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The Cultivation Mechanism of Engineering Talents Based on Emerging Engineering Education for Local and Comprehensive Universities -A Case of Qinghai University

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***Abstract*-New industry and its new types, leading by the new round technological revolution, promote the reform and innovation of higher engineering education. The basic features of new industry types and the evolution of discipline are introduced to understand the emerging engineering education, the connotation of emerging engineering education and the key competencies of new engineering talents are clarified. Considering the industry characteristics of western regions, the local and comprehensive universities like Qinghai University are provided to a developing path, which means that the universities should create the unique feather according to the local competitive industries. The combined dynamic and static thinking is presented to optimize the disciplinary layout and construct the corresponding course system, which are affected by the new industry types and requirements of local industries. Finally, the suggestions are put forward to developing the emerging engineering education for the western comprehensive universities.**

Keywords-emerging engineering, engineering talents cultivation, local and comprehensive universities, western universities, Qinghai University

I. INTRODUCTION

Major national strategies, including Made in China 2025, Internet + and Innovation-Driven Development, have promoted the development of new business forms and new economy. New requirements are put forward for engineering science and technology talents [1]. In order to meet the needs of engineering talents and promote the reform and innovation of higher engineering education, the ministry of education has held conferences in Fudan University and Tianjin University, and reached the "Fudan Consensus" and "new engineering" construction action line ("Tianda action ") [2]. Xia Jianguo, Lu Guodong, Shi Xiaoqiu, Zhong Denghua and others provided the corresponding ideas and suggestions for the construction of new engineering in comprehensive and local universities in developed areas from different perspectives [2-5]. The emerging engineering education provides a historic developing opportunity for the western universities and colleges. However, it is lack of experiences to implement the education and teaching reform for the local comprehensive universities, especially the universities in the western region. It is essential to construct the new curriculum system and disciplinary layout for adapting the new technology and industries. The dynamic-static curriculum system and dynamic disciplinary layout are presented to combine the local comprehensive universities with the local industries.

This paper is organized as follows. In section 2, the new industry types and the evolution of discipline are analyzed, and the core qualities and ability requirements of new engineering talents are explained. In section 3, the emerging engineering education is introduced briefly. On this basis, the dynamic-static talent training mechanism is provided for the local comprehensive universities in section 4. Finally, some thinking and suggestions are provided to improve the education reform in the local comprehensive universities, especially in the western universities.

II. NEW INDUSTRY TYPES AND EVOLUTION OF DISCIPLINE

A. Feathers of New Industry Types

With the development of big data, cloud computing and internet of things, the new industry types generate from the manufacturing and engineering activities. Compared to the traditional industries, the new industries have the following characteristics.

Technology integration. Information technology, biological technology and intelligent technology interact with each other and influence the engineering field, so that different industrial technologies are integrated organically, which forms many new products and services across the boundaries of traditional industries. For example, the deep intersection and integration of manufacturing technology, information technology and biotechnology has given birth to the bio-manufacturing discipline serving the medical field [6]. The technology integration provides new chances for the traditional engineering field, and brings new changes to the industry.

Manufacturing intelligence. The deep integration of information technology, digital technology and manufacturing industry leads the deep reform of manufacturing mode. In the manufacturing system, the smart equipment, smart factory and smart product have become the trend. The enterprises are developing towards networking, flattening and virtualization, and the product mode is also developing towards personalization and service. Therefore, all countries have taken the intelligent transformation as the key to the future strategy of the manufacturing industry. In particular, made in China 2025 takes the integration of industrialization and information as the breakthrough and intelligent manufacturing as the main direction [7].

Personalized service. Technological progress and consumer demand have transformed product manufacturing from large-scale to customization and shortened the life cycle of product. The engineering is bound to change from traditional intensification and large-scale to global distribution and deep personalization, which brings about changes in engineering design thinking, manufacturing process and product logistics [8]. Big data technology enables enterprises to understand the consumer demands, provide technical support for the optimizing production efficiency and the personalized services to meet different customers.

Morphological diversity. The new manufacturing industry based on big data, artificial intelligence, robotics, mobile internet and cloud computing has led to the disruption of traditional industrial forms, division of labor and organization. Manufacturing has become a cross-regional, cross-industry and cross-cultural activity form. The manufacturing participants will also need a more macro thinking mode, broader humanistic feelings and social collaboration. The resulted changes in the system and management mode have a more diversified impact on human society.

B. Evolution of Discipline

From the perspective of the history of discipline evolution, it shows the logic of "synthesis - differentiation - synthesis". Take the evolution of mechanical engineering (ME) as an example shown in Figure 1 to illustrate the logic of discipline evolution.

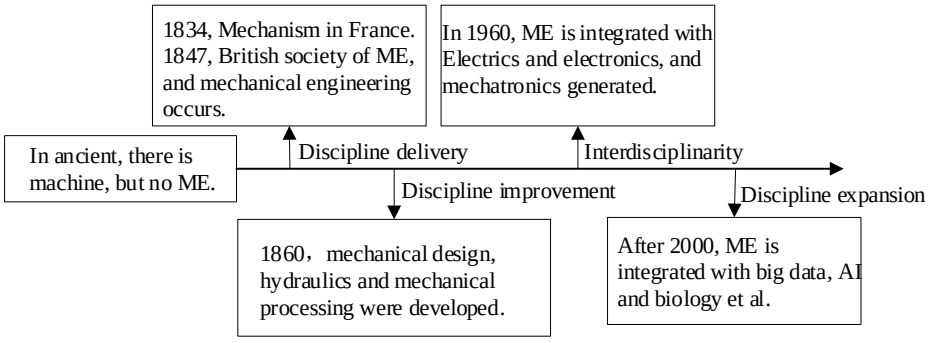

Figure 1. Evolution of Mechanical Engineering

Before the 13th century, various disciplines were collectively called philosophy, and there was no ME discipline. After the 17th century, physics, chemistry and biology gradually became independent disciplines from natural philosophy [5]. With the industrial revolution and technological development, ME was gradually promoted to an independent discipline, and its landmark event was the establishment of British society of mechanical engineers in 1847. In the middle of the 19th century, the age of electricity increased the demand for precision machinery. The mechanical engineering developed to high speed, precision, lightweight and automation, the mathematics and physics is injected widely into the ME research and engineering. Then, the secondary branch formed, including mechanical design, hydraulic transmission, mechanical strength, mechanical manufacturing. After World War II, the integration of electronics and ME formed the new branch of mechatronics in Japan [9]. At present and in future, ME will be integrated with big data, artificial intelligence, biotechnology and other disciplines, and the branches of ME will generate.

The evolution history of ME includes four evolution stages of discipline delivery, discipline promotion, discipline interdisciplinary and discipline extension. In this process of ME evolution, interdisciplinary is the main line. The

development of ME also reflects the close relationship between science, technology, engineering and mathematics, which becomes closer as the demand complexity increases, and finally makes the discipline tend to be integrated.

The evolution of science tends to be comprehensive, which is the internal driving force of discipline integration. The new industry types also provide the external driving force for the discipline integration. In order to break down the disciplinary barrier, the famous universities in Europe and America are actively promoting the interdisciplinary, integration and development. For example, University of Pennsylvania established Center for Bioinformatics and Cognitive Neuroscience Research Center to promote the intersection and integration of medicine, science and sociology [10]. In addition to the consensus reached by universities, the National Science Foundation of America, the Department of Defense and the National Aeronautics and Space Administration all provide research funding support for universities and promote interdisciplinary and interdisciplinary research [11]. The US government also puts forward the talent-training program of Science, Technology, Engineering, and Mathematics (STEM).

Emerging engineering education is an inevitable choice that conforms to the development law of engineering discipline and new industry types. Emerging engineering education provides new ideas for the contradiction between the current engineering education supply and the demand of economic and social development. For adapting emerging engineering education, it is necessary to change the traditional educational concept, to promote the interdisciplinary, to build a curriculum system integrating general and professional education, and to build a multi-dimensional and spatial-temporal talent training mechanism [12].

III. EMERGING ENGINEERING EDUCATION

Emerging engineering education is a Chinese model of engineering education when China's economic development has entered a new normal and higher education has entered a new stage. The emerging engineering education includes two aspects, namely the new engineering specialty and the new requirement of engineering education. The proposal of emerging engineering education is not only the result of the higher education adapting to the development of new technology, new industry and new economy and reflecting on engineering education, but also the embodiment of new industry types and evolution of discipline. Emerging engineering education is a new concept of engineering education proposed in the critical period when China's economy is moving towards the medium-high level, and it is an important guarantee to achieve the strategic goal of Made in China 2025. Emerging engineering education explores the new engineering paradigm for facing the changes and shaping the future. It also integrates the engineering with other disciplines, generates the new cross disciplines, and constructs the new structure of engineering specialty. The latest industrial development and technology are brought into the teaching processes, and the knowledge system of engineering talents is updated. The emerging engineering education promotes the close combination of industry, university, research and application, accelerates the transformation and application of scientific and technological achievements. We should open up and integrate engineering education into a new ecology, and enhance the international competitiveness of engineering education in China.

Tianda Action clearly puts forward the goal of new engineering. The emerging engineering education could bring up a large number of diversified, innovative and excellent engineering talents, and provide intellectual and talent support for the international competition of China's industries. The emerging engineering education also emphasizes the four core qualities, including humanistic quality, innovative thinking, specialty learning and communication abilities. The specific ability requirements are shown in Table 1.

TABLE 1. THE CORE QUALITIES OF TIANDA ACTION

Classifications of core qualities	Index of ability
Humanistic quality	National feelings, global vision, legal and ecological consciousness
Innovative thinking	Design thinking, critical thinking and Innovative undertaking
Specialty learning	Interdisciplinary integration, engineering thinking, digital thinking, independent lifelong learning ability
Communication ability	Communication skills, engineering leadership

The emerging engineering education provides a favorable opportunity for universities to promote the reform of engineering education. The comprehensive universities could take their own advantages, and carry out the international frontier and national major scientific research. The local colleges and universities should find the right position base on the regional advantageous industries, connect with the practical technology and service of enterprises, and strengthen the construction of local special industries (or with regional characteristics). Qinghai University should stand on the Qinghai-Tibet Plateau, aim at the local industries of Qinghai, take the emerging engineering education as an opportunity to promote the reform of engineering education, and help the upgrading of Qinghai's industry and the plateau ecological protection.

IV. CULTIVATION MECHANISM OF EMERGING ENGINEERING EDUCATION-A CASE OF QINGHAI UNIVERSITY

Located on the Qinghai-Tibet Plateau, Qinghai University (QHU) is a comprehensive university with four major disciplines of engineering, agriculture, medicine and management. Limited by geographical location and development space, Qinghai University, like other western universities, has unreasonable allocation of human resources [13]. QHU is lack of teachers, especially the high-level talents. The average educational expenditure is lower than that in the eastern region. The quality of students is not high, and the consciousness of innovation and entrepreneurship is weak. The unreasonable management system hampers the academic development of teachers [13-15]. The emerging engineering education provided a favorable opportunity for the western universities, especially Qinghai University, to realize leapfrog development.

A. Serving Regional Economies

The industry in the western region is highly dependent on natural resources [16]. The advantage of natural resources provides the natural endowment for the western universities [17]. Qinghai Action for Made in China 2025 focuses on promoting the transformation of manufacturing industry from over-dependence on resources to innovation-driven development. The Qinghai Action plan proposes seven key fields, which include high-level manufacturing equipment, new energy, chemical industry, new material, information technology and focusing characteristics of high-end manufacturing equipment, new energy, chemical industry, new material, energy saving and new energy vehicles and speial biology. Qinghai Province will construct four hundred billion industrial clusters, including salt lake, lithium battery, photovoltaic/photothemo and new material.

QHU should adapt the new economy, understand the demand of Qinghai industries, and accelerate the speed of industrial transformation and upgrading. Such that, Qinghai University should explore the new mode of talents cultivation, and promote the reform of engineering. QHU is playing an important role in the development of new energy, new material and special biological resources. Qinghai University-Tsinghua University Sanjiangyuan Research Institute, Caidamu Economic Cycle Research Institute and New Energy (Photovoltaic) Industry Research Center have been built up to tackle the scientific research projects.

B. Dynamic Layout of Disciplines and Specialties

The discipline is not static but dynamic from the new industry types and disciplinary evolution. The static disciplines and majors could not adapt to the development of the industries, especially the new industries and their frontiers. At present, all the fields need to be integrated with big data, things of internet and artificial intelligent et al. Therefore, we provide a novel thinking of disciplinary layout for Qinghai University, as shown in Figure 2.

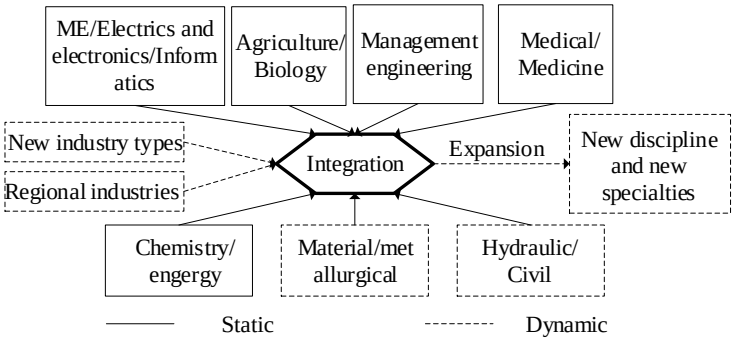

Figure 2. Thinking of dynamic layout of disciplines and specialties in QHU

Based on the thinking in Figure 2, 70 specialties in QHU can be adjusted and integrated to 7 blocks, including ME/electrics and electronics/informatics engineering, agriculture/biology engineeing, management engieering, medical/medcine engineering, chemistry/energy engineering, material/metallurgical engineering and hydraulic/civil engineering. The seven blocks could keep static and invariant. However, the new disciplines or specialties could be derived from the seven blocks according to the demand of new industry types and regional industies.

C. Dynamic-Static Course System

For adapting the dynamic specialties, it is necessary to construct the efficient course system. In the engineering education, the humanistic courses should be embodied to improve the students' abilities. 80% of all courses are the professional courses, and the students should spend 80% of time to study the professional courses. Constructing an efficient professional course system is beneficial for improving the abilities and qualities of engineering students. A new dynamic-static course system is provided to adapt with the dynamic disciplines and specialties in QHU. The basic thinking of dynamic-static course system is shown in Figure 3.

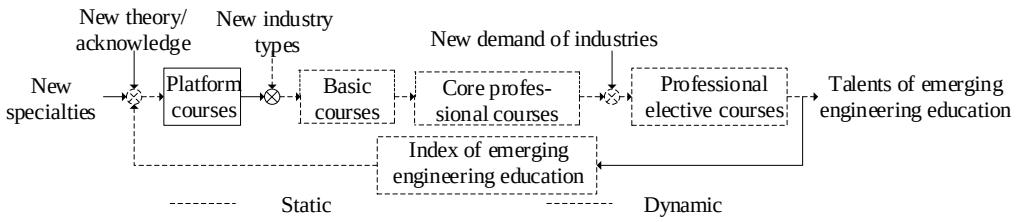

Figure 3. Schematics of dynamic-static course system in QHU

The dynamic-static course system includes four types of courses, including the platform courses, basic courses, professional core courses and professional elective courses. The platform courses include mathematics, physics, chemistry, electronics and electrics, mechanics and computer, and they belong to the general education. These courses are affected by the breakout of basic theories, so that they are relatively static and vary slowly. However, the platform courses are not variable. Biology could be brought as the platform course in future with the integration of biology and engineering.

The basic courses and core professional courses reflect the dynamic and static properties obviously. For mechanical engineering, mechanical design, automation control and engineering drawing have been the basic courses for a long time. They are relatively static as the basic courses. However, the teaching contents vary with the new demand of industry development, and they are dynamic. The core professional courses should reflect the feature of a university. As a local university, its feature must combine with the regional industries. So the core professional courses should embody the demand of local industries. The teachers in the local universities should focus on the advantages of local industries, do the corresponding research work, and offer the relevant courses for the students.

The professional elective courses mainly reflect the dynamic characteristics. They should combine with the new industry types and the demand of local industries. At present, the students should not only learn the international vision, innovative thinking and frontiers of engineering, but also learn the skills and industries for serving the development of local economics and society. For Qinghai University, industry robot, artificial intelligence and smart manufacturing should be offered to the engineering students for adapting the new industry types. Meanwhile, the salt lake and chemistry, new energy and new material also should be offered to the students, who can understand the local industries and sever them better in future.

Qinghai University developed a new teaching and training program in 2016, in which the total credits were reduced from 180 to 160. IN the curriculum system, the courses are divided into four categories, including public basic courses, platform courses, professional basic courses and professional courses. The new curriculum system could meet the needs of the increasing of enrollment students. However, the new curriculum system of QHU is lack of the dynamic properties, fails to reflect the new industry types and the characteristics of the regional industries.

V. CONCLUSIONS AND FUTURE WORK

The emerging engineering education calls for wider and deeper education reform. The quality of engineering talents not only depends on discipline layout and curriculum system, but also needs systematic and overall reform of colleges and universities. Taking Qinghai University as an example, we put forward the following suggestions to promote the emerging engineering education in local comprehensive universities.

The human resources in universities should be reformed and updated to satisfy the needs of the high-level teachers. The local comprehensive universities should improve the teacher evaluation and employment system, and strengthen teachers' engineering practice ability [5]. The teachers' research work should integrate with the students' learning. The western universities should not only cultivate the local talents and high-level teams, but also should introduce the younger doctors to compensate the teaching resources. Meanwhile, some new policies should be put forward to attract more experts, professors and engineers to join into the teaching and research work.

We should promote the integrations of different engineering specialties, the engineering and the science. Some new cross-compound specialties should be established to adapt to the development of new technology and local industries.

The emerging engineering education is the result of a new round of technological innovation and industrial transformation worldwide. And it is also the requirement of Made in China 2025, Internet Plus, One Belt And One Road and other national strategies. As a comprehensive university in the western region of QHU, it has the geographical environment and characteristic resources that are not available in eastern universities [17]. The emerging engineering education provides a historic opportunity for the western comprehensive universities to build high-level disciplines and enhance their overall strength. With the help of the new engineering program, Qinghai University will better serve the economic development of the Qinghai-Tibet plateau and the national innovation-driven development strategy.

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