‘New Engineering Education’ in Chinese Higher Education: Prospects and challenges

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Abstract: Since becoming a formal signatory of the Washington Accord in 2016, China has outlined an initiative ‘New Engineering Education’ (NEE) to reform its engineering education at university level. This paper elaborates upon the NEE initiative by presenting analysis of its domestic and international context, the goals of the initiative, how the initiative draws upon international standards, major actions under the initiative, and the challenges remaining for NEE to achieve its goals. The paper argues that China views international practices and standards of engineering education in developed nations as highlands to imitate and surpass, and the NEE goals embody an ambitious systematic rather than partial reform of the sector. China has pushed forward the NEE reform with measures such as formulating National Standards for dozens of categories of engineering programs, commissioning 600+ research projects on NEE development, establishing new engineering programs and interdisciplinary courses, strengthening university-partnership, updating accreditation for engineering programs, and improving both external and internal quality assurance mechanism. The sector, however, still faces challenges in achieving systematic quality upgrade due to hindering factors like enlarged uneven resource allocation, downplayed teaching activities and the difficulties in reforming the curricula system. Expected changes are also discussed.

Keywords: Higher Education; Engineering Education; Educational Reform; China; New Engineering Education.

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I. Introduction

As the world in 21st century is being and will be further revolutionized by the rapid development of science and technology, engineering skills impact individuals’ wages and jobs, determine whether countries survive in the fierce international competitions in the long run, and more importantly, whether our next generation will have the capability to meet the common global challenges in the decades to come. Engineering education sets young generations on paths to becoming successful engineers by teaching them the set of knowledge, skills and attitudes needed to solve complex problems, strengthen productivity, and achieve excellence. Graduates of engineering programs are usually expected to demonstrate special abilities distinguished from other areas like humanities or social sciences. These abilities usually include but are not limited to applying knowledge of math, science and engineering, designing and conducting experiments, analyzing and interpreting relevant data, demonstrating the competences to design systems, components, or processes to identify, formulate and solve engineering problems. For this reason, improving the quality of engineering education is a constant theme of higher education sector across the globe.

In many parts of the world, quality assurance of undergraduate engineering education is guided by the directions and goals of important international accords and agreements pertaining to cultivating engineering talents, such as Accreditation Board for Engineering and Technology (ABET), European Network for Accreditation of Engineering Education (ENAEE), Sydney and Dublin Accords (SDA), the Engineers Competence Agreements (ECA), and so on. For example, ABET sets criteria for accrediting numerous types of engineering programs, covering students, program objectives, student outcomes, improvement measures, curricula, faculty, facilities, and institutional supports that ensure quality assurance of given programs.[1] Another more widely recognized agreement of relevance is the Washington Accord, which works as an important constituent of International Engineering Alliance and is concerned with engineering education and competence in the form of a self-governing and autonomous agreement between signatories of various nations that provide external accreditation to higher education programs. All the signatories must undertake a periodic peer review to ensure the substantial equivalence of the accredited programs, and graduates of accredited programs enjoy the

[1] Ron MacKinnon, Kevin Lee Elder, and John Dyer, “ABET Accreditation of IS and IT Programs in 2013,” *Journal of Higher Education Theory and Practice* 16, no. 1 (2016): 20

privileges of being recognized by other signatories in terms of degrees obtained, thus ensuring that the quality of the commonly recognized advancement does not recess and the mobility of graduates between signatories is guaranteed.

China is no exception from many other countries in terms of the awareness to leverage its engineering education to update its national technological competence. Among various aforementioned accreditation and quality assurance mechanisms, Washington Accord is most directly related to China. Realizing the importance of international recognition and the considerable impacts that Washington Accord has made on improving engineering education worldwide since 1989, China actively prepared for joining other Washington Accord signatories from around 2006 and managed to become a formal member in 2016. The application for and the celebration of joining the Washington Accord signatories has embodied the aspiration of Chinese engineering education sector to move from the periphery towards the center, with one of the phrases most frequently talked about in the Chinese higher education sector being 'substantial equivalence'. This event is regarded as a milestone in China's history of the engineering education's development. One official from China's Ministry of Education said that 'Joining the Washington Accord marks that China's engineering education quality standard has been internationally equivalent to other matured standards, and the quality assurance system for China's higher engineering education has been recognized by the international community'.[2]

China's joining of Washington Accord occurs concurrently with the broader global technological revolution. The concept of 'Industry 4.0', originating from 'Germany 2020 High-tech Strategy' initiated by the German government to revolutionize Germany's core technology competitiveness, got fully known by Chinese during the HANNOVER MESSE in 2014. While 'Industry 4.0' is summarized mostly for the current trend of manufacturing technologies in areas such as cyber-physical systems, the Internet of things, cloud computing and cognitive computing, Chinese media portray such many areas in an astonishing fashion by using another equivalently and even more shocking term 'the Fourth Industrial Revolution' to indicate the urgency of updating its engineering sectors. Xinhua News Agency, one of China's most prominent state media, reports that:

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[2] "What does Entry into Washington Accord Mean to Chinese Engineering Graduates," Chinese Education Daily, accessed July 3, 2018, https://mp.weixin.qq.com/s?__biz=MzA4MTQxOTQzMw==&mid=2650271505&idx=1&sn=b651de4bd4e7159d2276e1248a1bf9f8&scene=0#wechat_redirect.

> This (the fourth) industrial revolution will not be confined to a certain area like before. Mobile network, sensors, nanotechnology, brain research, 3-D printing, material science and computer information processing, to name a few, as well as their interactive functions will all be impacted greatly by the fourth industrial revolution, which is a systematic rather than a single-product-like or single-service-like innovation.[3]

The drastic changes and the grave influences brought by this technological revolution are believed by the Chinese to be more far-reaching than all the previous historical industrial revolutions. The substantial descriptions of the upcoming societal changes driven by implantable techniques, big data, smart cities, automation and many other technological innovations already taking place in powers like the Unites States and Japan render the Chinese to feel a sense of urgency not to lag behind as they did a century ago.[4] Such resolutions to enhancing technological advancement are seen from national strategies to governmental reports and to business schemes.[5]

It was against such two backdrops – the demand to upgrade the engineering education sector to meet standards and criteria set by the Washington Accord, and the demand to cultivate more qualified engineering talents to meet the challenges of the times – that ‘New Engineering Education’ (NEE) was proposed.

This paper is organized into five sections. In Section ‘NEE: what are the new intentions’, we begin the paper by presenting the goals, contents of the three NEE policy documents issued by China’s Ministry of Education, highlighting the ‘new’ elements compared with the existing engineering education system in China. Then we present an analysis of how NEE visions reflect the standards and criteria set by some internationally renowned agreements pertaining to engineering education, especially the Washington Accord of which China has proudly claimed to be a member in Section ‘Reflections of international standards in NEE’. Section ‘Actions under the NEE initiative’ proceeds to analyze the primary impacts of NEE policy on Chinese higher education institutions over the past year since the catchphrase

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[3] “The Fourth Industrial Revolution: A Grand Social Change Sweeping the Globe,” Xinhua News Agency, accessed July 6, 2018, http://www.xinhuanet.com//book/2016-06/06/c_129042664.htm.

[4] Klaus Schwab. *The Fourth Industrial Revolution* (Geneva,Switzerland: World Economic Forum, 2016), 66

[5] Jinping Xi, “Securing a Decisive Victory in Building a Moderately Prosperous Society in All Respects and Strive for the Great Success of Socialism with Chinese Characteristics for a New Era,” accessed May 1, 2018, http://www.xinhuanet.com/english/download/Xi_Jinping’s_report_at_19th_CPC_National_Congress.pdf.

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was put forward. Next, in Section 'Challenges for China's NEE', we gesture to several challenges to be addressed if China wants its NEE visions to be fully realized. Finally, the possible consequences of China's NEE are discussed in 'Discussion'.

II. NEE – what are the new intentions?

'New Engineering Education'(NEE) refers to a reform initiative aimed at upgrading China's engineering education at university level against the backdrops of the global 'industry 4.0' technological revolution and China's joining the Washington Accord agreement. The ideas and visions of NEE are embodied in the three policy documents issued by China's Ministry of Education in 2017, namely 'Fudan Consensus',[6] 'Tianda Action'[7] and 'Beijing Compass'.[8] The three documents were issued in sequence as outputs of three meetings held at Fudan University, Tianjin University and Beijing Convention Center respectively in the same year. Each of the three policy documents addresses different facets of the holistic reforms to be implemented, and the three documents combined depict a blueprint of China's production of engineering talents through its tertiary education in the decade ahead. For example, the visions of developing a multiplicity of entities at various levels to facilitate engineering education such as universities of science and technology, colleges of industrialization, new polytechnic programs, new curricula, new praxis platforms, cross-disciplinary platforms, and industry-oriented innovation platforms depicted in 'Beijing Compass' signal a strong imagination of systematic engineering upgrade at both macro and micro level, thus rendering the picture of how China is going to develop its technology manpower not fully understood with NEE left unchecked.

The first of the three policy documents 'Fudan Consensus' is of relevance to the differentiated roles played by various stakeholders of higher education. Stakeholders identified in the document include higher education institutions

[6] "'Fudan Consensus' for 'New Engineering Education' Development," MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201702/t20170223_297122.html.

[7] "'Tianda Action' for 'New Engineering Education' Development," MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201704/t20170412_302427.html.

[8] "'Beijing Compass' for 'New Engineering Education' Development,". MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201704/t20170412_302427.html.

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strong in engineering programs, comprehensive universities, local universities and colleges, government bodies at all levels, and relevant social forces. With respect to higher education institutions, those having renowned engineering education programs are expected to take more advantage of the close ties with the industry to optimize existing disciplines and programs and promote interdisciplinary development, while comprehensive universities are expected to promote the extension of applied science to engineering and cross-discipline integration. Local universities in the meantime are required to respond to local economic demands by producing a large number of skillful talents with strong knowledge in the industry and strong application ability. Governments are asked to provide major supportive measures by strengthening policy consistence and forging united strengths from all relevant stakeholders. Enterprises and industries are encouraged to participate in all phases of education and teaching in order to ensure that engineering education matches industries' demands.

The second document 'Tianda Action' identifies a number of major respects on which engineering education must improve. The use of juxtaposition of six subheads put in a unified language formula especially grasps attention, with each subhead indicating an area to investigate and a goal for NEE reform to achieve. The language format of subheads all follow the pattern of 'studying + (an area) + to (work on) + (an aspect), in order to (achieve a goal)', which strikes a visual, audio and rhetorical effect on the readers. By going through the parallelism used, readers can vividly imagine an overall atmosphere of a stronger national capability to cultivate science and technology graduates based on the improvement of a large number of detailed aspects. The aspects identified to work on include investigation into industrial needs, course upgrade, teaching methods, accountability, resource mobility, and setting standards with reference to international yardsticks (Table 1).

The third document 'Beijing Compass' mainly pertains to the emphasis on the five areas to which NEE is to be developed with mounting attention – conceptual update, structural optimization, pattern innovation, quality assurance, and categorical development – as well as the expected outcomes of the whole reform after measures on those five areas are put in place. Detailed contents portrayed of the five areas are not presented here due to spatial constraints. For each area of the five, existing problems in the current engineering education sector to be resolved are identified. For example, on the area of pattern innovation, it writes that 'the barriers that prevent extensive social participation in the development of engineering education must be overcome by improving a mechanism of multi-agent collaborative education based on closer bonds between scientific development and engineering

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education, between industrial advancement and higher learning, and between universities and enterprises’. Apart from the five areas, the expected outcomes of NEE are presented in this document as well, which is to produce nine ‘multiplicity’ when the reform is finished. These outcomes include:

- a multiplicity of high-quality universities of science and technology
- a multiplicity of colleges of industrialization co-developed and co-managed by multi-agents
- a multiplicity of new polytechnic programs that meet industry demands
- a multiplicity of new curricula that reflect the state-of-the-art technology
- a multiplicity of praxis platforms that integrate education, training and R&D
- a multiplicity of highly professional instructors with strong competence in engineering praxis
- a multiplicity of cross-disciplinary platforms for the R&D of new technologies
- a multiplicity of local industry-oriented platforms for technological innovation
- a multiplicity of transferable reform outcomes

The ‘new’ element in ‘New Engineering Education’ is accentuated in mainly two folds. Firstly, it refers to an array of new programs to be established to meet the newest economic and industrial demands. The demand for manpower in emerging industries such as AI in China is believed to far outstrip supply in the years to come. It is reported that by 2020, the shortage of human power in industries of information and technology, electronic equipment development, high grade CNC machine manufacturing, robotics and new materials is to reach 7.5 million in China, while this number rises to 9.5 million by 2025 (Table 2).[9] The dramatic development of state of the art technologies such as big data, artificial intelligence, and the new businesses these technologies result in also have a big manpower chasm to fill in Chinese society. The ratio of supply and demand in China’s AI industry is reported to be only 1:10.[10] While universities do not have to add new programs to match every emerging industry, it is generally believed that a large number of new programs need to be launched to respond to the rapid

[9] “Compass for Developing Talents in the Manufacturing Industry,” MOE(Ministry of Education) China, accessed August 2, 2018, http://www.moe.edu.cn/srcsite/A07/moe_953/201702/t20170214_296162.html.

[10] “AI Talents Shortage in China over 5 Million in China, Supply Demand Ratio just 1:10,”People’s Daily, accessed August 10, 2018, https://gaokao.chsi.com.cn/gkxx/zybk/zyybk/201707/20170714/1619748158.html.

technological revolution happening across the globe. Secondly, the ‘new’ element refers to the necessity of upgrading existing engineering programs into new ones. Increasing the proportion of practice-related elements into existing engineering programs has become a consensus in the sector. Curricula renewal, teaching methods, governance and many other factors influencing the quality of engineering education are expected to be updated according to industrial demands and international standards.

No matter it’s the ‘new’ program to be established or existing programs to be updated, NEE puts a prominence on promoting connectedness among different disciplines as an approach to educating prospective engineers at higher education institutions. The understanding behind is the importance of an integrated curricula system in developing students’ comprehensive skills to solve complex engineering problems drawing on necessary theories and skills of application from a broad range of disciplines.

Table 1

The six subheads juxtaposed in NEE document ‘Tianda Action’

No	Original Subhead	Translation
1	问产业需求建专业，构建工科专业新结构	Studying demands of industry to establish and develop programs, in order to institute a new structure for engineering programs
2	问技术发展改内容，更新工程人才知识体系	Studying technological development to change contents, in order to upgrade the system for cultivating engineering talents
3	问学生志趣变方法，创新工程教育方式与手段	Studying students’ interest to change methods, in order to innovate teaching approaches and measures for engineering education
4	问学校主体推改革，探索新工科自主发展、自我激励机制	Studying institutions’ accountability to promote reform, in order to explore mechanism for self-development and self-motivation
5	问内外资源创条件，打造工程教育开放融合新生态	Studying resources available to create conditions, in order to build an open and inclusive engineering education
6	问国际前沿立标准，增强工程教育国际竞争力	Studying international frontiers to set standards, in order to enhance engineering education’s global competitiveness

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Table 2

Projections of manpower in ten key manufacturing industries in China

No.	Area	Year 2015	Year2020		Year2025	
		Manpower	Projected Manpower	Manpower Shortage	Projected Manpower	Manpower Shortage
1	New generation of Information & Technology Industry	10,500,000	18,000,000	7,500,000	20,000,000	9,500,000
2	Advanced CNC Machine & Robotics	4,500,000	7,500,000	3,000,000	9,000,000	4,500,000
3	Aerospace Equipment	491,000	689,000	198,000	966,000	475,000
4	Marine Engineering Equipment & Hi-tech Watercraft	1,022,000	1,186,000	164,000	1,288,000	266,000
5	Advanced Rail Transit Equipment	324,000	384,000	6,000	43,000	106,000
6	Energy-saving & New Energy Vehicles	170,000	850,000	680,000	1,200,000	1,030,000
7	Electronic Equipment	8,220,000	12,330,000	4,110,000	17,310,000	9,090,000
8	Agricultural Machinery Equipment	283,000	452,000	169,000	723,000	440,000
9	New Materials	6,000,000	9,000,000	3,000,000	10,000,000	4,000,000
10	Biomedicine & Hi-performance Medical Equipment	550,000	800,000	250,000	1,000,000	450,000

III. **Reflections of international standards in NEE**

Appearing a total of 18 times across the three policy documents, the word ‘国际’ meaning ‘international’ in Chinese language signals both means and end that China pursues. While attempting to develop NEE with Chinese characteristics, China still views engineering education in the developed nations and relevant international frameworks as highlands to imitate and surpass. That's why China regards joining Washington Accord as a milestone of its engineering education history. Regarding this, it has to be said that while the three NEE policy documents are not specific knowledge profiles or skill portfolio for engineering graduates to master, they do draw upon essences of the core spirit of internationally recognized agreements as to the operation of engineering education.

A core part of the Washington Accord is the 12 graduate attributes involving expectations of students on their engineering knowledge, problem analysis, design/development of solutions, investigation using research methods, modern tool usage, the engineer and society, environment and sustainability, ethics, individual and teamwork, communication, project management and finance, and life-long learning. Most of these elements are adapted into NEE's conceptions. For example, as the ability to work with complexity and uncertainty is a defining characteristic of professional engineer in the Washington Accord,[11] NEE absorbs the spirit by accentuating the need to facilitate engineering education based on carrying out increasing interdisciplinary talent training model. It writes that '(it's necessary to) establish new interdisciplinary organizations, offer students interdisciplinary courses, explore curricula patterns oriented to solving complex engineering problems, establish interdisciplinary teaching teams, set up interdisciplinary project platforms, and promote interdisciplinary and collaborative learning'.[12] In response to 'individual and teamwork' in Washington Accord that requires students to function effectively as individuals and members in diverse teams and multi-disciplinary settings, NEE holds that '(it's necessary to) explore an educational pattern that meets individualized needs, encourage students under instructors' guidance to freely select programs and courses in line with their own academic interest and career planning.[13] Similarly, in response to the 'modern tool usage' that calls for the creation, selection and application of appropriate techniques, resources and modern engineering tools, NEE holds that '(it's necessary to) promote further integration of information technology and

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[11] IEA (International Engineering Alliance), *25 Years Washington Accord: Celebrating International Engineering Education*

Standards and Recognition (Wellington, New Zealand: International Engineering Education Alliance Secretariat, 2014), 8.

[12] "'Beijing Compass' for 'New Engineering Education' Development," MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201704/t20170412_302427.html.

[13] "'Beijing Compass' for 'New Engineering Education' Development," MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201704/t20170412_302427.html.

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engineering education and innovate teaching methods under the context of 'internet +' in order to improve the overall efficiency of education and learning.'[14] In addition, the ideas of Washington Accord on educating engineering students such as increasing praxis and practical education, emphasizing problem-oriented and cooperative learning, and building up closer ties between universities and industries are well absorbed into the formulation of the three NEE documents.

Apart from the Washington Accord, NEE draws upon other internationally recognized agreements to plan the development of China's engineering education as well. For instance, when it comes to teaching and learning process, which is an important standard of EUR-ACE framework as well as the CDIO approach that aim to ensure graduates to demonstrate certain knowledge, understanding, skills and abilities by supporting active learning and integrated learning experiences,[15,16] NEE in response regards changing teaching methods in accordance with students' interest and learning science as an important dimension in which reform is supposed to take place. A paragraph is especially made in 'Tianda Action' on studying students' interest to innovate teaching methods, which specifies the urgency and necessity to 'build up a student-centered concept, enhance faculty-student interaction, reform teaching methods and assessment methods in order to form a learner centered engineering education pattern'. It also sets a goal that 50% of all undergraduate engineering students participate in relevant scientific programs during their academic years at school by extensively building up praxis platforms.[17] As for the internal quality assurance which is another yardstick of EUR-ACE that expects a defined and documented procedure for reviewing engineering programs at regular intervals, NEE employs a fairly lengthy paragraph to address how China is to focus more on quality assurance. Apart from measures to be further taken such as issuing quality standards for all science and engineering programs, building up internationally substantially equivalent accreditation system, and formulating

[14] "'Beijing Compass' for 'New Engineering Education' Development," MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201704/t20170412_302427.html.

[15] "EUR-ACE Framework Standards and Guidelines (EAFSG)," ENAEE, accessed Oct 13, 2018, http://www.enaee.eu/wp-assets-enaee/uploads/2017/11/EAFSG-Doc-Full-status-8-Sept-15-on-web-fm.pdf.

[16] Peter Gray, "CDIO Standards and Quality Assurance: From Application to Accreditation," *International Journal of Quality Assurance in Engineering and Technology Education* 2, no. 2 (2012): 34

[17] "'Tianda Action' for 'New Engineering Education' Development," MOE(Ministry of Education) China, accessed June 1, 2018, http://www.moe.edu.cn/s78/A08/moe_745/201704/t20170412_302427.html.

engineering program-oriented faculty evaluation standards and promotion mechanism, it also emphasizes the necessity to come up with a multi-agent evaluation mechanism to assure the quality of engineering programs. Besides, the emphasis on promoting faculty members’ engineering experiences and exposure to real engineering contexts in NEE documents is at one with numerous international agreements on engineering education including EUR-ACE framework, APEC engineer framework, and CDIO approach. The lack of sufficient engineering experiences in Chinese engineering has been repeatedly spotted in NEE documents as a severe barrier constraining the overall upgrade of the engineering education sector.

It’s worth noting that NEE is not a procedural regulation despite that it embodies the latest aforementioned internationally recognized ideas on developing engineering education. It charts out a picture of systematic engineering strengths at both macro and micro level, which are based on developing the sector in line with and even in a more vigorous manner than the international standards such as the Washington Accord graduate attributes. Rather than solely focusing on enhancing students’ learning at school, which is an important goal of NEE documents, NEE attempts to implement the reform by renewing the overall ecosystem of the engineering education sector into a more open one where students’ four years’ educational experiences at school are benefited by multiple stakeholders. This attempt could be a success if right measures on cultivating cross-disciplinary talents are put in place as it embodies the student-focused idea reflected by the numerous international agreements. However, there is also possibility of ‘putting the cart before the horse’ if a commensurate evaluation system is not put in place to truly shift the focus back to teaching and learning, upon which I will elaborate in the final section of the paper.

IV. **Actions under the NEE initiative**

A number of major efforts have been made to promote the reform of the engineering education sector since NEE series documents were issued in 2017, the most influential of which has been the formulation of the first edition of national standards (National Standards hereafter) on teaching quality for a total of 92 *categories* of specialties.[18] As mentioned, NEE is not

[18] “Information Briefing on National Standards of Undergraduate Programs,” MOE(Ministry of Education) China, accessed June 10, 2018, http://www.moe.gov.cn/jyb_xwfb/xw_fbh/moe_2069/xwfbh_2018n/xwfb_20180130/201801/t20180130_325928.html.

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a concrete procedural regulation, and therefore the formulation of National Standards attempts to be a follow-up of NEE guiding policies. Besides, the Ministry of Education has also commissioned hundreds of research projects to scholars nationwide to study engineering education sector to be updated on many fronts. Pilot attempts to develop interdisciplinary courses, strengthening university-industry partnerships and carrying out accreditation for engineering programs are other efforts.

IV.1. *Formulation of National Standards for a multiplicity of categories of programs*

According to the *Catalogue of Specialty* issued by China's Ministry of Education,[19] category is a unit at a higher level than program, and a category may include a few specific programs. For instance, under the category of forestry, there are a number of specific programs such as forest engineering, wood science and engineering, and forest chemical. Similarly, the category of electronic information includes a total of 16 programs such as telecommunication engineering, microelectronics science and engineering, photoelectric information science and engineering, integrated circuit design and integration system engineering, electromagnetic fields and wireless technology engineering and so forth. Calculated in this way, the National Standards issued in early 2018 cover a total of 587 undergraduate programs, approximately half of which are engineering-related.

The National Standards for each category of specialty includes exogenous and endogenous requirements of the program's development. The exogenous requirements include goals for learning outcomes, length of schooling, degrees awarded to qualified graduates, referential credits to be earned, faculty student ratio, expectations of faculty members' background, environment for faculty development, education facilities buildup, technological resources, institutional investment in the program, quality assurance mechanism, and so on. Endogenous requirements are more about the curricula that are supposed to be established, such as gateway courses, prerequisite courses, core courses, special courses, laboratory courses, internships, capstone projects and so forth. For instance, the National Standards for the Category of Electronic Information stipulates that the

[19] "Catalogue of Specialty (2012 version)," MOE(Ministry of Education) China, accessed June 10, 2018, http://old.moe.gov.cn/publicfiles/business/htmlfiles/moe/s3882/201210/143152.html

student faculty ratio for all the programs under this category must be less than 25:1, and the minimum number of full time instructors for every program must be equal to or higher than 10. It also sets 35% as the baseline for a program’s full time faculty members with a PhD degree, while this percentage for those with a master’s degree at least is set 60%. Besides, it requires that a program ensures that at least 20% of all its faculty members possess working experiences in enterprises or other forms of practical engineering experiences, and faculty members with a title of associate professor and above must account for at least 30% of all members within each of the program. With respect to endogenous requirements, apart from prerequisite courses such as advanced mathematics, engineering mathematics, advanced physics, and a few other general courses, the National Standards stipulates that the program of telecommunication engineering, for example, must include four modules of basic courses out of six from communication theory, digital signal processing, theoretical basis of information, information networks, communication circuit and system, and engineering graphics. In addition to the prerequisites and basic courses, telecommunication engineering programs must also offer students core courses including digital communications, theoretical basis of communication networks, modern switching technology, multimedia communication, wireless communication, broadband access and internet communication, antennas and radio waves, optical communications and optical networks, mobile internet and terminal, radio-frequency technology, satellite communications, and mobile communications as required.[20]

According to relevant officials in charge in the Ministry of Education, the formulation of the National Standards is a systematic project based upon hundreds of seminars and discussions involving more than 5,000 experts and professionals led by committees for each of the 92 categories of specialties.[21] Taking National Standards for programs under the Medicine Category for example, before the formulation of the standards, the preparatory efforts made included administering 15,000 questionnaires, setting up 16 projects, establishing a database of program status, investigated and surveyed approximately 50 representative pharmacy colleges and universities, 60 pharmaceutical praxis bases and 30 employers within the field, which

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[20] TCMOE(Teaching Committee of Ministry of Education), *National Standards on Teaching Quality for Undergraduate Programs* (Beijing: Higher Education Press, 2018): 304-314.

[21] “Information Briefing on National Standards of Undergraduate Programs,” MOE(Ministry of Education) China, accessed June 10, 2018, http://www.moe.gov.cn/jyb_xwfb/xw_fbh/moe_2069/xwfbh_2018n/xwfb_20180130/201801/t20180130_325928.html.

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provided abundant data to support the formulation of the program standards. Moreover, more than 80 medicine-related experts and 20 some professionals from the pharmaceutical industry participated in the formulation.[22] Having been formally issued in 2018, the National Standards are scheduled to wield influences as guidance on the formulations of detailed plans of program education and the implementations of basic development requirements for public higher education institutions across China.

IV.2. *Commissioning 600+ research projects on NEE development*

In line with a message conveyed by one of the three NEE documents – Beijing Compass that NEE development requires further research of various fronts such as how to realize ‘new idea’, ‘new structure’, ‘new pattern’, ‘new quality’, and ‘new system’, the Ministry of Education has had 612 research projects commissioned by scholars from hundreds of universities across the country,[23] among which 202 projects are pertaining to the comprehensive reforms of NEE while 410 projects are of relevance to engineering program reform.

Examples related to comprehensive reforms of NEE include projects entitled ‘Establishment of a Multidisciplinary Curricula System to Produce Engineering Talents’, ‘Explorations and Practices of Updating Traditional Engineering Programs in a New Industry and New Technology-oriented Context’, ‘Smart Engineering and Creative Design’, ‘NEE-oriented Engineering Praxis Education and Praxis Base Development ’, and so on, while those related to specific engineering program reform include projects such as ‘Exploring Establishment of Curricula System for Artificial Intelligence Program’, ‘Reform and Practices of Data-centered Computer Engineering’, ‘Exploration of the Pattern of “VR+Education” under NEE Context’, ‘Building Course System for the NEE Underpinning Course – Physics’ and many others.

It’s worth speaking that heeding international experiences is also a salient feature among the 612 projects approved. Cross-nation-related projects can be divided into mainly two major categories. One category is

[22] “Information Briefing on National Standards of Undergraduate Programs,” MOE(Ministry of Education) China, accessed June 10, 2018, http://www.moe.gov.cn/jyb_xwfb/xw_fbh/moe_2069/xwfbh_2018n/xwfb_20180130/201801/t20180130_325928.html.

[23] ”Announcement of NEE Research Projects, ” MOE(Ministry of Education) China, accessed June 18, 2018, http://www.moe.gov.cn/s78/A08/A08_gggs/s8468/201801/t20180123_325345.html.

comparative study of international experiences and lessons on engineering education development and reform, exemplified by projects such as 'Comparisons and Lessons of International Engineering Education Reform Experiences', 'Explorations and Practices of Educational Patterns fit for NEE with International Features', 'International Multidisciplinary Engineering and Technological Talents Cultivation Praxis Supported by Open Channel Bridging Undergraduate and Graduate Education'. The other type pertains to the internationalization of Chinese engineering programs like 'Development of Praxis Competence of Students of Sino-Foreign Joint Engineering Programs Oriented towards International Industrial Demand', 'New Patterns of Internationalization of Rail Transit-related Programs under the Belt and Road Initiative', 'Study of Internationalization of Architecture-related Programs' and many others.

For all intents and purposes, the Ministry of Education hopes through commissioning these research projects that NEE moves forward on an evidence and research-based ground, drawing upon a deeper understanding of the inner requirements of engineering disciplines and successful experiences of international peers.

IV.3. *Establishment of new programs and interdisciplinary courses at higher education institutions*

Many universities in China have developed resources to establish a number of new programs over the past year in line with one of the basic requirements of NEE policy documents, which is to establish new programs catering to new industrial demands. A majority of these newly established programs are engineering programs. It is expected that the new programs set up adopt an idea of 'concurrent engineering'[24] by requiring students to learn different modules of knowledge at the same time that only belonged to different programs in the past. For example, seeming hallow at first glance, the program of 'Internet of Things' in fact requires students to learn courses from different tracks during their four years covering information technology, sensor technology, embedded system technology, security insurance etc. Therefore, not every university is entitled to setting up whatever new programs they want. It's worth mentioning that every university has to apply first to the Ministry of Education and obtain approval if they want to set up a

[24] Paulo Davim, *Mechanical Engineering Education* (London: Hoboken, NJ: ISTE, Ltd., 2012), 89

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new program. Otherwise, the newly established programs without approval are not entitled to granting graduates graduation certificates. The Ministry of Education goes through a procedure to evaluate all the applications and offer permissions to institutions that only pass relevant standards.

One example of the new programs approved is the 'Program of Intelligent Architecture' at Tongji University in Shanghai, a renowned university boasting its architecture-related programs. The new program makes civil engineering as its core, incorporating elements from other majors like urban planning, mechanical engineering and electronic and information engineering, in order to guarantee that the element of 'intelligent' takes good advantage of both traditional theoretical foundations in architecture and modern means of information technology. In terms of qualifications to set up the new program, Tongji University is the only higher education institution permitted to launch 'Program of Smart Architecture' in 2018 based on its proven manpower and hardware resources.

Even with the Ministry of Education's stance to sift programs applied, there has been a prevalent momentum of setting up new programs at universities across the country. Among all the programs newly added, data science or big data technology, robotics engineering, artificial intelligence are the hottest keywords. According to Ministry of Education's announcement of approved newly-established programs across Chinese universities in 2017, a total of 250 universities newly established the program 'Data Science and Big Data'[25] as a result of the nation's emphasis on the advancement of data technology and data industry over the years. 'Robotics Engineering' was established by 60 universities, and 15 universities initiated 'New Energy Materials and Devices'.[26] Other emerging programs claimed to future-oriented include 'Smart Medical Engineering', 'Artificial Intelligence' and so on.

Apart from the attempt to cultivate artificial intelligence talents by setting up new programs, more than 10 first-tier universities such as Tsinghua University and Nanjing University have formally kick started a school of artificial intelligence as an independent department. This number is projected to continue to increase in the years ahead as the Ministry of Education has set

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[25] "Verification of Undergraduate Programs Applied in 2017," MOE(Ministry of Education) China, accessed July 20, 2018, http://www.moe.gov.cn/srcsite/A08/moe_1034/s4930/201803/t20180321_330874.html.

[26] "Verification of Undergraduate Programs Applied in 2017," MOE(Ministry of Education) China, accessed July 20, 2018, http://www.moe.gov.cn/srcsite/A08/moe_1034/s4930/201803/t20180321_330874.html.

a goal of having approximately 50 such departments across the nation by 2020.[27]

In addition to the establishment of new programs, many universities have attempted to adjust their course groups to develop interdisciplinary courses and increase the interdisciplinary features of existing courses. The promotion of cross-disciplinary connectedness is mostly carried out via two means. First is the enhancement of connectedness of engineering courses and their related disciplines. At one university in Anhui Province, for example, in the past students of the program of electronic information engineering would spend most time learning theoretical courses of 'signal and system', 'digital speech processing', 'digital image processing', 'digital signal processing' and 'complex variables functions' when it comes to signal-related fields. In the past year, the university has added project-based courses of 'FPGA chip technology', 'DSP chip technology', 'deep learning: speech recognition' and 'DSP & machine vision' based on previous courses to enable students' deep exposure to the curricula group. Moreover, courses of 'C programming language' and 'EDA technology and application' from the related disciplines are also provided to students.[28] The second measure adopted by many institutions is to enhance the connectedness of engineering disciplines and humanities. This attempt is reflected by many courses whose names include 'design thinking', 'innovation and entrepreneurship' or 'sustainable development' which usually require both engineering skills and visions of the future. In Tongji University, there were 96 interdisciplinary courses scheduled to be provided for students of Year 2018,[29] while Southwest Jiaotong University just finished developing 30 interdisciplinary courses to be delivered,[30] to name a few. To ensure the effective implementation of interdisciplinary courses provision, many universities have re-edited relevant regulations to align the relationship between core courses, minor courses, and elective courses.

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[27] "Higher Education Institutions AI Innovation Initiative," MOE(Ministry of Education) China, accessed July 28, 2018, http://www.moe.gov.cn/srcsite/A16/s7062/201804/t20180410_332722.html.

[28] Shishu Yin, Songtao Wang, and Kaiyu Duan. "On the Course Group Construction for Signal Processing in the Context of New Engineering," *Journal of Changsha University* 32, no. 2 (2018): 127.

[29] "NEE Explorations by Tongji University," Tongji University, accessed October 8, 2018, https://news.tongji.edu.cn/classid-18-newsid-57831-t-show.html

[30] "SWJTU issued 30 cross-disciplinary courses for selection," Southwest Jiaotong University, accessed October 8, 2018, http://dean.swjtu.edu.cn/servlet/NewsView?NewsID=1DC26A9BDF189B17.

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IV.4. *Strengthening university-industry partnership*

For a long time, China’s engineering education has fallen short of its international peers because of insufficient university-industry partnerships.[31] A deeper and more extensive collaboration between university and industry has been once again placed a high value under the NEE context. In response to the international standards in which university-industry partnership constitutes a central component of engineering education,[32] Chinese universities have been more aware of the importance and been more committed to establishing closer university-industry ties to facilitate the quality of engineering education.

The past few years have witnessed the growth of university-industry partnerships as well as the environment supporting such partnerships in China compared with before, featured by a large number of higher education institutions having established outside-campus internship bases in collaboration with businesses and other practitioner organizations. University technology transfer centers, university science parks, university-industry cooperative laboratories, university-affiliated state key laboratories, and internship bases have sprung up across the nation as forms of collaboration between higher education institutions and industries.

In addition, many higher education institutions have formulated relevant policies to require their instructors to work in business or relevant industry organizations for at least half a year if the instructors want to get promoted smoothly. To name a few, People’s Public Security University of China, a police-training university with engineering programs such as forensic science and traffic management, have established internship bases with police bureaus across the nation. Not only students are required to have 3-month internships at corresponding bases outside school before they graduate, it is also a must for instructors to work in a cooperative police bureau station for at least six months. Shanghai University of Engineering Science has worked with the company Shentong Metro to co-establish a praxis base where its faculty and staff can be more exposed to industry manufacturing procedures. Nanjing University of Posts and Telecommunications (NUPT), a relatively big name for electronics and information engineering programs in China, have instituted a mechanism called ‘three ins and three outs’ to strengthen the linkage with

[31] Zhenyi, Guo and Stephen Lamb. *International Comparisons of China’s Technical and Vocational Education and Training System* (Dordrecht: Springer, 2010), 20.

[32] Ruth Graham. *Achieving Excellence in Engineering Education --- The Ingredients of Successful Change* (London: Royal Academy of Engineering, 2012), 41.

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the information industry. ‘Three ins’ refers to the policy of bringing in industry expertise to classroom, developing laboratories co-established by the university and the industry, and bringing in curricula developed by enterprises in the relevant industry. ‘Three outs’ means sending out instructors to enterprises to enhance their industry experiences, sending out students to enterprises for internships, and sending out students to enterprises for the capstone projects before they graduate. Meanwhile, a set of curricula related to career development and sales management in telecommunications are co-developed by NUPT and some telecommunications giants like ZTE. In all these aforementioned universities, there are stipulated policies that without industrial experiences, the promotion is not feasible for instructors no matter how many publications they produce. These measures have indicated growing efforts of strengthening university-industry partnerships in the Chinese engineering education sector.

IV.5. *Accrediting Engineering Programs*

Consisting of 33 group members and some individual members, Chinese Engineering Education Accreditation Association (CEEAA) is the major organization responsible for accrediting Chinese engineering programs. Under the NEE context, CEEAA has placed a high value on the rigorous accreditation process to ensure that all accredited programs truly meet international standards set by the Washington Accord of which China strived to become a member. In the meantime, application for being accredited has much grown from Chinese universities in that joining Washington Accord indicates that the individual engineering programs accredited in China is also recognized by other international signatories, which could benefit the universities in terms of program brand, international mobility and student quality.

In Nov 2017, CEEAA issued an updated version of ‘Guidance on the Engineering Education Accreditation Self-assessment Report’[33] (‘Guidance’ hereafter) to raise expectations on individual higher education institutions that hope to apply for accreditation. Filling the report is the first step in the whole application procedure. The Guidance requires institutions to report on seven major aspects of program operation, including students, program

[33] “Guidance on the Engineering Education Accreditation Self-assessment Report,” China Engineering Education Accreditation Association, accessed June 23, 2018, http://www.ceeaa.org.cn/main!newsTop.w?menuID=01010704.

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goals, graduate attributes, mechanism of ongoing improvement, curricula system, faculty members and supporting facilities. The seven aspects are detailed in Table 3.

The formulation of the Guidance takes consideration in both international standards and Chinese higher education reality. It can be seen that each of the seven aspects has a number of major expectations with various detailed indicators to measure the actual performance of the program. It’s worth noting that the ‘Graduate Attribute’ part of the Guidance, which is a core part, draws entirely on Washington Accord except for just one minor difference on the aspect of ‘Communication’. It indicates that Chinese engineering education sector has completely used the internationally recognized standards as a basic yardstick to measure its own programs. The minor difference is the addition of ‘communicating effectively in a cross-culture setting with global visions’ to the aspect ‘Communication’, which further embodies China’s determination to get fully integrated into the international community and push forward internationalization. This echoes the aforementioned point that China still views ‘international’ standards led by developed nations as highlands to reach.

Among a total of 19,000 plus engineering programs across all Chinese higher education institutions, 846 programs of 196 universities have been accredited as of yet.[34] Currently, Chinese higher education institutions produce approximately 1.2 million engineering graduates every year. Those who graduate from the accredited programs are entitled to equivalent recognition by other Washington Accord signatories when they seek employment in relevant signatory countries, thus having more advantages than their fellow students who graduate from non-accredited programs.

[34] “Engineering Program Accreditation Covering 21 Categories, Expecting Full Coverage by 2020,” China Engineering Education Accreditation Association, accessed June 23, 2018, http://www.ceeaa.org.cn/main!newsView.action?menuID=01010401&ID=1000011710.

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Table 3

Guidance on Engineering Education Accreditation Self-assessment Report

Aspect	Expectation	Indicators
Students	Establishing mechanism to attract outstanding students	Existing sources of students in admission and streamlining procedures
		Regulations formulated and measures taken to attract outstanding students and how well they are implemented
		Analysis of changes of variation of source of students based on external factors such as admission policies, employment environment, as well as measures to cope with the changes
	Taking measures to improve student counseling, career development, employment guidance, psychological guidance	Regulations and measures to guide students’ learning, career planning, employment guidance, psychological counseling
		Contents and effects of all types of relevant guidance and counseling, including ways of guidance or counseling, implementer, and frequency of delivering guidance
		How guidance or counseling help students understand requirements on graduation, and course achievement, especially how instructors guide students to clarify learning goals, master effective learning methods and meet learning expectations.
	Tracking students’ learning process	Report on program stipulations on students’ graduation and acquisition of degrees
		Ways of tracking students’ ongoing performance at school
		Early warning system and assistances to students with academic difficulties
	Mechanism of recognizing program transfer and previous credit	Schemes, procedures and responsible persons to recognize programs’ new comers’ previous credits in another program
		Provision of specific cases of accepting transferred students, evidences and procedures of recognition of previous credits

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Aspect	Expectation	Indicators
Program Goals	Open, realistic goals catering to social and economic development	Complete written description of program goals, including areas of employment for graduates, job features and skills needed
		Elaboration upon the relationship of program goals, university positioning, talent orientation and social and economic development
		Channels of making program goals available to general public, and how students, instructors and the society understand the goals
	Periodic regulation of reasonability of program goals and revision of goals	Regulations and measures to evaluate the reasonability of program goals
		Contents of reasonability of program goals
		Methods of evaluation of reasonability of program goals
		The latest evaluation outcome
		Mechanism of revision of existing program goals
		The latest revision
		Roles of industrial and entrepreneurial experts' participation in the revision of program goals
Graduate Attributes	Engineering knowledge	Application of knowledge of mathematics, natural sciences, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
	Problem analysis	Application of fundamentals of mathematics, natural science and engineering science to identify, express and analyze through literature research complex engineering problems to reach substantiated conclusions
	Design/development of solutions	Designing solutions for complex engineering problems and designing systems, components or processes that meet specified needs with appropriate consideration for public health, safety, legal, cultural, societal, and environmental considerations
	Investigation	investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions

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Aspect	Expectation	Indicators
Graduate Attributes	Modern tool usage	Creation, selection and application of appropriate techniques, resources and modern engineering and IT tools, including prediction and modeling, to complex engineering problems, with an understanding of the limitations
	The engineer and society	Applying reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems
	Environment and sustainability	Understanding and evaluating the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts
	Ethics	Application of ethical principles and commit to professional ethics and responsibilities and norms of engineering practice
	Individual and teamwork	Functioning effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings
	Communication	Communicating effectively on complex engineering activities with the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, give and receive clear instructions, *and communicating effectively in a cross-culture setting with global visions*
	Project management and finance	Demonstration of knowledge and understanding of engineering management principles and economic decision-making and applying these in multi-disciplinary environments
	Life-long learning	Recognizing the need for, and being prepared and able to engage in independent and life-long learning in the broadest context of technological change

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Aspect	Expectation	Indicators
Ongoing Improvement	Quality control mechanism for teaching process	Report of quality requirements for all major phases of teaching
		Mechanism of quality control for teaching process and its implementation, including curriculum system, revision of evaluation, formulation and evaluation of syllabus, observation of classroom teaching, assessment methods
		Effectiveness of the quality control mechanism, including the latest outcomes of curricula revision, examination of syllabus, curricula, and realization of learning goals
		Evaluation of graduate students’ meeting graduate attributes, including evaluation methods, periods, persons in charge, evaluation standards, and feedback channels;
	Mechanism of tracking graduates’ development and societal evaluation	Mechanism of tracking graduates’ development and its implementation
		Mechanism of societal evaluation of graduates’ quality involving employers, alumni, and other stakeholders of higher education and its implementation
		Operation of tracking graduates’ development and multi-agent societal evaluation in the latest three years, including contents, methods and objects, based on which presenting analysis of realization of learning objectives
	Evidence of applying evaluation outcomes to the ongoing improvement of the program	Presentation of the latest evaluation outcomes for educational objectives, graduate attributes realizations, curricula system, and curricula quality and the evidence of how the evaluation outcomes are used for ongoing improvement of the program
Curricula	Curricula support of graduate attributes	Demonstration of how courses set correspond to relevant requirements of graduate attributes
		Formulation and revision of syllabus
		Demonstrations of complete teaching plans and illustration of how prerequisites support following courses
		Credits required to obtain for graduation and guidance to students on course selection

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Aspect	Expectation	Indicators
Curricula	Industrial experts’ participation in curricula design	Curricula revision and relevant requirements, including the latest procedures of revising curricula and contents, especially illustrating how industrial experts play their roles in revising the curricula
	Roles of engineering basic courses, program basic courses, and specialized courses in promoting students’ professional development	List of three categories of courses with credits for each course: ‘engineering basic courses’, ‘program basic courses’, and ‘specialized courses’
		Illustrating requirements of taking these courses
		Demonstration of how these different categories of courses facilitate system design capability and foster professional competence
	Engineering praxis and capstone projects (thesis)	Demonstration of praxis education system, including partnership with industries, and businesses; how topic of capstone project attempts to resolve practical engineering problems
		Credits for the compulsory capstone project before students graduate
		Requirements on individual students’ experiences of internships at business or enterprises
		Praxis education by students in groups
		Categories of capstone projects in the latest three years
		Establishment of praxis bases jointly established with enterprises
	General courses in humanities	Credits for courses set up
		Requirements of students taking these courses and supporting measures
		Roles of courses in fostering students’ comprehension and application of engineering knowledge in economic, environmental, legal and ethical terms.

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Aspect	Expectation	Indicators
Faculty Members	Quantity and structure	Demonstration of reasonableness of full-time faculty members' quantity, professional title structure, age structure, degree structure
		Demonstration of participation of part-time faculty members from industries and enterprises in teaching and other teaching-related work
	Professional competence	Teaching ability and professional level
		Demonstration of faculty members' engineering practices, engineering research, and other teaching-related academic exchanges
		Standards to evaluate individual faculty members' engineering backgrounds and the overall engineering level of the whole faculty
		Demonstration of faculty members' backgrounds and competence meeting complementary standards of teaching
	Time and energy invested in teaching	Regulations and measures to ensure faculty members invest sufficient time in teaching
		Faculty members' time-spending on teaching
		Regulations and measures that encourage faculty members' participation in teaching research and teaching reforms, including actuality and effects
	Support to students	Regulations and measures that require faculty members to provide counseling and instruction to students on their career planning and preparation
		Listing faculty members' all kinds of support to students in addition to classroom teaching
	Faculty responsibility	Regulations and measures that ensure faculty members bear responsibility to provide quality teaching, especially how to promote faculty members to comprehend outcome-based education and fulfill relevant duties
		Demonstration of methods of facilitating and judging faculty members' fulfillment of duties, as well as the accountability system for teaching quality

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Aspect	Expectation	Indicators
Supporting Facilities	Classrooms, labs and equipment	Basic requirements on the provision of classrooms, labs and other equipment
		Mechanism for operation, maintenance and security management of laboratories
		Reality of praxis bases outside campus and their roles
	Computer, network and library resources	Basic requirements on the provision of the resources to ensure the operation of the program
		Regulations and measures of managing and sharing relevant resources
	Educational funding	Regulations, stipulations and standards of educational budget, appropriation and use
	Institutional support of faculty development	Regulations and measures to support faculty members’ professional development
		Specific measures to support faculty members’ professional development and enhancement of teaching capability in the last three years
		Specific measures to support young faculty members’ professional development and engineering practices in the last three years
	Infrastructure for students’ completion of education	Infrastructure provided for students’ learning and achieving all educational goals, including practical and innovative activities
	institutional management and service	Management and service measures to facilitate students’ achieving all kinds of learning goals

IV.6. *Establishing external and internal quality assurance mechanisms*

Since NEE was initiated, China has endeavored to complete a quality assurance mechanism for engineering education with two tracks: external quality assurance and internal quality assurance. There are three-level stakeholders for external quality assurance involving the Chinese Engineering Education Accreditation Association (CEEAA), the Ministry of Education and engineering industries, while higher education institutions are the main subjectivity for the internal quality assurance.

For external quality assurance, firstly, as illustrated previously, CEEAA as the main accreditation authority for engineering programs exerts the most important impact on guiding and assuring the quality for engineering programs. They use a yardstick substantially equivalent to graduate attributes of Washington Accord to measure the performance of individual engineering programs and accredit qualified ones. As such accreditation defines both the reputation and recognition of the program and their providers, and also affects student employment, higher education institutions all place a high value on meeting accreditation standards if they want to attract more funding and more qualified students. Secondly, apart from CEEAA’s accreditation, the Ministry of Education (MOE) also evaluates the quality of engineering programs with their own evaluation standards. In the current context of China’s continued ambition to develop world-class universities and world-class disciplines (Double World-class),[35] MOE considers CEEAA accreditation results in its evaluation of relevant engineering disciplines, but their measures to evaluate the quality of disciplines, including engineering disciplines are more rigorous.[36] In other words, MOE’s evaluation standards are higher than CEEAA’s accreditation standards so as to push potential programs to not only meet the bottom line but also race to the top globally. The third stakeholder to for quality assurance of engineering programs is the industry. MOE encourages and supports enterprises’ in-depth collaboration with higher education institutions by issuing reports on manpower demand by the market, quality of graduates, providing feedback on praxis education, etc. These reports wield influences on institutions’ adjustment of curricula and education schemes by providing timely alarming precaution.

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35 Double World-class is a plan initiated by Chinese government to develop some Chinese universities to be globally renowned and some academic disciplines to be globally influential in the years to come.

36 “On Accelerating the Development of NEE and the Implementation of Outstanding Engineers Project,” MOE (Ministry of Education) China, accesed July 15, 2018, http://www.moe.gov.cn/srcsite/A08/moe_742/s3860/201810/t20181017_351890.html.

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In terms of internal quality assurance, every higher education institution is required to improve program quality through four aspects: 1) establishing a monitoring mechanism for educational process rather than outcome, namely, setting clear standards and goals for specific educational activities such as course development and assessment method development; 2) tracking program graduates on their employment and career development and also seeking their feedbacks on how engineering programs at school should further improve; 3) establishing a social participation mechanism such as asking an independent professional third-party organization to evaluate how well educational goals are achieved; and 4) providing evidence of actual adoption of evaluation results to ongoing program improvement.[37] While MOE leaves the responsibility of internal quality assurance to higher education institutions themselves, institutions are still required to submit an undergraduate education internal quality assurance report and fill in relevant data to an MOE online data collection platform, and these reports then all go public to be viewed by the society. The quality assurance mechanism in process is displayed in Fig 1.

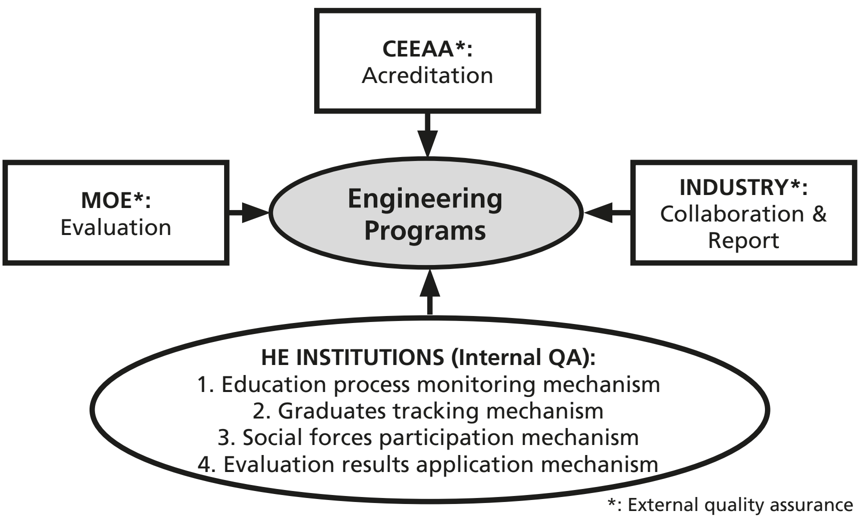

Fig 1

External and Internal Quality Assurance (QA) Mechanism

[37] MOE (Ministry of Education) China. *Annual Quality Report of Engineering Education in China* (2013) (Beijing: Higher Education Evaluation Center of the Ministry of Education, 2014), 69.

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V. Challenges for China's NEE

While joining the Washington Accord is a victory step and a new starting point for Chinese engineering education, challenges remain for NEE to achieve its original goals due to the complexity of systematic changes and other barriers constraining core activities of higher education – delivery of high quality teaching and versatile experiential learning.

V.1. *The enlarged uneven resource allocation could hinder the pace towards systematic reform*

According to the three NEE official documents, systematic changes in a broad range of aspects from curricula, praxis platforms, teaching methods, university-industry collaborations and many others are expected to be the ultimate goals of NEE. Systematic changes, however, demand collaboration and synergy of different departments within the system. Borrego and Henderson identified four levels of change that are usable to inform changes in STEM instruction at university level, including disseminating curriculum and pedagogy, developing reflective teachers, enacting policy, and developing shared vision. On each of these four levels, there are more detailed aspects in which practical operations should be conducted, including diffusion, implementation, scholarly teaching, faculty learning communities, quality assurance, organizational development, learning organizations and complexity leadership.[38] Each level and strategy demand different agents to discharge duties in a collaborative and synergetic manner before the fundamental systematic changes can be achieved, and the complexity of the system of engineering education demands strong and effective support from a professional leadership within an institution.

The current higher education system in Chinese mainland, however, is not without constraints in making the systematic changes happen. China's higher education institutions are standing in a hierarchical structure, with those standing at the top always drawing funding and recognition while those standing at the bottom become the disadvantaged.[39] This unevenness has

[38] Maura Borrego and Charles Henderson. "Theoretical Perspectives on Change in STEM Higher Education and Their Implications for Engineering Education Research and Practice," *Journal of Engineering Education* 103, no. 2 (2014), 224

[39] Ryen M. Allen, "A Comparison of China's 'Ivy League' to Other Peer Groupings through Global University Rankings," *Journal of Studies in International Education* 21, no. 5 (2017):396.

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grown enlarged over the years and contributed to the uneven pace of NEE development across institutions. One example of such resource is the research grant. The amount of grants obtained by top-tier institutions can be 150 times that gained by institutions in the bottom tier. For instance, in 2017, the first-tier Tsinghua University tops the list of total volume of research grants in China, obtaining 1.6 billion RMB (around 250 million US dollars) in total, followed by Shanghai Jiaotong University, Nanjing University and Zhejiang University which also belong to the first tier of universities obtaining approximately 800 million RMB (around 125 million US dollars). Comparatively, the grants gained by third-tier or even lower-tier institutions are astonishingly less compared with the top, with Wuhan Institute of Technology, Hebei Normal University, Shenyang University of Architecture being granted merely 10 million RMB, to name a few (Fig 2).

Money as a type of important resource directly makes a difference in the development of engineering education, determining institutions’ relationship with industries, facility set-up, and most importantly, the quality of instructors. As the vastly uneven distribution of resources received by different tiers of institutions signals different governmental expectations, official support as well as social recognition, the current stratification of the higher education institution structure is likely to continue and even enlarged in the future. Such stratification and resource distinction affect institutions’ capability to implement international standards on graduate attributes and other aspects in developing NEE. It’s projected that there is likely to be a continued quality gap between institutions of different tiers in the process of developing NEE, thus affecting the systematic change of the NEE initiative.

While such a gap is unlikely to be completely filled due to the salient advantaged positions of the top-tier universities, resources have to be mobilized towards a more balanced scenario in which lower-tier universities have access to more resources for the comprehensive improvement of their engineering programs. This requires a policy and focus shift at both state-level and provincial-level governments from ‘icing on the cake’ to ‘sending charcoal in snowy weather’.

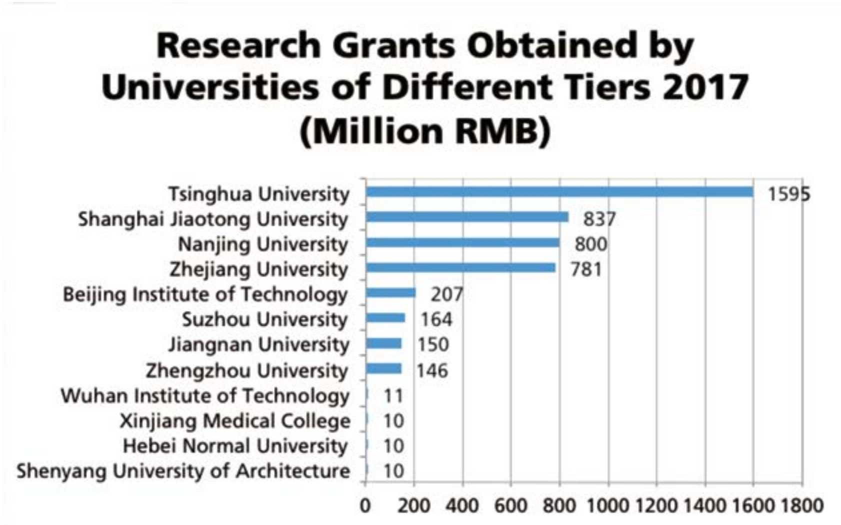

Figure 2

Research Grants obtained by Universities of Different Tiers in 2017
Source: Formulated based upon http://www.polymer.cn/sci/view.aspx?id=13253

V.2. *The core mission ‘teaching’ downplayed by bureaucratization and over pro-research evaluation system*

No matter how much investment an institution can make in the hardware facilities, there are constant things determining whether students learn and acquire skills effectively. For example, there are important issues as to whether students are learning in an environment where their curiosity and passion for the field are easily ignited, and whether they receive great teaching from highly trained faculty members to form a solid theoretical and applicable foundation. Bureaucratization and the over-pro-research evaluation system, however, are barriers that hinder students from having the best possible educational experiences. Such system constrains individual instructors and departments from working in solidarity towards the realization of NEE goals. Jia and Xiao[40] identified five stakeholders of China’s engineering education sector: students,

[40] Guangshi Jia and Chengbin Xiao. “Research on Five Stakeholders and Five Relationships of Higher Engineering Education in China,” *L.J. Modern Education and Computer Science 1,* (2009): 63.

teachers, universities, employers and governments. Among the five, government is the dominant stakeholder possessing the power of resource allocation to different universities. Excessive influences from the government and insufficient effective influences from the employers on higher education institutions have rendered universities to form pro-government policies while downplaying industries' roles. Dominant roles of the government have shaped the internal relationship within an institution as well. Internally, administrative bodies that directly receive governmental funding are also usually in charge of allocating them, thus having more say than academic bodies and individuals, which means that voices from students and instructors are far weaker in promoting a change. Under such a power structure, academic departments more than often prioritize demands from administrative bodies over issues pertaining to the improvement of students' learning.

Besides, the current pro-research evaluation system could also pose a threat to engineering students in receiving the best quality of instruction. For example, many projects instructors undertake required by the promotion system are not related to teaching engineering or engineering education reform. Moreover, the current evaluation system puts instructors under great stress who have no mood to care about how well they teach. Huang, Pang and Yu[41] through analyzing academic identities of instructors working at two Chinese universities known for their engineering programs, categorized Chinese academics into six categories: 1) the managerial advocate, 2) the academic chameleon, 3) the knowledge worker, 4) the stressed faculty, 5) the resolute pilgrim, and 6) the careless outsider. From the six terms the authors chose to use, a competitive and stressful climate where Chinese university instructors are working is revealed. For instance, knowledge workers refer to the junior academic people who feel themselves workers on an academic assembly line and only make efforts to meet the lowest expectations of teaching students. The stressed faculty and the resolute pilgrim believe that the current evaluation system is rather bureaucratic than academic, and they strive a great deal in a system of 'up or go' that caters little to the quality of teaching. As for the careless outsiders, while teaching constitutes the major work of their careers, they are regarded as incompetent by their peers and the system because they are outsiders of the research circle.

The bureaucratization and the over pro-research evaluation system could undermine the ultimate commitment of institutions and instructors to the

[41] Yating Huang, Sun-Keng Pang and Shulin Yu, "Academic Identities and University Faculty Responses to New Managerialist Reforms: Experiences from China," *Studies in Higher Education* 43, no. 1 (2016): 8-16.

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most important aspect of NEE reform, namely improving students’ learning experiences and outcomes through well-designed engineering courses and teaching them completely according to international standards such as the Conceive-Design-Implement-Operate approach. For institutions, they may not be sufficiently incentivized to update their curricula, programs and teaching methods by collaborating with the industry. For instructors, they tend to lack the motivation to improve teaching and care about how well students acquire professional knowledge and skills in reality, thus affecting the realization of one of the most important indicators of NEE reform – graduates’ attributes.

Bringing about such a transformation will require attitudinal, behavioral, organizational and cultural changes to form a system in which each element carries both individual and collective learning objects for the engineering programs. Among all related factors, it is a crosscutting issue to adjust faculty rewards and incentives as they pertain to teaching and mentoring. Nothing much will happen without these changes. While the ‘top-down’ approach of government and the administrative bodies within an institution continues to play a role in steering the direction of the NEE at macro level, a ‘bottom up’ approach that takes full advantage of wisdom and experiences of front-line instructors must also be simultaneously adopted. On the one hand, while the government or administrative bodies should provide necessary resources to universities and their relevant departments, they should by no means intervene too much on the operation of institutions and the programs. On the other hand, the evaluation system must be fixed to shift towards one that casts equal value to teaching and research and encourages instructors to incorporate industrial experiences into course design and implementation.

V.3. *Curriculum reform: easier hoped than done*

Studies have revealed that students’ overall satisfaction at universities have been largely determined by their course experience.[42] Students’ engagement in academic activities and learning outcomes is highly related to good teaching.[43] While Chinese engineering education sector has realized the importance of developing interdisciplinary courses and praxis courses that

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[42] Hongbiao Yin and Wenlan Wang, “Assessing and Improving the Quality of Undergraduate Teaching in China: the Course Experience Questionnaire,” *Assessment & Evaluation in Higher Education* 40 no. 8 (2015): 1034.

[43] Eman M. Almarghani and Ivana Mijatovic. “Factors Affecting Student Engagement in HEIs – It Is All About Good Teaching,” *Teaching in Higher Education* 22, no.8 (2017): 951.

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mutually support each other in an integrated curriculum system, individual institutions are now in a merely exploratory stage for such course development. How to develop courses that reveal connections of one engineering field with others while not undermining the fundamentals of the field is a salient challenge in curricula reform. As human resources at universities are always limited, it is sort of suspicious as to how many resources can ultimately be input into curricula research and development.

If no changes take place in the curricula system, the efficiency and effectiveness of students' learning outcomes are unlikely to be improved as expected. As in many other countries, China's engineering education removed many hands-on experiences, resulting in students having little concrete experience upon which to base engineering theories. Moreover, lecturing remains a dominant teaching approach in Chinese universities even nowadays.[44] Learning science and cognitive science based on constructivism, however, reveal that people learn from the concrete to the abstract, construct their own knowledge, test concepts on prior experience, apply these concepts to new situations, and integrate the new concepts into prior knowledge.[45] Therefore, the lack of practical experiences and an environment of experiential learning affect students' digestions of engineering theories and hamper their ability to realize the practical usefulness of engineering theories. This demotivates learning and results in low retention in the engineering sector for further study or for employment. While there has been a common sense of urgency to reform the curriculum system, the change of the status quo of curricula structure and teaching methods and institutionalizing evidence-based approaches still take time to accomplish.

VI. **Discussion**

Launching educational reforms demands a visionary all-of-the-above design and a variety of pragmatic conditions and support. The overall progress of Chinese higher education over the past two decades and the size growth of the engineering education sector has created mature conditions in which NEE is likely to develop supported by sufficient resources such as

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[44] Hongbiao Yin and Genshu Lu. “Development and Validation of an Instrument for Assessing Mathematics Classroom Environment in Tertiary Institutions,” *Asia-Pacific Educational Researcher* 23. no. 3, (2014): 665.

[45] Edward F. Crawley, John Malmqvist, Sören Östlund, Doris Brodeur. and Edström Kristina, *Rethinking Engineering Education: The CDIO Approach* (Singapore: Springer, 2007), 24.

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infrastructure, hardware, and funds. Generally speaking, investment in engineering education is not a problem either as a consensus or as an actual action by various stakeholders. Of prominence are the development path and the quality of manpower underpinning the reform.

China’s upholding the international standards to develop NEE and make structural adjustments is a salient feature in the history of its engineering education sector. The most important embodiment of upholding international standards is reflected in the framework guiding accreditation of engineering programs which draws heavily on international practices such as the Washington Accord and considers Chinese realities. Covering seven aspects of student, program goals, graduate attributes, ongoing improvement, curricula, faculty members, and supporting facilities, the framework reveals China’s determination to rebuild its engineering education in a comprehensive manner to one that focus more on students and cater more to industrial demands as many developed nations do.

Creating new and upgrading existing programs on an extensive scale are both ambitious and bold endeavors for China to make, which involve a tremendous amount of cost and cross-departmental synergy. With aforementioned challenges properly addressed, it’s likely that China’s engineering education system is to become more efficient to ensure the match between graduate attributes and industrial demands. Despite the possible pace gap between top universities and those in lower tiers in developing NEE towards desired goals due to vast distinction in resource allocation, China can still be expected to become a leading nation in terms of cultivating graduates in emerging programs such as artificial intelligence, in that the current prevalent establishment of new programs among hundreds of higher education institutions is likely to sift certain reform patterns and models that prove successful and replicable. Outcomes of NEE are supposed to be scrutinized in around 2022, the time point of graduation of the first session of undergraduate students who began their study right after the framework of the Guidance on Engineering Education Accreditation Self-assessment was released in Nov 2017.

VII. **Conclusion**

This paper takes China as an example to illustrate a developing nation’s aspirations and endeavors to advance from periphery towards center in the global higher engineering education landscape. Along with such an educational dream, NEE has also been initiated with a pragmatic purpose of producing quality engineering talents to underpin the country’s technological advancement and long-term economic development. Despite the distinction of Chinese society, culture and politics from those of the West and China’s intention to keep such unique features of its own, in terms of engineering education, China does value international standards (represented by Western standards) a great deal, and such valuing is reflected in the formulation of its own accreditation schemes that fully incorporate international standards such as the Washington Accord. Since 2017, China has taken various actions to develop NEE, including formulation of National Standards for many categories of programs, commissioning hundreds of research projects on NEE development, establishment of new engineering programs and interdisciplinary courses, strengthening university-industry partnerships, accrediting engineering programs, and improving both external and internal quality assurance mechanisms. Challenges, however, remain to be addressed. A more even resource allocation mechanism must be worked for to ensure higher education institutions of various tiers all have necessary resources to reform engineering programs. More importantly, the fundamental mission of teaching must be re-valued by adjusting the current evaluation system to be a more pro-teaching one and addressing the issue of bureaucratization. And finally, upgrading the curricula system by issuing policies and mechanism to increase practical experiences of instructors, build a culture of experiential learning and effectively enhancing interdisciplinary features of courses are essential in the production of quality graduates. In a nutshell, China has established structural mechanisms to ensure the quality of its engineering education development, and the key to success lies in getting rid of visible and invisible barriers in the implementation of such mechanisms.

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‘New Engineering Education’ in Chinese Higher Education: Prospects and challenges

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