

# On the Reform and Development of Engineering Education Based on the Emerging Engineering Education

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## ABSTRACT

With the acceleration of the new industrial revolution and the deepening of the globalization process, the development of a new economy and the complexity of modern situation need China to act on higher education of engineering and establish new engineering education. The evolution of discipline shows that emerging engineering education (3E) has its necessity. In this paper, the 3E is discussed from the reflection of modernity, classification guidance and higher education institution's self-exploration, integrity-oriented engineering discipline reconstruction, engineering education comprehensive reform, and other aspects. Under the background of 3E, there are many difficulties in the reform and development of engineering education in local HEIs (Higher Education Institutions), such as the fixed logic of development, the outdated of ideology of running school, the absence collaborative teaching resources, the barriers of organization and management, the weakness of teachers' practical ability etc. Getting rid of these problems, local HEIs should design their orientation, set up disciplines according to the needs of regional industry, break down barriers among disciplines, integrate the resources of government, enterprises and universities, promote the reform of engineering education, improve the teaching evaluation system.

**Keywords:** *Emerging Engineering Education (3E), Local HEIs, Discipline, Reform, Development*

## 1. INTRODUCTION

From 2016, the discussion on engineering education reform from the perspectives of the emerging engineering education (3E) has become increasingly heated. The initiative of 3E is a positive response of China engineering education to major national strategies such as Internet plus, China Made 2025, and One Belt One Road <sup>[1]</sup>. With the deepening of the discussion, such programmatic documents as Fudan Consensuses <sup>[2]</sup>, Tianda Actions <sup>[3]</sup>, and Beijing Guides <sup>[4]</sup>, have been gradually formed, pointing out the direction for the next step of engineering education innovation.

It is foreseeable that engineering education will face the great challenge from the new business of engineering in the next two decades, which is based on the whole-chain innovation in engineering manufacturing and the subversive form change in terminal products and services resulting from new-type industry <sup>[5]</sup>. To the current 3E, universities should fully realize the challenge, better research on the predictive of future new business, careful analysis and tease the concrete form of future new business, emphasis on the landing paths of 3E based on this new business, and take positive measures to change the current engineering

education mode and means, in order to express the connotation and pursuit of 3E. To local HEIs, the 3E should pay attention not only to the construction of new programs for new industries and new technologies, but also to the upgrading and transformation of existing programs for traditional industries <sup>[6]</sup>. The construction of emerging engineering education (3E-construction) should cover the whole field of talent needs from emerging to traditional industries, from large multinational groups to small, medium and micro enterprises.

Under the background of new business and new engineering, local HEIs should actively response 3E-construction, improve the mechanism of multi-agent collaborative education, break down institutional barriers to the training of talents through social participation, and promote the cooperation between enterprises, universities and research institutes in running schools, educating students, employment and development, so as to achieve win-win cooperation. Promote the innovation of university organization, and build a group of regional shared talent training practice platform integrating education, training and research. However, local HEIs also face some difficulties and bottleneck problems in the reform of engineering education, such as lacking the ability of applied

research and absence of experience to service local economic and social development<sup>[7]</sup>.

## **2. DISCIPLINE EVOLUTION LOGIC AND 3E-CONNOTATION**

The concept of discipline has a long history. As the mark of knowledge classification, it has the implication of power. With the institutionalization and specialization of discipline, it has become the main basis for the establishment of modern universities and their faculty structure. From the evolution history of subject, it presents the path of differentiation-synthesis. In the beginning, the discipline consisted only of the classical division of philosophy; in the 17th century, physics, chemistry, and biology were separated from philosophy, and became independent natural sciences, while social sciences were separated from moral philosophy. The modern discipline was basically formed in the 19th century. In the 20th century, the humanities became an umbrella term for disciplines other than the natural and social sciences. The division of disciplines guaranteed the systematic of knowledge fields, and split the scientific integrity. A scholar ever considered that the classification of knowledge was caused by the limitations of human understanding. Facing the increasing complexity of economic and social development, the disempowering discipline has become increasingly weak and powerless, interdisciplinary research has obtained steady development in the United States after the World War II<sup>[8]</sup>.

From the historical logic, the reconstruction of disciplines is of a normal state. The development of science and technology, the accumulation of knowledge, the change of paradigm, and the expansion of cognition all contributed to it, but social demand was the main driving force for the discipline evolution. Up to now, there has been a consensus in the higher education circle on the importance of discipline interplay, interdisciplinary research, interdisciplinary construction, and discipline integration. The proposal of 3E is a reflection based on the comprehensive cognition of times situation, social demand, current engineering education and development laws of engineering disciplines. First, the 3E responses to the requirement of economic and social development. In the stage of social and economic transformation, the realization of national strategy and the rapid development of new economy urgently need the support of new engineering talents, which puts forward new demands for the transformation of engineering knowledge and the reform of engineering education. Furthermore, it grasps the development laws of engineering disciplines. In 1747, the school of the road and bridge, founded in Paris, marked the beginning of modern engineering education. Today, its discipline of civil engineering is continuing. In the meantime, the process of industrialization has led to the continuous differentiation of engineering disciplines. Mechanical disciplines and electric disciplines have appeared successively with the first and second industrial

revolutions. The third industrial revolution was marked by the application of atomic energy technology, aerospace technology and computers. The era of the Internet and artificial intelligence (AI) is calling the transformation of knowledge education and engineering disciplines.

The emergence of 3E is the results of the reflection on the status quo of engineering education in the high modernity stage of industrial society. Reflection runs through the reconstruction of engineering disciplines and the whole process of engineering education reform. The discipline reconstruction and the practice of education reform will enrich the connotation of 3E. The reconstruction of engineering disciplines will follow the development laws of engineering disciplines, actively carries out interdisciplinary exploration among branches of engineering, science and other disciplines, and promotes the reconstruction of engineering knowledge, knowledge innovation, production mode and the reform of knowledge organization system. The 3E-construction is not the local reform in field of engineering education, but is a new paradigm<sup>[9]</sup> to promote the reform in professional structure of disciplines, the knowledge system, the forms, resources and education standards of engineering education, such as a full range of comprehensive reform, and ultimately achieve engineering education goal with new ideas, new structures and new model, new quality, new system<sup>[10]</sup>. The 3E will realize the harmonious development of engineering education and economic society. Its goal is also toward the future.

The 3E is a modernistic concept, is also the product of the development of social economic transition, aims at the contradiction between the supply of current engineering education and the demand of social and economic development, and the conscious reflection in the development laws of engineering discipline. It is a sublation of the traditional engineering, and intrinsically points to economic and social development in the future, is aimed at the intellectual support and talent support for economic and social development, innovation of science and technology.

## **3. ROLE OF LOCAL HEIs IN 3E-CONSTRUCTION**

By 2019, there are 2,956 regular institutions in China, local HEIs are more than 90 percent in all. In the 3E-construction, how to orientate is the logical starting point of engineering education reform in local HEIs.

In the context of 3E, the role of local HEIs should be reflected in the following aspects. First, the most important attribute of local HEIs is locality. Serving regional economic and social development is an important function of local HEIs. Fudan consensus points out that local HEIs should play a supporting role in regional economic development and industrial transformation and upgrading. Second, to cultivate application-oriented talents. Application-oriented talents are mainly engaged in the design, planning and decision-making related to seeking direct benefits for the society. With the changes of industrial

and technology structure in China, enterprises demand for high-level application-oriented talents is gradually expanding. It is of great significance for local HEIs to train application-oriented talents by combining their own advantages and characteristics. Third, to research and develop the industry-oriented technology. Local HEIs should focus on the development, innovation and service of practical technology based on the demands in the adjustment of regional industrial structure or the technological progress of enterprises, such as the design and development of new products, the improvement of technology and equipment, and the promotion and service of high-tech. All in all, local HEIs should accurately goal their school-running orientation in the reform of engineering education, provide services for the development of the government, enterprises and people, establish a model of interactive development between engineering education and economic society, and promote the industrial transformation and upgrading.

#### **4. BARRIERS OF LOCAL HEIs IN 3E-CONSTRUCTION**

Taking the 3E-construction as an opportunity to promote the comprehensive reform of engineering education is beneficial for local HEIs to find the correct school-running orientation and develop their own characteristics. However, the tradition and foundation of school-running in many local HEIs will restrict the reform of engineering education. First, the shackles of ideas. Controlled by the traditional ideology, many local HEIs deviate from the school-running orientation and the aims of talent cultivation, which directly impact on the system design and promotion path of engineering education reform. Second, the logic ossification in the long-time dependency development. Due to the short history, weak foundation, lack of experience, and disconnection between disciplines and regional industrial structure, local HEIs are weak in talent training, technological innovation and the ability to serve regional economic and social development. Third, the lack of cooperative school-running mechanism. Local HEIs are lack of independent development ability, lack of innovation consciousness in cooperative education, mismatch between supply and demand of talent training and weakened service ability, leading to the blind spot of common interests between the universities and enterprises. In addition, the absence of cooperation platform makes collaborative technological innovation and collaborative education difficult to achieve. Fourth, barriers in organization and institution. Traditional organization structure of university-college-department in local HEIs directly limits the interdisciplinary communication and cooperation. In addition, teachers are from a single source, emphasize the background of education, despise the engineering practice, and are weak of engineering practice ability.

#### **5. EXPLORATION OF LOCAL HEIs IN 3E-CONSTRUCTION**

Local HEIs should aim at the construction of modern university, orient the demands of the modern industry, rely on the integration of industries and education, take the cultivation of practice ability and innovation ability as the core, coordinate the development of multi-disciplinary, train high quality application-oriented talents, and gradually form the school-running characteristics, region-saved, industry-closed, application-oriented

Local HEIs should actively incorporate in the regional development strategies, rely on industries to run schools, and serve the local development. In terms of raining talents, they should meet the demands of the society for high-quality higher education, cultivate application-oriented talents with sound personality, innovative thinking and ability, international vision and social responsibility. In terms of sci-tech innovation, they should accurately align the strategy of China Made 2025, take the integration of industry and education as a platform, strengthen discipline construction, and enhance the strength and competitiveness of sci-tech innovation in schools. In terms of social services, they can take the region-school cooperation and school-enterprise cooperation as links, build a wider and more flexible platform which integrates the government, industry, university and institution. In the meantime, they should optimize the structure of disciplines and focus on building their superior and characteristic disciplines.

Local HEIs should encourage the competition, collaboration, crossover and integration of disciplines. Promoting the teachers develop themselves by teamwork and across disciplines, HEIs can take into consideration the diversity of teachers' disciplinary backgrounds, set up scientific research teams, encourage disciplines, teams and enterprises to jointly set up teams to participate in sci-tech R&D projects or take the new needs of economic and social development as the orientation, and cultivate significant achievements by collaborating the more resources.

Local HEIs can focus on the characteristic disciplines and research directions by creating an interdisciplinary organization, explore the mechanism of the special discipline zones and the general institute of scientific research, the model of scientific research organization at different levels including the interdisciplinary centers and the professional research institutions through the internal and external collaboration, promote cooperation with universities, enterprises and local governments to build collaborative innovation centers. They can also integrate the organizational structure of each school, change the research mode to the interdisciplinary and inter-school organization, and establish several interdisciplinary innovation bases.

Local HEIs can forms the three-synergy mode which constitute of the collaborative school-running, collaborative education and collaborative innovation in practices. They cooperate with government, industry and enterprises to build a community of engineering education. Adhering to the principle of opening the school to the outside world,

they structure a strategy of going out of school for development in the new stage, and further strengthened the efforts of collaborative education, to improve students' engineering practice ability, innovation ability and entrepreneurship ability.

Local HEIs could clarify engineering problems and grasp the laws of engineering education and teaching by formulating a series of educational and teaching reform measures. First, local HEIs should construct a perfect engineering education system. They actively apply for a master's degree authorization based on training bachelors and joint training doctoral degree to build an engineering characteristics degree system of bachelor, master and doctoral. Second, HEIs need to align the Washington Accord, actively promote engineering education accreditation, establish a teaching quality assurance system linked to the engineering education accreditation to enhance students' cognitive ability, innovation ability, engineering practice ability and life-learning ability, and improve the construction level of disciplines and faculties. Third, HEIs should strengthen the education of engineering ethics. The cultivation of talents should not emphasize tool rationality unilaterally, but promote the value rationality and pay attention to the integration of professional courses and humanistic courses, humanistic spirit and social practice. Fourth, local HEIs should strengthen international exchanges and cooperation to improve students' international competitiveness. Fifthly, HEIs should improve the teacher evaluation and employment system and enhance their engineering practice ability, draw up a series of rules and regulations of teachers' employment, development and title promotion, put forward the strategy of strengthening the school with talents, improves the mechanism of part-time employment and flexible introduction, and employs experts and scholars from domestic and foreign institutions. Sixthly, HEIs could pay attention to the construction of teaching and research groups, employ enterprise mentors to enrich the teaching teams, realize the effective integration of education and teaching resources, and promote the improvement of teachers' education and teaching ability and professional development.

## 6. CONCLUSION

With the development of economy globalization, the reform of higher engineering education in China is imperative. This paper discussed the concept of Emerging Engineering Education (3E) and the 3E-construction in local HEIs for the discipline evolution logic. It also analyzed the difficulties of local HEIs in the 3E-construction such as the outdated of ideology, the absence collaborative teaching resources, and the barriers of organization and management, etc. To get rid of these problems, local HEIs should design their orientation, set up disciplines, break down barriers among disciplines, and improve the teaching evaluation system.

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