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New Engineering Education initiative of China: A Policy Debrief

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Executive Summary

This article discusses and critiques one Chinese national strategy, New Engineering Education (NEE). To maintain globally technical and scientific competitions, increasing demands of qualified engineering talents becomes imperative. Building on previous experiences of engineering education reform, the Ministry of Education (MOE) in China proposes three-stage sequential policy documents to lead the directions and pathway in constructing new and revised engineering disciplines and programs along with exploring potential talent development mechanisms. Intending to train sufficient industry-needed engineering graduates, the systematic reform movement takes initiatives in conducting over 600 research and practice projects from various perspectives and with multiple stakeholders. Although the success of the Chinese NEE initiative sounds promising, two major challenges are identified for policy change. The resource distribution gap among different tiers of institutions needs to be reduced and teaching need to be centralized as one of the cores in NEE reform.

Problem Definition

To survive and thrive in the rapid and fierce international competition in the era of the fourth round of industrial revolution and to meet and overcome the emerging global challenges in the future, all major countries, including China, recognize and stress the importance of improving the quality of engineering education. Accordingly, China proposed its national strategic policy for innovation-driven development, "Chinese manufacture 2025", "Internet +" to adapt and lead the new economy characterized as new technology, new industry, new forms of business and models [1], [2]. Preparing high-quality engineers becomes an essential and fundamental prerequisite to support the national strategies, for which the NEE initiative leads to research and practice in developing plans for new engineering development in the future and in exploring more student-centered training mode [1].

Preparing enough high-quality engineering graduates requires insight and input from all relevant stakeholders, to name a few, involving Chinese government (especially the Ministry of Education (MOE)), higher education institutions and their administrators, faculty, and staff, industry (including corporations and industry associations) both in China and globally, research institutions, and finally undergraduate and prospective students (especially engineering students). Multiple levels of Chinese government create policy and goals to guide the corresponding actions and reformation at Chinese higher education institutions, where the administrators, faculty, and staff turn the initiatives into actions to actually influence engineering students, especially at the undergraduate level. Stakeholders outside the higher education institutions are also encouraged to get involved in the loop. The inputs and stakeholders of the system are synthesized in Figure 1 in the Appendix.

Context

As a major industrialized country, supply-side reform is needed for China to fulfill the large demand of well-trained engineering graduates to industry to enable its upgrade and transformation. Before the proposal of NEE, one significant milestone of Chinese engineering education advancement was that China became an official signatory of the Washington Accord. According to one official from China's Ministry of Education, "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 [3]."

China also explored the construction and reformation of NEE in new majors based on strategically emerging industries and effective talent development mechanisms and modes. Since 2010, MOE authorized the establishment of 22 new undergraduate engineering majors in 1401 departments, including data science and big data techniques, robotic engineering, aerospace control, and informatics engineering, GIS, material design science and engineering, etc. [1]. As an experimental exploration in the effective talent development plan, the software engineering program was chosen and later demonstrated an effective pathway to train urgently needed engineering graduates with reformation on faculty career development mechanism and school-industry collaboration mode [1].

Policy Description

Although China made efforts in earlier exploration in improving engineering education, more systematic work is needed to advance engineering education to a world-class level. After examining Chinese context and experience and drawing lessons from international practices and standards of engineering education, the MOE then proposes the systematic NEE initiatives to reform the Chinese engineering education system. In 2017, the MOE published three-stage sequential policy documents to illustrate the ideas and visions of Chinese reformation of engineering education, those stages being the "Fudan Consensus", "Tianda Action", and "Beijing Compass". Each document addresses different facets of the intention and implementation of Chinese NEE. Specifically, the actions responding to NEE policy vary from establishing engineering programs, developing interdisciplinary courses, funding over six hundred research projects for NEE, strengthening university-industry partnerships, updating Chinese engineering accreditation, and improving both internal and external quality assurance mechanisms [4].

The "Fudan Consensus" mainly discusses connotations, characteristics and construction pathway of NEE. Particularly, it proposes the expected roles of various stakeholders in this initiative, including tertiary education institutions, all levels of government, and enterprises and industry [5]. For example, regarding higher education institutions, those with renowned reputations for their engineering programs are expected to take advantage of their close ties with industry to further enhance the engineering innovation in technology and industrial chain and optimize the existing disciplines and programs. Comprehensive universities (roughly equivalent to R1 institutions; not specialized in engineering) are expected to promote the development of interdisciplinary and cross-disciplinary innovative programs and technology. Local universities (roughly equivalent to R2 institutions) are required to respond to and meet the needs of local economics by supplying skillful talents with practical industry knowledge and experience. The "Tianda Action" identifies the main agents or identities for whom the NEE needs to address for improvement, including exploration of the development paradigm for future industry, industry needs, student development plan, course upgrade, pedagogy advancement, resource mobility, and setting leading international standards [6]. Lastly, the "Beijing Compass" emphasizes five aspects of NEE to conduct research and seek for investigating the best practice, including conceptual update, structural optimization, pattern innovation, quality assurance, and categorical development along with the expected outcomes [4], [7].

In all, the three-stage policy documents depict the directions and guidelines of the Chinese reformation of engineering education. The main goal of NEE is expressed as "actively deploy, set up, and construct engineering disciplines and majors that serve national strategies, meet industry needs, and face future development, and cultivate a group of various cross-composite excellent engineering and scientific talents with innovative and entrepreneurial capabilities, cross-border integration capabilities, and high-quality [2, p.28]." The implementation of Chinese NEE is grounded by constructing and developing three unique types of engineering disciplines, which are unprecedented (new-born subjects), innovative (reformed based on traditional ones), and emerging (interdisciplinary/transdisciplinary one based on all subjects) [2].

Policy Evaluation and Discussion of Policy Alternatives

Outcomes of NEE are supposed to be systematically examined and evaluated in around 2022 as the first cohort of engineering undergraduate students will graduate under the comprehensive reformation [4]. However, some actions have been taken to achieve NEE's goal, including setting and revising national standards on teaching quality, fund 600+ research projects related to Chinese NEE development, establish new programs and interdisciplinary courses or revise the existing ones at Chinese higher education institutions, strengthen university-industry partnership and collaboration, and establish external and internal quality assurance mechanism [4]. Up to the end of 2018, both current and graduated students take up one-third of the counterpart in the Chinese higher education system; the total number of engineering graduates consists of one-third of that in the world [8]. The Chinese engineering education movement has several characteristics: (1) excellent incoming students, as the current matriculation system still attracts numerous top-tier talents to engineering majors; (2) a big volume of engineering graduates, composed of the largest portion of Chinese higher education as well as the world's; (3) close coupling with national economic and social development; (4) emphasis on the connection between science and engineering [8].

Although the plans and guidelines of NEE seem very promising to lead to desired outcomes, some challenges remain. Firstly, resource allocation among different tiers of Chinese higher education institutions is uneven, which resulted in an unbalanced pace toward systematic reformation of engineering education. The Matthew effect of accumulated advantage in the context of NEE has the phenomenon that the top-tier universities attract the majority of resources, including research funding and social recognition while the bottom counterparts are placed in a disadvantaged situation. In 2007, Tsinghua University and Shanghai Jiaotong University, the top two institutions which got the most research funding from the central government, received 1.59 billion and 0.84 billion RMB compared to the least two third-tier institutions only obtaining 10 million RMB funding [9]. The uneven distribution of resources, especially research funding, is very likely leading to further enlarged stratification in Chinese higher education of engineering. Therefore, alternative policies and mechanisms need to be deployed in a more balanced way favoring the lower-tier institutions in China so that they could locate more resources for more comprehensive improvement of their engineering programs. This advocacy needs both central and province-level governments to shift and refocus their attention to the disadvantaged institutions for the societal overall wellbeing. Local enterprises should also be encouraged by both universities and the government to actively participate and collaborate in training engineering students to fulfill their needs.

Secondly, the set of NEE policies does not emphasize enough the importance of teaching, which is downplayed by hierarchical bureaucratization and existing pro-research evaluation system [4]. Although scholars stressed that NEE projects are not research-oriented research and practice projects [10], the existing plans and evaluation systems are made by the top authority and government administrators whose views are systematic and at a high level. The initial project primarily seeks to explore the theory development, paradigm exploration, effective talent cultivation, and even teaching quality evaluation system at the macro level but little attention and support are given to research on the best practice of teaching methods and curriculum construction at the micro level. In the Chinese higher education ecosystem, the government maintains the dominant power position as it holds the power of key personnel patronage and allocation of educational and research funding. Administrators at universities give the most attention to the tasks assigned by nation- and province-level governments. In turn, the needs of instructors are sometimes overlooked by the limited number of school administrators. Besides, the Chinese current professor evaluation system mainly focuses on academic publications rather than a comprehensive assessment combining the teaching, service, and research capability, which inspires professors to spend the majority of their time on research rather than teaching. Given the instructor-student relationship is the most fundamental one ensuring the success of the NEE initiative, more support in terms of resources and policy should be placed towards improving the effectiveness and efficiency of teaching to both enact instructors' commitment in teaching and promote student learning. The whole transformation needs to take attitudinal, organizational, and cultural changes at the whole ecosystem of engineering education at both macro and micro level [4].

Recommendations and Implications for Policy and Practice

The Chinese NEE initiative employs a top-down change paradigm on an extensive scale. On one hand, the systematic and synergetic comprehensive arrangement minimizes the internal frictions while maintaining the promise of project success. The three-stage policy guides the directions and pathway of NEE development draw on experiences of China's unique culture, context, and history as well as the best practice of engineering education reform across the world. The NEE is supported by sufficient resources of infrastructure and funds from MOE. Given China's specific political system, a massive investment in engineering education usually accompanies the consensus and actual actions of various stakeholders. Among those, the accentuation of building university-industrial collaboration is outstanding as the policy advocates enterprises to participate not just in providing practical experiences for both students and instructors but also in getting involved in the establishment in industry-level talent standards and criteria as well as supporting university to build new engineering disciplines or revise the existing one to fulfill the future needs. All the evidence indicates the future success of NEE projects with lots of established new or revised engineering disciplines/majors with successful and replicable reform models and patterns.

On the other hand, the current policy could be revised to better serve the need to educate high-quality engineering graduates. As mentioned above, the current mechanism to allocate the research and practice funding of NEE needs to be altered in a new and more balanced way so that lower-tier institutions could be equipped with the necessary funding to uplift the quality of their engineering programs. In addition, the core mission of teaching needs to be stressed and centered at both macro and micro level to ensure the quality of student learning in engineering to become qualified graduates, which could be achieved by adopting a new professor evaluation

system to comprehensively assess one's commitment in teaching, research and service and addressing the issue of bureaucratization [4].

Connections to Other Leadership and Policy Research

Borrego and Henderson proposed a four-level model suited for changes in STEM education at the university level: disseminating curriculum and pedagogy, developing reflective teachers, enacting policy, and developing shared visions [11]. For the changes to improve teaching quality, their framework could be adapted to enact on each institution in China. As I have emphasized the importance to focus on the fundamental mission of teaching in higher education institutions, Borrego & Henderson's model guides the dimensions to be focused at the institutional level. The presidents and provosts need to create a supportive environment for professional development for instructors to improve their scholarly teaching capability by enacting temporary, transitionary, and permanent policies to inspire instructors to improve their teaching quality and effectiveness. It is also essential to create a shared vision among instructors and administrators to understand and support NEE initiatives as it makes all stakeholders benefit, which serves as the prerequisite to make excellent teaching part of a sustainable culture in the long run.

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Appendix

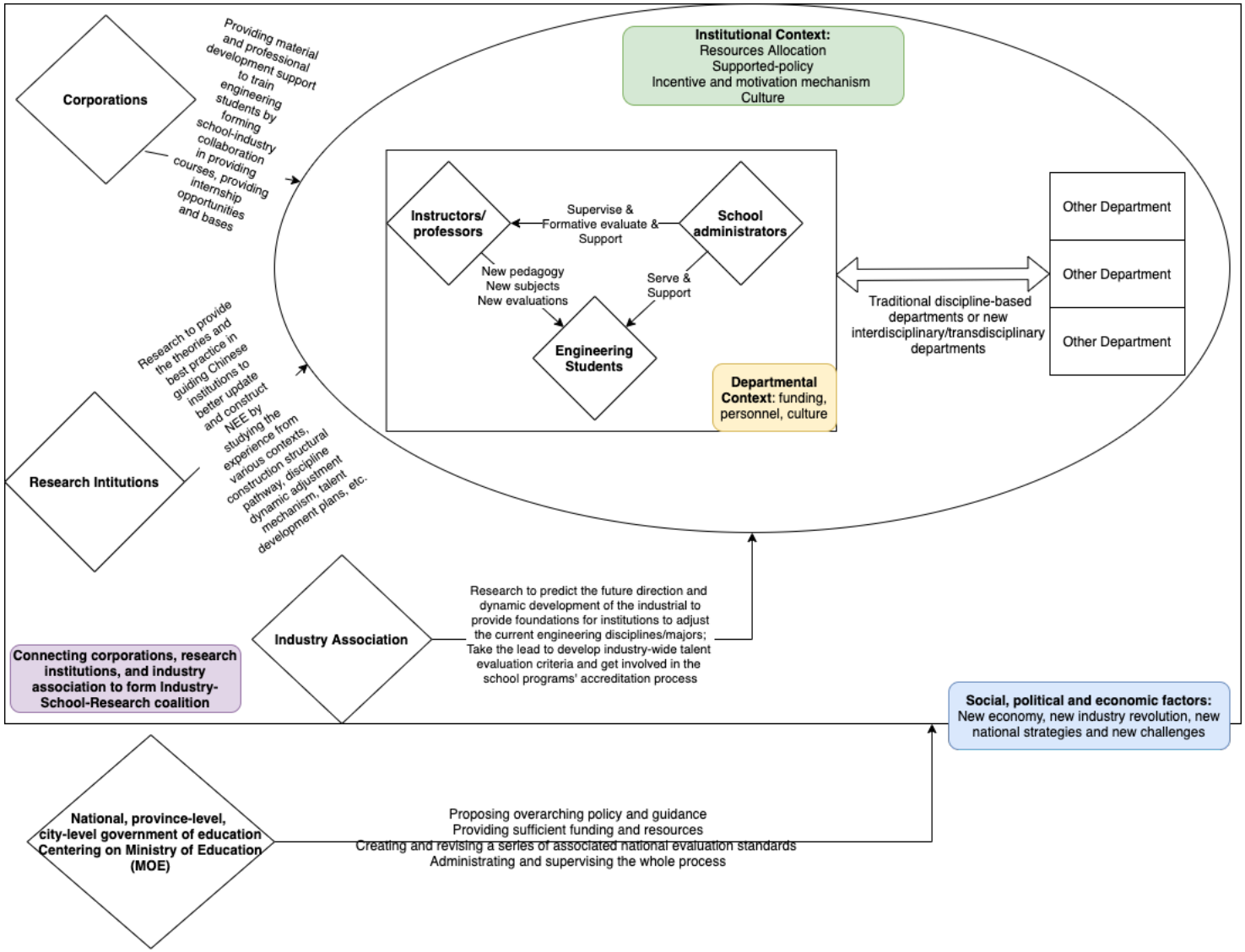

Figure 1: Diagram of Landscape of Chinese New Engineering Education initiative