2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #36971

Tracing the policy shift to new engineering education in China: An analytical lens of historical institutionalism

Dr. Yanru Xu, University of Chinese Academy of Sciences

Dr Yanru Xu is an assistant professor in University of Chinese Academy of Sciences. Her research interests focus on research-teaching-study nexus in higher engineering education, higher education management, and the sociology of higher education.

Ji'an Liu
YaXuan Wen
Dr. Lufan Wang, Florida International University

I am an Assistant Teaching Professor at Florida International University.

Dr. Yan Wei, Southern University of Science and Technology

Teaching Associate Professor at Southern University of Science and Technology, research interests focus on engineering education

Prof. Yiming Rong, Southern University of Science and Technology

Professor Rong is the founding chair of mechanical and energy engineering department at Souhtern University of Science and Technology, Shenzhen, China. He has worked as a professor and researcher in the area of manufacturing for many years, including with Tsinghua University, Beijing, China, Worcester Polytechnic Institute, Worcester, MA, and Southern Illinois University, Carbondale, IL.

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Dr Yanru Xu, University of Chinese Academy of Sciences
Yanru's research interests focus on research-teaching-study nexus in higher engineering education, higher education management, and the sociology of higher education.

Professor Ji'an Liu, University of Chinese Academy of Sciences
Professor Liu's research interests focus on higher education management, and students' teaching and learning in higher education.

Miss Yaxuan Wen, University of Chinese Academy of Sciences
Miss Wen is a master student in Sino-Danish College, University of Chinese Academy of Sciences, Beijing, China. Her research interest focus on higher engineering education.

Dr Lufan Wang, Florida International University
Dr Lufan is an assistant teaching professor at Florida International University.

Dr Yan Wei, Southern University of Science and Technology
Dr Yan is a teaching associate professor at southern university of science and technology. Her research interests focus on engineering education.

Professor Yiming Rong, Southern University of Science and Technology
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Abstract
The global landscape of higher engineering education (HEE) is changing rapidly in response to and alongside the sci-tech revolution and industrial global transformations. Echoing such trends, China is transforming its HEE through new engineering education (NEE) initiatives. China has contributed to the largest scale of HEE worldwide, and its economic power and strategic impact has significantly grown at the global stage. Developing a comprehensive understanding of the evolutionary path of HEE to NEE in China higher education is increasingly important at both the domestic and global scope. However, there has been a lack of research efforts in this regard. Historical institutionalism, an integrated approach examining structural, institutional, and actor contextual factors with the view of gradual change, provides a powerful analytical framework to fill such research gap. Based on an analytical review of policy documents and scholarly research since the founding of People's Republic of China (PRC) in 1949, this paper aims to investigate the structural and institutional factors that facilitate the policy shift to NEE in China's HEE, and the intertwined relationships among these factors. The results of this research depicted the big picture of path evolution concerning the policy shift to NEE in China's HEE, thus contributing to the current gap in literature regarding HEE in China as a socio-historical phenomenon.
Keywords: New engineering education; Higher engineering education; China; Policy shift; Path evolution

Introduction
Engineering is about using technology to solve problems for society [1], and about applying changing technologies to meet the demands of the increasingly knowledgeable, interconnected, and interdependent human enterprise. Today, human society is facing enormous challenges in terms of climate change, cybersecurity and safety, carbon emission and wars. These, alongside the sci-tech revolution and industrial global transformations, have rapidly changed the global landscape of higher engineering education (HEE) [2-3]. Echoing such trends, China is transforming its HEE through new engineering education (NEE) initiatives [4]. China has contributed to the largest scale of HEE worldwide, and its economic power and strategic impact has increasingly grown at the global stage. In such context, it becomes increasingly important to develop a nuanced understanding of the evolutionary path of HEE to NEE in China.

However, there has been a lack of research efforts in this regard. According to historical institutionalism, institutional changes can be both gradual and radical. The former occurs when a relative balance is maintained within institutions and between institutions and the environment [5]; the latter happens when institutions are interrupted by critical junctures, when there is imbalance between the supply of institutions and social demands [6]. Historical institutionalism tends to find influential factors on instructional changes from the macro-, meso- and micro-levels [7]. Drawing on the view of institutional changes and the macro- and meso-level analytical lens in historical institutionalism, this article examines the evolutionary path of HEE to NEE in China through a systematic analysis of policy documents and extant research literature since the founding of the People's Republic of China in 1949 to date. The developmental phases of China's HEE to NEE are divided into five stages: (1) exploratory development (1949-1965); (2) relative development (1966-1976); (3) adjustment during reform; (4) improvement through learning outwards; and (5) leading through innovation. This evolutionary path was further analyzed at the macro-level – the national strategies in China, and at the meso-level – the transformation of HEE system.

Theoretical and methodological considerations

Since the 1950s, the new institutionalism has crossed the disciplinary boundaries of economics, political science and sociology, becoming a new research paradigm for explaining real-world problems because of its unique disciplinary field and analytical perspective [8]. Although there are different schools of new institutionalism, sociological institutionalism, rational choice institutionalism, and historical institutionalism are widely accepted divisions [9]. Sociological institutionalism analyzes institutions from a macro perspective, focusing on the macro structure and on the co-occurrence of institutional development. Rational choice institutionalism analyzes institutions from a micro perspective, focusing on actors and the synchronic development of institutions. Historical institutionalism combines the advantages of both. It focuses on the diachronic nature of institutional development to find the roots of the institutions from those incremental, foundational events [10], thus, performing analysis from an integrated approach at structural, institutional and actor levels [7].

According to historical institutionalism, there is self-reinforcing and self-learning mechanisms after the formation of institutions, which is manifested as path dependence [11]. Path dependence emphasizes the historical inheritance and continuity of institutions, focusing on the influence of the past on the present. For example, the established patterns and development trajectories formed by a certain policy choice and implementation at a previous stage tend to influence the formation and development of policy options at a later stage. When the relative balance is maintained within institutions and between institutions and the environment, the development of institutions is gradual [5]. Also, institutions can be interrupted by critical junctures, when there is imbalance between the supply of institutions and social demands. Then, radical institutional changes will occur [6]. The structural level analysis focuses on the influence of socio-political and economic factors on institutional change; the institutional level focuses on constitutional or legislative rules and procedures and educational paradigm; and the actor level focuses on stakeholders in a specific field [7].

This article adopts the view of institutional changes and the macro- and meso-level analytical lens in historical institutionalism to examine the evolutionary path of HEE to NEE in China since 1949. We adopted a systematic analysis of national policies and national leaders' public speeches, taking into consideration of the commencing or ending of critical events, such as cultural revolution, accession to World Trade Organization and the national strategy of 'Made in China 2050', etc. The systematic analysis of documents is also combined with reviewing extant research literature on China's HEE. See Table 1 for national policies and national leaders' speeches since 1949 regarding China's HEE.

Table 1 National policies and national leaders' speeches since 1949 regarding China's HEE

No.	Issue Year	Document Names Translated in English
1	1958	Instructions on Education
2	1961	Sixteen Principles on Higher Education
3	1971	Minutes of the National Education
4	1981	Regulations of the People's Republic of China on Academic Degrees
5	1983	Report on Accelerating the Development of Higher Education
6	1984	General Catalog of Engineering Undergraduate Programs in Higher Education
7	1985	Decision of the Central Committee of the Communist Party of China on the Reform of the Education System
8	1997	Engineering Master Degree Setting Program
9	1998	Catalog of Undergraduate Programs of General Higher Education Institutions
10	2007	Hu Jintao. Report to the Seventeenth National Congress of the Communist Party of China. "Hold High the Great Banner of Socialism with Chinese Characteristics and Strive for New Victories in Building a Moderately Prosperous Society in all Respects"
11	2010	Notice of the Ministry of Education on the Approval of the First Batch of Universities under the "Excellent Engineer Education and Training Program"
12	2010	Outline of National Medium and Long-term Education Reform and Development Plan (2010-2020)
13	2010	The Decision of the State Council on Accelerating the Cultivation and Development of Strategic New Industries
14	2012	Hu Jintao. Report to the Eighteenth National Congress of the Communist Party of China. Steadfastly advance along the road of socialism with Chinese characteristics and strive to build a moderately prosperous society in all aspects
15	2015	Made in China 2025
16	2017	Xin Jinping Report to the Nineteenth National Congress of the Communist Party of China. To build a moderately prosperous

		society and win the great victory of socialism with Chinese characteristics in the new era
17	2018	Opinions of Ministry of Education, Ministry of Industry and Information Technology, Chinese Academy of Engineering on Accelerating the Construction and Development of New Engineering Departments and Implementing Excellent Engineer Education and Training Program 2.0
18	2018	Reform Program of Cultivation Mode of Engineering Doctoral Degree Graduate Students
19	2019	China's Education Modernization 2035
20	2020	Notice of the General Office of the Ministry of Education on the Guidelines for the Construction of Future Technical Colleges (for Trial Implementation)
21	2020	General Office of the Ministry of Education General Office of the Ministry of Industry and Information Technology on the Guidelines for the Construction of Modern Industrial College (for Trial Implementation)
22	2021	Xin Jinping. Address on the general assemblies of the members of the Chinese Academy of Sciences and the Chinese Academy of Engineering. "Accelerated efforts in building China into a leader in science and technology and achieving sci-tech self-reliance and self-strengthening at higher levels."
23	2022	Catalog of Graduate Education Subjects (2022)
24	2022	Xi Jinping. Report to the 20th National Congress of the Communist Party of China. "Hold High the Great Banner of Socialism with Chinese Characteristics and Strive in Unity to Build a Modern Socialist Country in All Respects"

The historical changes of HEE in China

1949-1965：Exploratory development

When the People's Republic of China (PRC) was founded in 1949, the nation faced significant challenges in terms of its agricultural-based economy, outdated industrial foundation, high illiteracy rate, and poor economic situation. In order to address these challenges, the central government has launched policies and strategies for industrialization. To achieve the industrialization goals, China's HEE thus started its early-stage explorative development, learning the practices used in Soviet Union.

The Soviet Union was seen as a model for China's industrialization and modernization efforts due to its rapid industrialization and modernizing success [12]. At the time, a vast majority of the Chinese population was illiterate, and the number of universities and university graduates was small. In 1949, more than 80% of Chinese was illiterate; and there were only 205 universities with 117,000 students around the whole country. Out of the total population, university graduates only account for 0.034% [13]. Among the 205 universities, only 28 were engineering universities (13.7% of the total number), and the number of engineering students was 30,320, accounting for 26.2% of the total university students. Therefore, it was urgent for China to rapidly develop its higher education system in order to support the country's industrialization and modernization efforts. In 1953, the then president of PRC, Chairman Mao Zedong proposed to "pool resources into the development of heavy industry, to establish the foundation for industrialization and modernization of the country's national defense" [14], which further reinforced the necessity of HEE to achieve this goal. As a result, the Soviet model of higher education was completely adopted [15] to cultivate the specialized talents that are urgently needed for national economic construction [16]. Soviet-style subjects, disciplines, and textbooks were introduced, and all the college departments and disciplines were developed based on the Soviet university system [13].

This adjustment for higher education in China lasted for six years from 1952 to 1957 and was divided into two stages: the first stage, from 1952 to 1953, focused on the development of specialized industrial colleges within the major administrative regions; the second stage, from 1955 to 1957, focused on the nationwide adjustment of the layout and specialization of institutions and the consequent reform of the teaching system. According to the adjustment plan of the Ministry of Education at that time, the emphasis was placed on the development of specialized colleges, especially industrial colleges, while also constructing comprehensive universities. Four-thirds of the Chinese universities participated in this restructuring [17]. By 1956, there were 227 higher education institutions in China, an increase of 22 compared to 1949. Among them, the number of industrial colleges increased from 28 to 48, and the proportion of higher education institutions increased from 13.7% to 21.1%; the number of engineering students increased from 30,320 to 149,360, and the proportion of total students in higher education institutions increased from 26.0% to 37.0% (See Table 2). These changes reflected the efforts to align the higher education system with the national industrialization development strategy.

Table 2 Changes in the Proportion of Engineering and Industrial Students before and after the Adjustment of the Faculties (1949-1956)

Year	Total Number of Higher Education Institutions	Number of Industrial Institutions	Proportion (%)	Total Number of Students	Number of Engineering Students	Proportion (%)
1949	205	28	13.7	116 504	30 320	26.0
1952	201	43	21.4	191 147	66 583	34.8
1956	227	48	21.1	403 176	149 360	37.0

In terms of major setup, China adopted the major catalog from Soviet higher education institutions and began to train students by specialties. For the course contents, in order to guarantee the quality of teaching, the Ministry of Education formulated a nationwide unified teaching plan and syllabus, and introduced and translated the textbooks from

Soviet as teaching materials. For the cultivation mode, China emphasized the link between education and practices. Therefore, students in engineering were required to go to production and construction units for field practice. This helped to establish a highly specialized higher education system. It is widely recognized that the emphasis on certain majors in undergraduate education was one of the most significant legacies of the Soviet Model, which "played almost a decisive role in shaping China's engineering education system" [18].

But with the collapse of the relationship between China and the Soviet Union, Chinese educators have started reflecting on the problems that arose from simply copying the Soviet Model in a form without grasping the essence. Therefore, from 1957 to 1965, China began to forge its own unique path in the realm of higher education towards a more indigenous approach to build a socialist education system[15]. But this was soon weakened by the "Great Leap Forward" social production movement, which focused too much on speed and quantity, and neglected quality [17]. In 1956, the First Five-Year Plan was completed ahead of schedule, and Mao Zedong proposed at the preparatory meeting of the Eighth National Congress in September 1956 to create 1-1.5 million senior intellectuals during the next three Five-Year Plans [19]. In May 1958, at the Second Plenary Session of the Eighth Central Committee of the Communist Party of China (CPC), Mao Zedong proposed that "we should strive to build socialism with the fastest speed, the highest quality and the lowest cost". The "Great Leap Forward" and "People's Commune" social movements were launched nationwide, at the same times the "Great Revolution in Education" was started in higher education.

During this period, the focus of higher education shifted into a high degree of specialization – engineering colleges and universities set up majors and courses according to the development needs of their counterpart industries and specified cultivation objectives. Targeted training of engineering talents needed by the country has provided solid foundation for the construction of socialist economy [16]. The development of higher education and engineering education in this period is thus characterized in two aspects. First, talent training mode was reformed by combining education and production labor [17]. A large number of students from colleges and universities were sent to the countryside to participate in the construction of people's communes. Second, education scale and development speed were dramatically expanded [17]. In 1957, there were 229 colleges and universities in China, but in the next year, there were 791 colleges and universities, and the number reached highest in 1960, with 1,289 colleges and universities in total. Among them, the growth rate and scale of industrial colleges were the most significant, from 44 in 1957 to 472 in 1960, which was more than 10 times.

It was soon recognized that the excessive and unconventional expansion of HEE had led to a serious of problems, including the reduction of education quality, the lack of student engagement, the overproduction of unqualified graduates, and the wastage of educational resources. In response, starting from January 1961, the government began to adjust the proportional relationship between agriculture, light industry, and heavy industry in the national economy, and the education sector was also adjusted accordingly. In 1962, at the Conference on Teaching Work of Higher Technical Schools, the fundamental measures to improve the quality of teaching in higher industrial universities were discussed, and the "Regulations of the Ministry of Education on Revision of Teaching Plans of Directly Administered Higher Industrial Schools (5-year system) (Draft)" was discussed and issued. The development of engineering education gradually returned to the right track (See table 3).

Table 3 Number of Higher Education Institutions by Category from 1958 to 1965 [20]

Year	Comprehensive Universities and Colleges	Engineering Universities and Colleges	Agricultural Universities and Colleges	Forestry Universities and Colleges
1958	27	251	96	13
1959	29	274	99	14
1960	37	472	180	24
1961	32	269	106	13
1962	31	206	69	9
1963	29	120	44	8
1964	29	122	44	8
1965	29	127	45	8

Year	Medical Universities and Colleges	Normal Universities and Colleges	Language and Literature Universities and Colleges	Economics and Finance Universities and Colleges
1958	134	171	5	12
1959	142	175	5	13
1960	204	227	8	25
1961	158	163	6	17
1962	118	110	6	17
1963	85	61	6	16
1964	85	59	14	18
1965	92	59	16	18

Year	Political Science and Law Universities and Colleges	Physical education Universities and Colleges	Art Universitie s and Colleges	Other Institutions	Total
1958	5	21	28	28	791

1959	5	24	33	28	841
1960	9	30	45	28	1289
1961	4	20	38	19	845
1962	3	11	28	2	610
1963	4	10	22	2	407
1964	6	10	22	2	419
1965	6	10	22	2	434

1966-1976：Relative development

From May 1966 to October 1976, China experienced the "Cultural Revolution", historically known as the "Ten-Year Catastrophe", which caused the greatest disruption and destruction of human capital since the founding of the country [21]. The development of engineering education was significantly affected. Nevertheless, HEE during this period still managed to achieve relative development, and the process of national modernization did not come to a full stop. Specifically, with the emphasis of the Third Five-Year Plan (1966-1970) on material accumulation, certain breakthrough achievements were made in the industrial and scientific domains.

In 1966, Mao Zedong proposed to set up revolutionary "communist schools" in all sectors of the country. It was advocated that students should not only further study their own majors but also learn a wide range of knowledge in literature, agriculture, engineering, military and other fields in school [22]. In 1968, Mao Zedong further encouraged Polytechnic universities, "but the academic system should be shortened, education should be revolutionized, and students can be selected from among experienced workers and peasants to study in schools for a few years and then return to production practice" [23].

During the Cultural Revolution, higher education institutions encountered numerous drastic changes, and there was a significant adjustment to engineering colleges and universities. In 1971, the National Education Conference adopted the "Adjustment Plan on Colleges and Universities", which reduced the number of universities from 417 to 309, majority of which are engineering universities [13]. Despite the turbulence and instability during this time, engineering universities maintained some stability and growth in both the number of institutions and the size of their enrollment (See Table 4-6).

Table 4 Development Status and Ratio of Engineering Universities and Colleges during "Cultural Revolution"[27]

Year	Total Number of Universities and Colleges	Engineering Universities and Colleges	Ratio of Industrial Universities and Colleges
1965	434	127	29.26%
1971	328	115	37.07%
1972	331	116	35.04%
1973	345	118	34.20%
1974	378	120	31.75%
1975	387	123	31.78%
1976	392	126	32.14%

Table 5 Proportion of Students by Discipline in Higher Education Institutions from 1965 to 1976 (Unit: %)[27]

Year	Engineering Universities/ Colleges	Agricultural Universities/ Colleges	Forestry Universities/Colleges	Medical Universities/Colleges
1965	43.8	7.9	1.5	12.3
1966	43.0	8.3	1.5	12.1
1967	45.9	7.7	1.5	12.4
1968	49.4	7.2	1.4	12.4
1969	56.6	5.2	0.9	16.5
1970	24.3	2.3	0.7	27.7
1971	28.4	5.8	0.8	21.7
1972	36.1	5.9	0.8	19.8
1973	37.8	6.5	0.4	18.2
1974	39.1	5.9	0.9	17.0
1975	37.2	7.2	1.2	17.2
1976	35.1	8.9	1.5	17.4

Year	Normal Universities/ Colleges	Language& Literature Universities/ Colleges	Scientific Universities/ Colleges	Economics & Finance Universities/ Colleges
1965	14.0	6.8	9.2	2.7
1966	13.8	7.3	9.2	2.9
1967	11.9	7.0	9.1	2.7
1968	9.7	6.5	9.5	2.3
1969	2.3	5.7	11.5	0.6
1970	19.1	15.1	9.1	0.2
1971	20.2	12.7	7.7	0.3
1972	17.3	10.2	7.7	0.6
1973	18.0	9.1	7.0	0.9
1974	18.3	8.4	7.0	1.2
1975	19.4	7.4	6.8	1.4
1976	19.4	7.6	7.0	1.2

Year	Political Science & Law Universities/ Colleges	Physical education Universities/ Colleges	Art Universities/ Colleges
1965	0.6	0.6	0.6
1966	0.7	0.6	0.6
1967	0.6	0.6	0.6
1968	0.5	0.5	0.6
1969	0.1	-	0.6
1970	-	-	1.5
1971	0.1	1.2	1.1
1972	-	0.9	0.7
1973	0.1	1.3	0.8
1974	0.1	1.3	0.8
1975	0.1	1.4	0.7
1976	0.1	1.0	0.8

Table 6 Number of Students Enrolled in Engineering (partly) during the Cultural Revolution [29]

Year	Geology	Mining	Dynamics	Metallurgy	Mechanical
1970	204	999	418	369	2575
1971	300	690	470	501	3100
1972	2826	2184	1785	2463	12673
1973	2553	3571	1917	3931	14612
1974	3465	3346	2372	2769	17057
1975	3535	3588	2825	2846	16878
1976	3837	3562	3165	3523	19054
Year	**Electromechanical**	**Electronics**	**Chemical**	**Civil Engineering**	**Total Enrollment**
1970	432	2143	743	542	10450
1971	710	2990	1350	1570	13550
1972	2782	5266	4703	4682	50395
1973	2627	5534	4998	5461	56671
1974	1672	6846	5222	6420	63283
1975	2550	6966	6417	7212	65870
1976	1958	8876	5845	6912	71618

Table 7 Number of Graduate Students by Discipline from 1978 to 1983 (Unit: person) [27]

Year	Total	Engineering	Agricultural	Forestry	Medical	Normal
1978	10934	4011	276	55	1474	693
1979	18830	6102	510	88	3113	1138
1980	21604	7206	618	106	3651	1704
1981	18848	6889	947	74	2442	1347
1982	25847	10414	1375	167	2558	1732
1983	37166	14932	1964	197	3781	2204
Year	**Language and Literature**	**Science**	**Economics and Finance**	**Political Science and Law**	**Physical**	**Art**
1978	1358	2774	49	-	62	182
1979	2495	4507	339	122	169	247
1980	2628	4705	451	171	200	164
1981	1825	3979	738	358	168	81
1982	1822	6088	917	582	92	100
1983	2253	8930	1500	1137	123	145

During the Cultural Revolution, progress was made in the areas of science and engineering technologies. The development of the country's basic and national defense industries, as well as the establishment of important railroad trunk lines and a number of industrial bases for iron and steel, machine manufacturing, coal, and automobile industries, helped lay the foundation for future growth. Additionally, achievements were made in cutting-edge large-scale science and technology, such as nuclear technology and artificial satellites [24].

1977-2000: Adjustment during reform

After a decade of the Cultural Revolution, China's modernization suffered serious losses and the gap between China and the world widened once again. The Chinese government realized the importance of science and technology in modernization and began to prioritize it [17]. Deng Xiaoping stressed that "science and technology are the first productive forces" and emphasized the need to innovate ways to discover and cultivate outstanding talents; the country needed to "train a group of science and technology experts of world-class level as soon as possible". The status and role of engineering education once again received nationwide attention. And at this stage, China's HEE was constantly adjusting in response to the reforming process.

The Third Plenary Session of the Eleventh Central Committee held in December 1978 marked the beginning of a new era in China's modernization drive and adjustments to the national economy. With the implementation of the reforms and opening up, there was a growing demand for engineering and technology talents in various fields to support the modernization process and the acceleration of industrialization [17]. This emphasis on science and technology in higher education was seen as a way to support China's modernization efforts and catch up with the developed countries. Before 1985, China has the most universities in science and technology than any other country in the world [25]. For example, the number of colleges and universities increased 283, from 392 in 1976 to 675 in 1980, and engineering achieved the largest increase: the number of engineering colleges and universities increased 77, and the number of students in engineering expanded continuously, which reached 56.6% among all the college students in 1969. However, this also resulted in an imbalanced development in other important fields such as liberal arts, politics, law, and finance. For example, for the 32 years after the founding of the PRC, 211,000 students graduated from liberal arts, accounting for only 6% of the total number of graduates; 28,000 graduates from politics and law, accounting for only 0.8% of the total number of graduates; and 104,000 graduates from finance and economics, accounting for only 3.2% of the total number of graduates. Within the engineering field, the subjects are also heavily imbalanced. Subjects in heavy industry and military industry still prevailed, while specialties such as light textile and food science, which were categorized as the secondary and tertiary industries, graduated 35,500 people between 1953 and 1980, accounted for only 3% of the engineering graduates [27].

At this time, there was a serious disproportion between higher education and economic development, and the structure of majors in higher education was under urgent need for reformation [26]. HEE has overly divided its majors. There were 137 engineering majors in colleges and universities in 1954, 285 majors in 1963, and as many as 664 in 1982. Facing the overly narrow degrees and too many divisions of majors, China began to reconstruct its HEE, including the structure of majors and the structure of levels.

The reformation of higher education majors included the restructuring of the proportion of majors in different disciplines (i.e., science, engineering, agriculture and medicine), as well as the restructuring of majors within engineering, focusing on strengthening the interdisciplinary development and accelerating the development of politics and law, finance and economics, management, and arts.

From 1982 to 1987, the reform centered on adjusting the number of engineering majors and fundamentally improving graduate-level education. As can be seen from table 7, from 1979 to 1982, there was a serious disproportion between the number of postgraduate, undergraduate and specialist engineering students. On the one hand, engineering education was mainly at undergraduate level; both specialist and postgraduate education were defective and there was no clear difference among different degree levels [27]. On the other hand, the majority of postgraduate students were master's students, and there was a scant amount of doctoral training. As a result of the reformation, the total number of engineering majors was reduced from 664 to 225. Within engineering, the development of light industry majors was accelerated, while the development of heavy industry majors and military majors was maintained and stabilized (or even moderately slowed down), so that the previously marginal disciplines and majors (such as new materials engineering) were introduced to engineering colleges.

Degree levels were designed as a three-tier structure with the launch of the Regulations of the People's Republic of China on Academic Degrees since January 1, 1981. At the end of 1981, the State Council approved the first batch of 151 doctoral degree awarding units, with 812 disciplines and specialties; the first batch of 358 master's degree awarding units, with 3185 disciplines and specialties; and the first batch of 458 colleges and universities awarding bachelor's degrees[29]. However, based on the Opinion on the Restructuring and Reform of Higher Engineering Education issued by the Ministry of Education in 1984, the training and boundaries among postgraduate, undergraduate and specialist were still unclear, and the role of specialists was very similar to that of undergraduates, without developing their own characteristics. In fact, undergraduates were the only backbone in the whole society at the time, while challenges such as insufficient number, aging, and discontinuity of high-level engineering talents still remained unresolved [28].

Thus, from 1984 to 1993, the number of engineering majors was reduced from 255 to 181, and the professional degree of Master of Engineering was officially added the degree structure, to cultivate engineering talents at different types and levels. A pilot scheme for the cultivation of engineering research students was conducted from 1984 to 1989. And the total number of engineering master's degree students rose from 0.17% before 1987, to 14% in 1989, and reached 20% in 1991. And in 1994, the “Program for Setting Professional Degree of Engineering Master” was officially adopted, and engineering master thus became an important part of China's postgraduate education [17].

As the structure and degree level of HEE gradually stabilized, China began to improve the quality of engineering education, to adapt to the needs of national economic development and the new technological revolution emerged worldwide [28]. This was reflected in the change of the management system and the school running system. From the founding of China to 1956, China's higher education basically takes the form of a combination of the central government, other operational departments of the State Council and provinces, autonomous regions and municipalities directly under the Central Government. The Decision of the Central Committee of the Communist Party of China on the Reform of the Education System (hereinafter referred to as "the Decision") promulgated in May 1985 clearly pointed out that the main drawback of the original higher education system in China was that government ministries had too much management over higher education institutions and the authority of schools to develop and manage themselves independently was too low. Ultimately the Party Central Committee decided to expand the autonomy of higher education institutions, to strengthen the links between higher education institutions and production, scientific research and other aspects of society, and to give higher education institutions the initiative and ability to adapt to the needs of economic and social development.

Starting from 1993, the reform of HEE entered to the final stage of further developed, marked by the introduction of the Outline in 1993 and the National Education Work Conference held in 1994. Two major measures were implemented in higher education: 1) decentralizing formerly ministry-affiliated colleges and universities to localities; and 2) merging industrial monotechnic colleges and universities organized and directly managed by industries into comprehensive universities. As a result, the proportion of universities belonging to the central ministries and commissions in the total number of universities in the country was reduced from 33.96% in 1995 to 11.14% in 2000 and continued to fall in the coming years [29].

2001-2014: Improvement through learning outwards

Under the context of reform and opening up, China’s higher education gradually resumed contact with Europe and the United States, organizing large-scale delegations to visit, and initiating exchange and study programs in Europe and the United States. China's accession to the World Trade Organization in 2001 marked its full participation in the process of economic globalization. At this stage, China's HEE continuously learned outwards to improve its quality.

On January 9th, 2006, General Secretary Hu Jintao announced at the National

Conference on Science and Technology that the goal of China's science and technology development in the next 15 years is to build an innovative country by 2020, so that science and technology development can become a strong support for economic and social development. This required China to further improve the engineering education model and cultivate more types of innovative engineering talents. At this stage, China's engineering education faced two main problems, one was the challenge brought by economic globalization and internationalization of higher education, Chinese engineers must compete with international talents, and the training objectives, specifications and evaluation standards of engineering talents had to be in line with international standards. The second was the challenge from within the country, referring to the huge impact of the massification of educational resources on universities.

In 1995, the State Education Commission organized a study tour to the United States for engineering education. The study report has far-reaching influence on guiding the subsequent engineering education reform in China. Firstly, it answers the question of "what exactly is engineering education"; secondly, it establishes the belief that engineering education in China must return to engineering; finally, it points out that the reform of engineering education in China must be cautiously researched, boldly tried, oriented to the world and the future, and widely absorb advanced experiences at home and abroad. Since 1999, the declining quality of education has become a common concern in China's higher education sector, including the engineering education sector. At the same time, the reform of engineering education is also facing the problem of tilting heavily towards scientification and becoming more and more detached from "engineering" itself. The solution is to introduce the "The Idea of Large-Scale Engineering", so that engineering education in China can return to engineering [28].

In January 2000, the Ministry of Education (MOE) approved the first batch of 670 projects for undergraduate education teaching reform. The aim of the project is to adapt to the needs of China's modernization in the new century, to cultivate high-quality talents with innovative spirit, practical ability and entrepreneurial spirit, and to carry out comprehensive reform research and practice on the mode of cultivating talents, teaching contents, curriculum system and teaching methods in higher education, so as to promote the deep development of teaching reform. The project places particular emphasis on the holistic, integrated and practical application of teaching reform. As an important part of the project, the Ministry of Education approved in August 2000 the establishment of 266 projects for the "World Bank Loan for Teaching Reform in Higher Science and Technology Education at the Beginning of the 21st Century", involving more than 170 universities in 31 provinces [17].

Afterwards, a series of teaching reforms have been carried out in China's higher engineering education sector [30]. On 23 June 2010, the Ministry of Education (MOE) held a kick-off meeting in Tianjin to launch the Excellence in Engineer Education and Training Programme, and the first batch of 61 universities started to implement the programme in September of the same year. 362 undergraduate majors or professional categories in 133 universities became the second batch of implementation units in 2011. In 2011, the State Council and the Ministry of Education set up a "Special Experimental Zone for Educational Teaching Reform", or National Pilot College, in 15 universities to implement the National Medium and Long-term Education Reform and Development Plan (2010-2020). The content includes four main areas: school management system mechanism, teacher appointment, assessment and evaluation system, talent recruitment and selection mechanism, and talent training model.

The second revision of the catalogue of undergraduate majors began in 1989, and in July 1993, the State Education Commission issued the Circular on the Issuance of the Catalogue of Undergraduate Majors in General Colleges and Universities, which reduced the number of undergraduate majors from 671 to 504, including the reduction of engineering majors from 255 to 181. In April 1997, the Ministry of Education issued the "Opinions on the Principles of Revision of Teaching Plans for Undergraduate Majors in General Higher Education Institutions", starting the third revision of the catalogue of undergraduate majors. In July 1998, the Ministry of Education issued the "Catalogue of Undergraduate Majors of General Higher Education Institutions", in which the original 504 undergraduate majors were reduced to 249 majors, with the number of engineering majors reduced from 181 to 70. The three adjustments of undergraduate majors have further broadened the calibre of undergraduate talents training [17]. The three undergraduate majors, including the restructuring of engineering majors (See table 8).

Table 8 Three professional adjustments since reform and opening [31]

	Three Professional Adjustments since Reform and Opening	**Publish Professional Directory Time**	**Total Number of Majors**	**Engineering Majors**
1	Year of 1982	Year of 1987	1343→671	664→255
2	Year of 1989	Year of 1993	671→504	255→181
3	Year of 1997	Year of 1998	504→249	181→70

By 2014, the number of schools with engineering majors reached 1,653, accounting for 88.75% of all colleges and universities; of the 17 million students enrolled in undergraduate programs, 6.72 million were engineering students, accounting for 37.5% of the total. Among postgraduates, there were 182,088 engineering students, accounting for 34.4% of the total number (Table 9). The scale of engineering education and the total number of engineering talents are among the highest in the world. The distribution of majors and students within the engineering disciplines has also changed and the situation where heavy industry was dominant has been improved (Table 9).

Table 9 Number of Students by Field of Studying Regular Higher Education Institutions from 2000-2014 (Unit: in Person) [32]

Major	2000	2001	2002	2003	2004	2005	2006	2007
Philosophy	-	873	1223	1562	1854	2249	3117	3738
Economics	2042	N/A	4433	6578	8098	10930	14784	17239
Law	2050	N/A	5139	7484	11097	14103	19413	22556
Education	4987	N/A	1946	2764	4276	5101	7767	9854
Literature	6944	N/A	5157	7426	10483	13314	20107	25064
History	425	N/A	1395	1926	2407	2657	3497	4424
Science	3551	N/A	9866	13220	17540	22028	29137	35266
Engineering	947	N/A	30078	41337	56074	72941	94516	114621
Agriculture	-	N/A	2790	3849	5165	6038	8853	11297
Medicine	325	N/A	8677	12207	16128	19405	26415	32453
Administrators	-	N/A	10104	12662	17596	20848	28179	35164

Major	2008	2009	2010	2011	2012	2013	2014
Philosophy	4175	4518	4620	4708	4760	4401	4234
Economics	17614	18327	19110	19232	19828	22790	25606
Law	23849	21681	26165	36451	40093	39571	38596
Education	12127	13406	13565	19706	23420	24890	29063
Literature	28038	31634	33623	37496	29586	31484	31651
History	4908	5082	4857	5258	5352	5193	5206
Science	34380	41822	43654	42711	47302	47020	48465
Engineering	117894	130514	128678	139653	164447	171966	182088
Agriculture	12333	13425	14079	12164	15573	16625	18671
Medicine	36696	34629	35582	48342	55252	57798	60563
Administrators	39114	31636	32703	49757	58274	65337	69083

2015 to date: Leading through innovation

The fourth industrial revolution has promoted the all-around transformation of education in engineering. For example, innovative educational concepts, ecological quality requirements, intelligent technical skills and a service-oriented knowledge structure. As a base for the cultivation of engineering talents, higher engineering education arises from the needs of industry and is inextricably linked to industry. In May 2015, the "Made in China 2025" strategic plan was announced and implemented, which is the first ten-year action plan of China's "three-step" towards becoming a powerful manufacturing country. The plan clearly points out that the cultivation of talents is the key to realizing the strategy of manufacturing power, and accelerates the formation of a route to cultivate high-quality engineering talents. The implementation of "Made in China 2025" strategy has put forward new requirements for HEE.

In 2017, the Ministry of Education launched the construction of "New Engineering Education (NEE)", accelerating the cultivation of engineering and technology talents in emerging fields, renovating and upgrading traditional engineering majors, and proactively laying out the cultivation of talents in areas that will be strategically important in the future. The main purposes of NEE are: 1) proposing a new concept to establish an innovative, comprehensive and fully-cycled engineering education; 2) forming a new structure to combine the new and traditional engineering majors; 3) exploring a new model to cultivate the engineering technological talents; 4) developing a high-quality evaluation to improve international competitiveness of engineering education; and 5) constructing a new system to strengthen engineering education. The main approaches to build NEE are inheritance and innovation, integration and emergence, coordination and sharing, which means to transform subject-oriented to industrial demand-oriented, transform subject independent to subject integrated, transform the role of adapting the requirements of application to the role of leading to the development of industry [33]. On 18th February 2017, the Ministry of Education held a seminar on the development strategy of higher engineering education at Fudan University. The participating universities held a live discussion on the cultivation of engineering talents in the new era, jointly discussed the connotation characteristics of new engineering disciplines and the path options for the construction and development of new engineering disciplines, and reached the following consensus [34]: NEE includes three types, they are new pattern engineering (reform existing disciplines), newborn engineering (develop new interdisciplinary) and new emerging engineering (establish unprecedented disciplines). Specifically, the new pattern engineering is formed by transformation, modification and upgrade of the existing or traditional engineering disciplines, which indicates the expansion of connotation, the improvement of training objectives and standards and the reform and innovation of training method. And the new born engineering is formed by the cross-combination between current engineering disciplines and traditional engineering disciplines and the interdisciplinary fusion between engineering and other disciplines. As well as the new emerging engineering is formed by the extension of other disciplines or the transformation of new technology and new industry. The expected results of NEE should also include: obtaining an effective method for cultivating innovative engineering talents, establishing an entrepreneurial oriented training mode and forming a marketed employment mechanism to promote the close combination of industry, education, research and application.

Understanding the evolutionary path of HEE to NEE in China

Macro-level analysis: national developmental strategies

As discussed, engineering education in China has long served the industrial construction and development. Thus, China's national development strategies, as the macro-level factors, have significantly influenced the evolutionary path of HEE. In different historical periods, the national policies on HEE were different, thus, promoting the development of HEE in different ways.

The adjustment of departments and disciplines initiated from 1952 integrated China's higher education into the track of training specialized talents for economic construction. This led to a rapid increase in the number of engineering colleges and engineering technology talents, and a significant expansion of China's HEE. After the cultural revolution, there was a drastic dilemma between people's desire for new life and the countries' backwards. This became a strong push factor for China to develop HEE. Before the Reform and Opening-up, China pursued a policy of prioritizing the development of heavy industry, when HEE in China was characterized as high specialization. Engineering colleges and universities cultivated engineering talents needed by the country and provide solid engineering talents for socialist economic construction. Since 1978, the marketized mechanisms begun to enter into China, where the develop of light industries have been stressed. Thus, China's HEE has experienced large-scale restructuring and started institutional reform. However, China's industry have largely depended on the importing, and its own enterprises was at the low end of the industry chain until the 1990s. As such, it is imperative to cultivate innovative talents to build an innovative country [35-36].

In 2001, China' accession to WTO has not only promoted its economic internationalization, but also facilitated China's international exchange and cooperation of HEE and engineering and technical talents with advanced countries. The domestic HEE in China have learnt educational experiences such as CDIO, as discussed. Since 2015, China began to implement strategies, such as "innovation-driven" and "Made in China 2025" to support the new economy and new industry. In order to enhance China's innovation capability at the world stage, innovative engineering talents are fundamental [37]. The NEE initiative is the response to the national strategy of building innovative country. This is expected to be achieved through cultivating talents who can adapt to, lead the future engineering needs [38], resolve national, industry and technological needs [39]. In this way, China is expected to be innovative enough to compete at the world stage [40].

Meso-level analysis: the transformation of HEE system

The relationships between sciences and practices in HEE has attracted plenty of academic discussions [41]. Since the late 1900s, 'returning to engineering' in HEE has been called [42]. The paradigm of engineering is thought to be an integration of sciences and practices [43], which means that the talents of engineering should be overall developed. However, HEE in China has long faced the problem of over-specialization of majors, which cannot meet the convergent trends in technology and industry revolution, and demands from the national needs [44].

In the post-industrialization era, modern information technology has brought great influence to engineering practice. It is inevitable that HEE adopts the concept of innovation to cultivate innovative engineering talents [45], who own a balance of solid professional technology and complex knowledge background. The NEE initiative is China's active response to the worldwide trend of HEE transformation. The NEE initiative in China does not only call for building new disciplines during discovering knowledge, but also call for upgrading and transforming traditional industries and old professions [46-47]. The NEE initiative is a dynamic concept, envisioning 'creative-innovation-entrepreneurship' education system [48]. Therefore, the NEE initiative can be considered as the new transformation of HEE system in China through active layout and deepening reform in order to promote the new economy characterized by new technology, new industry, new production and new mode to flourish. The educational vision of NEE resides in meeting national needs through producing engineering talents, transforming engineering disciplines, driving technological and economic innovation, eventually shaping the future [49].

Conclusion

Drawing on the view of institutional changes and the macro- and meso-level analytical lens in historical institutionalism, this article examines the evolutionary path of HEE to NEE in China through a systematic analysis of policy documents since the founding of the People's Republic of China in 1949 to date, as well as extant research literature. We categorized the evolutionary path of HEE to NEE in China into five phases: (1) Exploratory development (1949-1965); (2) Relative development (1966-1976); (3) Adjustment during reform; (4) Improvement through learning outwards; and (5) leading through innovation. We also analyzed such evolutionary path through both the national strategies (the macro-level) and in China and the transformation of HEE system (the meso-level). In so doing, we contribute to a nuanced understanding of the evolutionary path of HEE to NEE in China. In future studies, we will deepen micro-level analysis on China's historical developments of HEE through, such as, interviewing key stakeholders.

Acknowledges:

Authors Yanru Xu, Ji'an Liu, and Yaxuan Wen acknowledge the support of the National Social Sciences Fund of China on Educational Sciences Planning Project of the year of 2022 for National Youth Scholars - "International Comparison of the Organizational Models and Synergistic Mechanisms of the Research-Teaching Nexus" under grant number CIA220288.

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