enterprises, the implementation of "double certificate" have been trained, that is, when students graduate, not only the corresponding graduation certificate, degree certificate are obtained, but also vocational qualification certification for the industry training and the corresponding vocational qualification certificate are obtained.

#### C. Innovative Education

Based on the competition-driven cultivation of College Students' innovative ability, competition promotes learning and replaces examination, making full use of various types of innovative science and technology competitions, and obtaining corresponding credits according to the results of the competitions.

#### D. Training of "Double Tutor"

Knowledge needs to be consolidated in practice, ability needs to be exercised in practice, and quality needs to be improved in practice. The practice links of experiment, practice and training in our institute include the establishment of a tutor team by enterprises and schools, and the implementation of the "double tutor" system. In principle, the title of "enterprise mentor" is senior engineer and above.

#### E. Focusing on the Training of Engineering Ability

Taking the requirement of students' ability training as the basic starting point, integrating the training system of students' knowledge, ability and quality, optimizing the teaching content and reconstructing the curriculum system, finally meet the requirements of "Excellence Program" for students' ability training.

The whole training plan consists of theoretical study and practical study. In addition to general education courses, theoretical learning courses mainly include basic engineering knowledge courses, basic engineering technology courses, engineering technology orientation courses and optional engineering technology courses. Table 1 shows the distribution of hours and credits.

In practice teaching, the introduction of Engineering background, the use of "double mentors" co-guidance, taking enterprise production cases as a typical example, to truly achieve "learning by doing". Table 2 shows the distribution of hours and credits in practice.

**TABLE I. SCHEDULE OF HOURS AND CREDITS FOR THEORETICAL LEARNING**

<i>Course category</i>	<i>Credit</i>	<i>Hours</i>	<i>Proportion</i>
Humanities and Social Sciences	11.5	240	6.8
Natural Science Foundation	22	368	13
Foundation of Quality and Ability	30.5	512	19.9
General Education Elective Course	9	144	5.3
Engineering Knowledge Base	17	272	10
Engineering Technology Foundation	13	216	8
Engineering Technology Direction	6	96	3.6
Selection of Engineering Technology	5	80	3
Centralized Practice Course	52	52 weeks	30.4
Graduation Requirements	166	1928+52 weeks	100

**TABLE II. SCHEDULE OF HOURS AND CREDITS FOR PRACTICAL LEARNING**

<i>Course category</i>	<i>Credit</i>	<i>Weeks</i>
Military Training	2.0	2.0
Cognition Practice	1.0	1.0
Mechanical Drawing Operation	1.0	1.0
Metalworking Practice	4.0	4.0
Electronic Practice	1.0	1.0
Comprehensive Course Design of Mechanical Principles	2.0	2.0
Mechanical Design Engineering Practice	2.5	2.5
Innovative Design of Mechanical and Electrical Products (I)	1.0	1.0
Course Design of Electronic Technology	1.0	1.0
Engineering Practice of Advanced Vocational Skills (I)	3.0	3.0
Comprehensive Course Design of Machinery Manufacturing	2.5	2.5
Mechanical Manufacturing Engineering Practice	2.0	2.0
Engineering Practice of Mechanical and Electrical Systems	2.0	2.0
Innovative Design of Mechanical and Electrical Products (II)	2.0	2.0
Production Practice	4.0	4.0
Engineering Practice of Professional Direction	2.0	2.0
Advanced Vocational Skills Engineering Practice (II)	3.0	3.0
Graduation Practice	5.0	5.0
Graduation Project	11.0	11.0
Total	52.0	52.0

## VI. CONCLUSION

Facing the construction of new subjects, a new training plan has been a new training plan, three professional directions including mechanical manufacturing and automation, mechanical and electronic engineering, robotics technology and application have also been set up. To strengthen the construction of teaching staff as the key, to cultivate high-quality application-oriented professionals as the orientation, to meet the needs of enterprises and industries, to optimize the curriculum system reform as the core, and to strengthen students' practical teaching as the support. After years of exploration and construction, we have made some achievements in professional development, teaching and scientific research achievements, teachers' team building, practical teaching and students' employment capacity building, and gradually formed a "three solid and one strong" (solid foundation, simple style, solid work, strong practical ability) talent training characteristics.

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