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STUDY OF ENGINEERING TALENT CULTIVATION IN EMERGING ENGINEERING EDUCATION[1]

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ABSTRACT. ***The concept of New Engineering Education (NEE) is essential to reforming higher education for engineering talents in China. However, the theoretical system and the application of it are not complete as NEE is a newly proposed concept. This paper adopts textual and comparative analysis methods to study NEE's development in China. It suggests that the developing path, innovation paradigm, and theoretical system of NEE should be studied from the perspective of talent cultivation. The research finds that two key issues should be firmly grasped: "new demand" of industrial development and "new quality" of talent cultivation. Besides, three major integrations should be underlined including the integration between traditional majors and interdisciplinary technology, the theoretical teaching and practical education, the knowledge transfer and application inquiry. Therefore, a new engineering talent cultivation model should be built featuring "three major reforms" including the***

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reform of curriculum structure, teaching staff and educational platform.

KEYWORDS: new engineering education, talent cultivation, engineers, interdisciplinary training, reform.

JEL classification: I21, O31.

Introduction

China is implementing many major strategies such as "Innovation-driven Development", "Internet+", "Cyber Power", and "One Belt One Road" initiative in response to Chinese national strategic needs. The new economy supported by new technologies, new formats, new industries, and new models is embracing a vigorous development. After mastering the key technologies, China has occupied the strategic high ground in the future global innovation ecosystem. Therefore, engineering and technology talents are in great needs. To further promote the reform of China's engineering education, China's higher education management department points out a new direction: New Engineering Education (NEE) based on theoretical and practical researches.

In-depth researches are required to meet the new requirements posed by the development of economy and society and the transformation of industrial structure. The *National Medium and Long-term Educational Reform and Development Plan Outline* (2010–2020) clearly states that China should continuously optimise the structure of higher education and the setting of disciplines, majors, and promote interdisciplinary integration and enrich the cultivation of application-oriented, interdisciplinary and skilled talents (MoE, 2010). It is the first time that China has written application-oriented talent cultivation into a national official document. China is at a critical point of economic transformation. Along with the contradictions between people's growing needs for a better life and the unbalanced and inadequate development becoming the main contradictions in society, the developing goal of today's China has become "to achieve new industrialisation, informatisation, urbanisation and modernisation of agriculture" and the key motivation of economy has shifted from factor-driven, investment-driven to innovation-driven (MoE, 2010). Therefore, a large number of high-quality application-oriented talents are required to support China with solid professional knowledge, strong technical strength and outstanding practical ability.

During the period of social transformation, NEE needs to achieve intensive growth. Since the 1990s, the concept of Social Transformation has been introduced to the Chinese academic terminology system and has been adopted into disciplines such as philosophy, sociology, history, cultural studies, and even literature. It is mainly used to describe and analyse the process of social transformation and changes in Chinese society since the 1980s (Lin, 2005). Economic variables are essential in social transformation. Professor János Kornai, a Hungarian economist, is a master in studying socialist system. In *Reflections on Post-socialist Transition* (Kornai, 2011), he is very concerned about China's great achievements in economic reform and development. He defines China's late start and its dependence on low wages to enhance international competitiveness as extensive growth. On the contrary, the economic growth with higher labour efficiency is defined as intensive growth which lacks the stamina for sustainable development. The Chinese government, academia, and business circles insist on promoting the transformation of national economic growth mode

and strive to gain intensive growth. The upgrading and transformation of the manufacturing industry is a typical and important section in the process of economic transformation.

Achieving high-quality development and enhancing national competitiveness requires vigorous development of NEE. Whether cultivated talents match the economic and industrial structure is essential not only to the national economic development but also to social stability. The famous American political scientist Giovanni Sartori pointed out in his famous book *The Theory of Democracy Revisited* that "The large-scale expansion of higher education, together with other factors, has resulted in a very large intellectual population. It is increasingly difficult for them to find appropriate jobs. Intellectuals who are unemployed or not using their disciplines are now horribly increasing. Therefore, more and more people are gathering in the remaining pools, the lowest pools. Since public opinions originally come from thoughts, then the increase in ideological groups in the lower part of the society leads to the boiling dissatisfaction in society" (Sartori, 1988).

This paper aims at proposing suggestions on the cultivation of innovative engineering talents when constructing China's NEE from the perspective of talents cultivation, after analyzing the statistics of experience from six Chinese universities and three representative global universities.

1. Literature Review

The academic circles have conducted extensive discussions on the definition of NEE. According to Wang (2018), the first step to understand NEE is to clarify the boundary between scientific disciplines and engineering disciplines. Western "technical sciences" are usually referred to as "applied sciences". Thus under the influence of western countries, Chinese scholars generally regard the disciplines about the foundations of natural sciences (including mathematics) as "scientific disciplines", and see technical disciplines as "applied scientific disciplines". Zhong (2017) agrees that NEE should be regarded as an "applied scientific discipline". He believes that the definition of NEE is to foster talents under the guidance of virtue, to construct the discipline in accordance with the changes in society, to train students through inheriting from the past, innovating for the future, interdisciplinary education, and sharing across universities. Only in this way, can multi-skilled and innovative engineers be cultivated in the future. To answer such questions as "Why do we need to construct NEE", "What is NEE", and "How to construct NEE", Zhong (2017) points out that China has the largest scale of engineering education, and it has some realistic problems. To realise the transformation from a major country to a powerful country in engineering education, China must establish and improve a new system of engineering education with Chinese characteristics. Regarding the question "what is NEE", Zhong introduces the explorations and practices of Tianjin University from six aspects including matching education and industrial needs, setting interdisciplinary courses, promoting innovation and entrepreneurship education, implementing student-centred teaching method, and training students' global vision and patriotism. Lin (2017) from Tsinghua University points out that "NEE represents the latest direction for industry development". In NEE, "Engineering" refers to engineering disciplines; and "New" has three meanings, namely newly born, a new mode and new development. Gu (2017) holds the idea that NEE can be understood as a new engineering discipline, a new field and a new type of engineering education. It is a result of innovation and interdisciplinary cooperation among science, applied science, engineering science and engineering practice. He elaborates NEE from such five dimensions as new ideas, new models, new methods, new content, and new quality. He states that NEE should be an

integration of science, humanities, and engineering, and it should cultivate comprehensive talents who have a global vision, leadership and practical ability, and who can be the leaders in both engineering and humanistic fields.

NEE is a concept proposed by the Chinese educational department, which corresponds to international higher engineering education. The research report *Engineering Education in a Rapidly Changing World* from the Delft Institute of Technology (Kamp, 2016) shows that future engineering education mainly includes the following key aspects: engineering preciseness, critical thinking, non-standardised problem-solving-ability, interdisciplinary and systemic thinking, imagination, creativity, initiative, communication and cooperation, global thinking mode, diversity and mobility, student participation and professional learning community, employment and lifelong learning. Chowdhury (2015) takes the University of the United Arab Emirates as a study case. He focuses on the learning style of engineering students, the teaching mode of staff, and the role of intelligent technology in engineering projects. He conducts researchers on how to improve the effectiveness of project learning by adjusting learning methods and teaching styles. Vemury *et al.* (2018) introduce the teaching methods newly developed and implemented to provide sustainable education for engineering undergraduates at Newcastle University. Bae and Woo (2019) conduct researches on the development of architectural engineering education in online universities by investigating the course setting, course system, course plan, and course management of "Architectural Engineering". Siddique *et al.* (2010) suggest that in project-oriented design courses, experiential learning is applied to open-ended problems rather than traditional closed-ended exercises, to stimulate creativity and innovation. Some scholars believe that compared with traditional teaching design, engineering education pays more attention to the formation of complementary learning values through learning experiences (Kapp, 2012; Revelo, Baber, 2018). The values cover different aspects such as project management, communication, language skills, team spirit and related ethics. Some researchers argue that in terms of how to achieve engineering education, the most typical example is the Formula SAE concept proposed by SAE International. It is a typical example of applying "practical" methods in teaching American and British engineering courses (Hurtado *et al.,* 2009; Goleman, 1995). In those courses, students are allowed to show design concepts, costs, manufacturing and hypothetical business cases. De-Juan *et al.* (2016) believe that projects provide students with a learning platform that makes real practices possible. In a survey of teachers' projects with students' participation, Crisp *et al.* (2017) discover that the staff who value the transformational model of engineering teaching can better see the potential of students and better help students enter these competitive environments. This proves that students under the reform of teaching methods are more likely to succeed than students in the traditional environment. Judging from the existing researches, NEE, as a new educational concept meeting current social needs, mainly refers to an ideology of cultivation high-level interdisciplinary engineers with innovation using new ideas, new methods to achieve new quality in accordance with the dynamic social development.

From the perspective of market demands for talents, NEE is different from traditional engineering education focusing on the sharing and application of static knowledge. From the standpoint of learners' knowledge structure, the talents cultivated by NEE should have a multidisciplinary knowledge background or education experience. From the perspective of the process of talent cultivation, NEE has broken through the barriers of classrooms and realised "immersive" learning. From the perspective of the core competitiveness acquired by learners, NEE talents should have creative thinking and innovative spirit. From the perspective of the evaluation criteria, the talent cultivation quality in NEE is double tested by educational

theories and market standards instead of the quantity of knowledge acquired in traditional campuses (Zhuang, Xu, 2018).

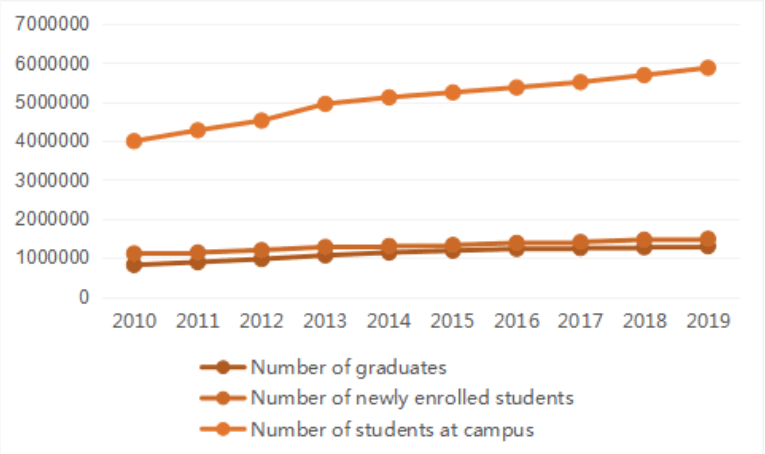
The pace of today's economic and social development is so fast that it has far surpassed the extent to which people can make predictions based on past experiences. The cultivation of NEE talents involves the quality standards, educational resource allocations, and learners' requirements, and needs to look into the future (Ojewumi, Fagbenro, 2019). In the report issued by the American Academy of Engineering (2004) *Engineers in 2020: Vision of Engineering in the New Century*, excellent analytical skills, practical skills, creativity, communication skills, business and management knowledge, leadership, ethical standards, professionalism and lifelong learning ability are regarded as the qualities that future engineers should possess. The future engineers' cultivation standards should highlight family and country sentiments, innovation and entrepreneurship, interdisciplinary education, critical thinking, global vision, independent lifelong learning, communication and negotiation, engineering leadership, sustainable environmental development, and digital literacy.

2. Research Method and Data Analysis

2.1 Research Method

The talent cultivation objectives in China's traditional engineering majors are relatively vague. There is a certain degree of disconnection between cultivation objectives and social needs. Although the developing speed and quality of engineering education in China have gained world-renowned achievements, the education of engineers still cannot fully meet the needs of society.

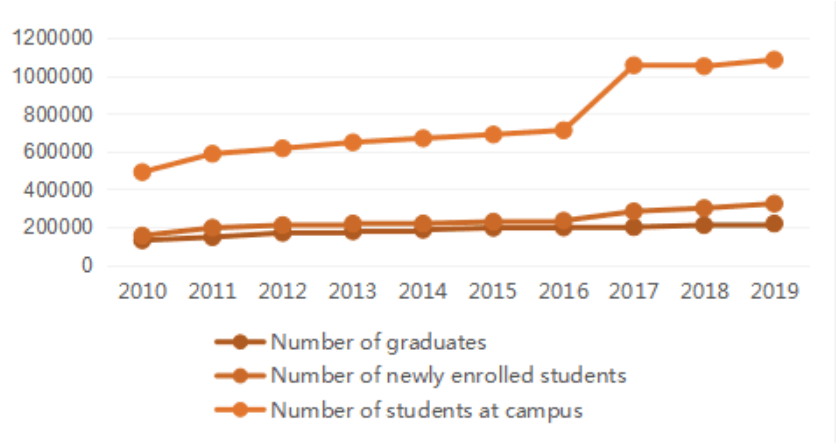
As it is seen from *Figure 1*, from 2010 to 2019, the number of China's engineering graduates increased from 813,218 to 1,295,015 with the average annual increase reaching 5.92%. The number of engineering students at campus increased from 3,995,779 to 5,877,763, with an average annual increase of 4.71%.



Source: educational yearbooks published by Chinese Ministry of Education from 2010 to 2019.

Figure 1. **Number of Engineering Undergraduates in China from 2010 to 2019**

In the meantime, the enrollment of engineering postgraduate students also embraces a significant increase. According to *Figure 2*, the number of engineering post-graduates at campus exceeded one million for the first time in 2017, reaching 1,056,897.



Source: educational yearbooks published by Chinese Ministry of Education from 2010 to 2019.

Figure 2. **Number of Engineering Postgraduates in China from 2010 to 2019**

The new paradigm of engineering education is one of the core tasks of NEE construction and reform. In order to better compare and analyse the developing path of engineering education at home and abroad, six domestic universities are selected as study objects including Tianjin University, one of the initiators of NEE, Sun Yat-sen University, a representative comprehensive university, Nanjing Normal University, a comprehensive university which was originally a university without engineering disciplines, Nanjing University of Science and Technology and University of Electronic Science and Technology of China, a representative university featuring engineering, and Dongguan University of Technology, a representative of local application-oriented universities. A textual analysis is carried out on relevant researches and the practices adopted by those six universities mentioned above. According to the principle of natural language processing, the frequency of the keywords is analysed using the word frequency analysis software *Tuyue*. In addition, to further analyse the reform measures adopted by global universities in engineering education, this paper adopts the method of case study to write parallel case descriptions, so as to provide references to Chinese universities on the way of developing NEE (Yin, 2017).

2.2 Data Analysis

From the perspective of resources input, according to *Table 1*, "strengthening construction" is a common practice of the six universities. By breaking the original institutional boundaries, integrating related disciplines, NEE is promoted with new systems. At the same time, enhancing the cooperation between universities and enterprises is also one of the significant features.

From the perspective of teaching staff, according to *Table 2*, six universities all strengthen the training of interdisciplinary teachers and emphasise the shift of focus from scientific research to students' education. They all attach great importance to the integration among education, teaching and researches. Teachers' own ability, especially the ability to combine theoretical knowledge with practical application, is in great emphasis.

Table 1. Text summary of NEE-relevant practices adopted in six domestic universities, resources input

Universities	Texts described in documents about NEE practices
Tianjin University	A department of Seeking Truth was established to implement new policies of talents training to the whole university regardless of tradition and benefit 20,000 students.
Sun Yat-sen University	Twenty-five strategic engineering majors in emerging industries were established in the campuses in Guangzhou, Shenzhen, and Zhuhai and research institutes in Shunde, Dongguan, and Huizhou, accounting for 19.8% of engineering majors.
Nanjing Normal University	"Nari College" was established in 2017, moving the laboratories for undergraduates and masters into enterprises, impelling a practical teaching platform for experiments, internship, trainings and practices.
Nanjing University of Science and Technology	An academy of education and experiments was founded through intercollegiate cooperation. An academy of intellectual property was founded through school-enterprise cooperation. An academy of Sino-French engineers was founded through international cooperation.
University of Electronic Science and Technology of China	A comprehensive challenging research-based teaching reform was conducted since 2016. Seven hundred and sixty-two high-quality, challenging, research-oriented courses and two university-level, eighteen college-level top-notch programmes were built.
Dongguan University of Technology	Emphases were put on the overall acceleration in the construction of a high-level science and engineering university. Emphases were put on the key breakthroughs to improve the level of modern industry colleges. Emphases were put on the support for disciplines to create clusters of specialty disciplines.

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

Table 2. Text summary of NEE-relevant practices taken in six domestic universities, teaching staff

Universities	Texts described in documents about NEE practices
Tianjin University	A team of multi-disciplinary teachers was built. Famous teachers, governments, enterprises and research institutes were introduced into a collaborative education platform led by universities.
Sun Yat-sen University	The innovation and entrepreneurship general courses were integrated into the professional curriculum system. The training of innovative thinking was combined with the training of innovation and entrepreneurship practical ability.
Nanjing Normal University	The university-enterprise joint construction was built to recruit, introduce and train teachers, so as to optimise the teaching staff.
Nanjing University of Science and Technology	Internationalisation, integration, interdisciplinary, teamisation
University of Electronic Science and Technology of China	A series of core courses for challenging projects were developed by high-level scientific research teams, realising the implementation of the ideology of education by scientific researches in classrooms.
Dongguan University of Technology	The foundation of teachers' capability was strengthened to build a team of teachers with dual abilities. The plans of talents introduction and training were designed to meet the needs of different types and levels of talents according to the "new engineering-industry" matrix.

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

From the perspective of cultivation objectives, according to *Table 3*, students' innovation, problem-solving abilities in practice and leadership are highlighted. A common practice is applied in the universities, which is to cultivate students' sense of social responsibility against the background of enormous economic and social development.

Table 3. Text summary of NEE-relevant practices adopted in six domestic universities, cultivation objectives

Universities	Texts described in documents about NEE practices
Tianjin University	leading engineering talents; high-quality innovative engineers with creativity, power of practice, leadership and international competitiveness
Sun Yat-sen University	to have capabilities and integrity, leadership and patriotism; talents with humanistic background, solid scientific foundation and multi-dimensional knowledge structure; be good at solving engineering problems across disciplines and industries
Nanjing Normal University	to change cultivation goals according to the requirements of industries
Nanjing University of Science and Technology	to cultivate engineering scientists; applied engineers; comprehensive engineers; to cultivate international engineers
University of Electronic Science and Technology of China	to cultivate innovative leading talents who can shoulder the task of national rejuvenation
Dongguan University of Technology	to strengthen the market demand orientation in talents training and to solve key issues in industrial innovation and development

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

Table 4. Text summary of NEE-relevant practices adopted in six domestic universities—teaching methods

Universities	Texts described in documents about NEE practices
Tianjin University	to strengthen the student-centred method; to shift students' thinking of "be told to learn" to "want to learn"; to adopt the "four in one" teaching method covering the exchanges among teachers and students about thinking, knowing, speaking and acting
Sun Yat-sen University	to carry out interdisciplinary and integrated teaching; to realise the integration of teaching among disciplines and majors; to guide students to build a broad and solid base of knowledge
Nanjing Normal University	to change teaching methods according to engineering practices
Nanjing University of Science and Technology	to establish a multi-project system covering "basic practices—scientific research training—innovation competitions—innovation experiments—enterprise actual practices" and help students develop engineering innovation ability
University of Electronic Science and Technology of China	to implement the plan of Freshmen Projects and the Project of NEE Education System Design and Practice, so as to encourage teachers to teach in researches
Dongguan University of Technology	To promote direct interactions between education and industries; to reform the curriculum systems, teaching contents and practical teaching methods

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

From the perspective of teaching methods, according to *Table 4*, innovation, changes in teaching methods, and the combination of theoretical knowledge and practical application are regarded as the most important missions now. The integration between knowledge and practicalities is strengthened through project-oriented teaching. Three key proposals are initiated as follows. The practical teaching environment needs to be improved, the applications of theories need to be strengthened, and the integration of different disciplines needs to be accelerated.

Table 5. Text summary of NEE-relevant practices adopted in six domestic universities, teaching content

Universities	Texts described in documents about NEE practices
Tianjin University	to establish a comprehensive curriculum system; to rebuild the curriculum objectives; to optimise the knowledge structure, and to reorganise the content of the curriculum so that students can have sufficient knowledge of natural sciences and engineering technology; to integrate the knowledge of humanities and social sciences
Sun Yat-sen University	to incorporate new knowledge and technologies in multiple disciplines with classic textbooks; to optimise course content to draw "knowledge maps"; to break through discipline barriers; to build a cross-disciplinary professional curriculum model
Nanjing Normal University	to reform the teaching content according to the technical development
Nanjing University of Science and Technology	to cultivate students with all-round development with the guidance of "Big Engineering Concept"; to teach students how to recognise, how to do things, how to cooperate, and how to survive
University of Electronic Science and Technology of China	to promote teaching content that is future-oriented and problem-oriented; to promote project-oriented learning
Dongguan University of Technology	to introduce advanced technology systems, equipment, and cultivation models from an enterprise; to jointly design the plans of education; to jointly develop project-based courses

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

From the perspective of teaching content, according to *Table 5*, curriculum reform has become the consensus of the six universities. A shift of focus from students' knowledge learning to practical abilities learning is generally identified. The teaching content needs to be innovated around the core of students and needs to cover knowledge from different subjects.

Table 6. Text summary of NEE-relevant practices adopted in six domestic universities, students' core abilities

Universities	Texts described in documents about NEE practices
Tianjin University	ability to comprehensively solve problems; cross-cultural communication skills; leadership, teamwork skills, humanity quality, and international awareness
Sun Yat-sen University	interdisciplinary knowledge reserve; multidisciplinary research capabilities and interdisciplinary team spirit; the multidisciplinary thinking method; compound knowledge
Nanjing Normal University	abilities in practice; research and innovation
Nanjing University of Science and Technology	engineering innovation ability; cross-cultural communication ability
University of Electronic Science and Technology of China	curiosity and learning abilities; global vision and leadership
Dongguan University of Technology	abilities to solve new problems in industrial reform and realistic problems in industries and enterprises; pursuit of excellence; innovation and hard work

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

From the perspective of students' core abilities, according to *Table 6*, innovation ability, cross-cultural communication and cooperation ability, learning ability across disciplines are underlined. In future practices, students are supposed to apply creative thinking to professional knowledge.

Table 7. Text summary of NEE-relevant practices taken in six domestic universities, quality evaluation

Universities	Texts described in documents about NEE practices
Tianjin University	to pay attention to the development of students' personality; to allow students to determine learning goals, select learning content and formulate learning schedules according to their personal interests and ambitions; to transform the ideology of education to student-centred effective learning
Sun Yat-sen University	to serve industry development, enabling the Pearl River Delta to join together with the Yangtze River Delta, the Beijing-Tianjin-Hebei region and the Bohai Bay Rim, to provide innovative engineering talents for the transformation and upgrading of the riverside and coastal industries
Nanjing Normal University	to alter the quality standards according to employment satisfaction
Nanjing University of Science and Technology	to closely related to industry needs; to have remarkable results in competition; to cultivate engineers majoring different disciplines, to meet the urgent needs of economic and social development and lead the future of the new economy.
University of Electronic Science and Technology of China	to fully initiate the reform of the curriculum construction, to identify demonstration courses at university and college levels; to innovate teaching methods and evaluation methods adopted in demonstration courses
Dongguan University of Technology	to serve local industrial strategic needs; to innovate and develop; to mark key indicators including patent applications, achievement transformation, technical services, and horizontal funding; to establish an evaluation system with "contribution, satisfaction, and recognition" as the main measurement criteria

Source: Zhang, 2017; Yu, Ji, Yu, Yu, Duan, 2020; Chen, Chen, 2017; Hu, 2019; Zhang, 2018; Zeng, 2020; Cheng, 2019.

From the perspective of quality evaluation, according to *Table 7*, the universities agree that they need to break the original frameworks and implement multiple evaluation standards to meet the actual needs of local economic development. Only through this way, can students' comprehensive development and the sustainable development of the local economy and society be guaranteed.

3. Case Analysis

3.1 Reform and Innovation of Massachusetts Institute of Technology (MIT)

In August 2017, the Massachusetts Institute of Technology (MIT) launched the "New Engineering Education Transformation" (NEET) programme, which carried out bold and innovative reforms in the goals and missions, principles and focuses, teaching methods and development directions of engineering education. The specific reform measures can be found as follows.

MIT (2019) believes that the focus of engineering education should shift from the current to the future development of the industry. Modern technologies such as big data, artificial intelligence, and virtual reality are in the ascendant, and the pace of industrial transformation and structural adjustment is accelerating. Engineering education should face the future of new technologies and New Engineering systems and reflect future orientation. Only in this way can the continuously changing demand of industries be met.

The implementation of the NEET plan aims at cultivation outstanding leading engineers who will lead future development, create new knowledge and serve society. The plan is committed to attracting the best talents in the world to create, innovate and pave the way into the future world. NEET is dedicated to helping students gain the ability to adapt to

unknown environments, to encourage students to explore new areas, solve problems beyond reality, and emphasise the actions to create a better world (MIT, 2019).

The School of Engineering at MIT establishes four types of interdisciplinary series of centre courses, including advanced material machines, automated machines, life machines, and low-carbon energy systems (MIT News, 2019). The New Engineering reform has adopted an integrated path, which is embodied in "Tandem". Tandem is composed of several research sub-projects which are consciously and purposefully built around a certain theme and are gradually increasing in difficulty. Besides, Tandem urges students to master professional abilities and merge knowledge from various disciplines into an analytical, critical, and creative system. Students can study related courses independently according to the requirements of the tasks they undertake in projects which are usually cross-disciplinary and cross-college course. In this way, students can prepare themselves for later course learning (Zhu, Li, 2019). Besides, students can apply cross-integrated knowledge in the process of problem-solving and achieve self-learning and innovative abilities. According to the objectives and content of projects, students from different disciplines are attracted. Through the collaborative learning of peers, students' interpersonal communication and teamwork skills are strengthened, which are the indispensable core literacy to cope with future changes.

This New Engineering reform help MIT rethink the teaching methods of engineering education, shift the focus from teaching facts to increasing students' engagement and make students become "discoverers" in engineering education. MIT proposes that NE talents should have eleven new ways of thinking: manufacturing, discovery, interpersonal skills, individual skills and attitudes, creative thinking, systemic thinking, critical and metacognitive thinking, analytical thinking, computational thinking, experimental thinking and humanistic thinking (Xiao, Tan, 2018). MIT provides students with a closely connected living and learning environment, attaches great importance to students' research and life experience, and stimulates students' active exploration and autonomous learning capabilities.

3.2 Reform and Innovation of Georgia Institute of Technology (GIT)

In 2018, the Georgia Institute of Technology (GIT) put forward the innovation campaign "Creating the Next in Education", which aims to review the current educational principles and methods of GIT, to establish a benchmark for higher education practice, and to better serve the college's future engineers in different eras. The main reform and innovation measures are explained as follows.

GIT proposes that higher education experience should be dedicated to helping students acquire a solid knowledge base to encounter professional and life challenges and have the ability to adapt to the future. To achieve the goals, GIT adopts advanced teaching methods, innovates learning technology, optimises realistic and virtual learning spaces, and provides instant feedback to students about their development at different stages. Students are constantly being pushed to face their own limitations in the learning process. GIT provides effective support to help students overcome their shortcomings, so that students can learn the ways to learn, to enrich themselves, and finally to become whom they want to be (Li, Tang, 2017).

There are two changes in the educational philosophy of GIT. The first change is the multi-dimensional characteristics of the learning experience. The cognitive dimension mainly covers innovation ability, information integration ability, problem-solving ability, critical thinking, reasoning ability and argumentation ability. The interpersonal communication dimension includes communication skills, cooperation skills, sense of responsibility,

leadership and conflict resolution skills. The personal development dimension emphasises students' adaptability, initiative, respect for diversity and metacognition (ability to conduct self-reflection and effective learning). GIT aims at developing students' multi-dimensional skills to achieve Whole-Person Education. The second change is to build a culture of whole-person development through the system of Edge-Home-Groove. Edge refers to placing students on the edge of the challenges to reveal their shortcomings and limitations. Home refers to the environment universities provide students with. Groove refers to the intention of paving a path for students to grow. GIT provides students with a real and interconnected learning environment, to create a global diversified environment, to expand campus curricula, and to enhance students' cultural understanding, cooperative communication, and critical thinking skills. It cultivates graduate students' professional abilities through research-based projects and the Whole-Person Education process (Melkers *et al.*, 2012).

Practical education in GIT education is project-oriented (GIT, 2018). It cultivates students' practical ability, innovation, leadership, teamwork and ability to solve practical social problems through the school's VIP (Vertically Integrated Projects) Programme, C2D2 (Centre for Career Discovery and Development) Programme, international exchange projects, undergraduate scientific research projects, etc. GIT emphasises students' ability to discover problems, pays attention to the integration of interdisciplinary knowledge and Real-World practice. It encourages students to get out of campuses, to cultivate their sense of civic responsibility, and to strengthen the connections between their skills with social development (Sonnenberg *et al.*, 2017).

Judging from the typical practices of cultivation engineers in some high-level representative universities in developed countries, the key measures to improve the quality of talents training are aiming at the forefront of industry development, focusing on project-oriented teaching, paying attention to the continuous development of students, and strengthening students' engineering practical capabilities. This also provides valuable reflections for Chinese local application-oriented undergraduate colleges and universities in the construction of NEE.

3.3 Reform and Innovation of Purdue University

The School of Engineering at Purdue University is committed to "putting students in the real world" and is famous for its New Engineering Education and freshman engineering education. Professor Lin Jian and his team conduct deep research on Purdue's explorations in NEE construction (Lin *et al.*, 2019). Purdue effectively improved its talent training quality through multi-party participation in establishing the training standards and multi-disciplinary training projects.

In the past, the traditional teaching method at Purdue is generally teacher-led. In recent years, Purdue's focus on teaching has shifted from teachers' teaching process to students' learning effects. On the one hand, this shift reflects the central position of students in teaching activities. On the other hand, students' participation and experience in the teaching process should be stressed because the needs of students are diverse rather than consistent, dynamic rather than static, emphasising the application rather than the storage of knowledge. The traditional teaching and knowledge-stuffing has gradually changed into a complex teaching process involving "teaching", "guidance" and "stimulation", which is conducive to cultivation students' enthusiasm for discussions, and is of great benefit to help students identify, analyse, understand and solve problems (Amadin *et al.*, 2013).

The First-Year Engineering Programme (FYE) implemented by the School of Engineering at Purdue is a comprehensive training programme for all freshmen. After admission, all freshmen will study for one year according to FYE regardless of their majors. Their majors will be determined after one year. In the entire interdisciplinary system, FYE is the foundation of all projects. Its cultivation goals include: 1) learn to think like an engineer; 2) master the basic knowledge of a wide range; 3) learn to collect and interpret data, and to discover the relationship between data and phenomena; 4) develop the habit of discovering and solving problems, and improve thinking, practical, and teamwork abilities; 5) learn the requirements of different majors; explore career interests and potentials; establish clear career directions (Lei, Gong, 2009).

Purdue cultivates students' interdisciplinary engineering capabilities through the EPICS project, which is the abbreviation of "Engineering Projects in Community Service". It is an interdisciplinary project centred on engineering to promote exchanges and integration among different disciplines and to cooperate with community services to explore collaborative education mechanisms. Students earn credits by meeting the needs of local or global communities (Peng *et al.,* 2019). EPICS helps build the bridge between students and society and encourages students to observe and meet social needs, so as to enhance students' interdisciplinary capabilities.

Conclusions

This paper discusses the new ideas, new models, new methods, and new contents of engineering education reform against the background of China's NEE construction. The conclusions are as follows. Firstly, the core issue of reforming higher engineering education is to coordinate the developing industrial needs and the quality of talent cultivation. Whether talents can meet the needs of industries determines whether the talent cultivation system in universities is in the right way. Secondly, the engineering talent cultivation model covers many aspects, among which the utilisation of social resources, the allocation of teachers, the optimisation of curriculum structure, and the improvement of teaching quality are the essentials. Thirdly, the construction of NEE is based on the future talent needs and the sustainability of students' abilities, so the cultivation of students' innovation and the teaching of frontier disciplines should be put in the first place in the talent cultivation model. The concept of NEE provides new ideas for cooperation in transnational higher education. Based on China's experience in implementing NEE and the methods of cultivation engineers overseas, this research provides the following theoretical and practical paths that can be referred to for the cultivation of engineering talents around the world. First, a new version of engineering talent cultivation model should be built featuring "three major reforms" including the reform of curriculum structure, teaching staff and educational platform to support the construction of NEE. Second, the processes including value shaping, knowledge learning, ability training and innovation and entrepreneurship cultivation should be emphasised. Besides, the three major integrations should be underlined including the integration between traditional majors and interdisciplinary technology, the theoretical teaching and practical education, the knowledge transfer and application inquiry. Lastly, the cultivation of engineering talents should involve universities, governments, enterprises and other related forces, to accelerate the transformation of research achievements and meet the new requirements posed by global economic development, social and industrial transformation, and technological innovation.

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INŽINERINIŲ TALENTŲ UGDYMAS BESIFORMUOJANČIAME INŽINERINIAME ŠVIETIME

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SANTRAUKA

Naujojo inžinerinio išsilavinimo (NEE) sąvoka, viena vertus, yra esminė pertvarkant aukštąjį mokslą inžinerijos talentams Kinijoje. Kita vertus, teorinės medžiagos ir jos pritaikymo nepakanka, kadangi NEE yra naujai siūloma sąvoka. Šiuo darbu siekiama pritaikyti tekstinius ir lyginamuosius analizės metodus, siekiant ištirti NEE plėtrą Kinijoje. Siūloma, kad plėtros kelias, inovacijų paradigma ir teorinė NEE medžiaga būtų tiriama iš talentų ugdymo perspektyvos. Tyrimai rodo, kad reikėtų suvokti dvi esmines problemas: augančią pramonės plėtros paklausą ir naują talentų ugdymo kokybę. Be to, reikėtų pabrėžti tris integracijos etapus: pagrindinių tradicinių ir tarpdalykinių technologijų integraciją, teorinį mokymą ir praktinį išsilavinimą bei žinių taikymo ir perdavimo tyrimą. Taigi, reikėtų sukurti naują inžinerinius talentus ugdantį modelį, kuriame būtų pritaikytos trys pagrindinės reformos: mokymo struktūra, akademinis personalas ir švietimo platforma.

REIKŠMINIAI ŽODŽIAI: naujasis inžinerinis išsilavinimas, talentų ugdymas, inžinieriai, tarpdalykinis mokymas, reforma.