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Global evolutionary trends of the discipline of engineering education and their empirical implications

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ABSTRACT

This study explores the gradual evolution and institutionalization of engineering education research (EER) as a discipline across different countries and regions through the perspective of historical institutionalism. By employing bibliometric and historical retrospective methodologies, the research provides a systematic analysis of the development and transformation of EER in the United States, Europe, and China, along with the dynamic progression of their engineering education disciplines. The findings reveal several key insights. First, the evolution of engineering education in the United States unfolds across five stages: educational standardization, the rise of scientism, re-engagement with engineering and reflective scholarship of teaching, the initiation of discipline construction, and the establishment of disciplinary norms. In Europe, this progression is marked by three phases: educational standardization, the development of the scholarship of teaching, and the exploration of discipline-building. Second, the alignment between China's higher engineering education and modern industrial development demonstrates a comprehensive and dynamic adaptation. The advancement of China's engineering education discipline has gone through four distinct phases: educational reform exploration, the standardization of academic community building, the formation of teaching scholarship organizations, and the initiation of discipline construction. Third, the characteristics of discipline development differ across regions. The United States's approach emphasizes practicality, professionalization, and disciplinization; in Europe, the focus lies on professionalization, networking, and practical integration; and China's model emphasizes professionalization, institutionalization, and disciplinization. Finally, the study identifies five key dimensions for guiding future reforms in the development of China's engineering education discipline, offering pathways to enhance its growth and impact.

Key words: engineering education research, engineering education discipline, teaching scholarship culture, academic community

INTRODUCTION

Research in engineering education serves as a critical foundation for promoting high-quality development in the field and plays a pivotal role in advancing engineering education and teaching practices.[1] However, debates over the nature and status of engineering education research (EER) as a discipline persist within academic circles. In 2005, the director of the School of Engineering Education at Purdue University, Dr. Haghighi, asserted that EER had emerged as a new discipline.[2] This claim faced criticism

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from some scholars who opposed the use of the term "discipline," arguing that it might detach EER from practical applications. Instead, they advocated for terms like "community" or "field."[3] This divergence of opinions has since sparked a sustained debate between proponents of the "discipline theory" and the "field theory" within the engineering education community.

Despite the ongoing debates, EER has progressively evolved toward disciplinization. This development is evident in efforts such as the recruitment of engineering education researchers, the establishment of engineering education departments, the creation of doctoral programs in engineering education, and the construction of a knowledge system specific to the field.[4,5] As early as the 1980s, the National Science Foundation (NSF) in the United States began funding projects aimed at reforming engineering education. These initiatives injected substantial financial support into engineering education practice and research, with institutions like Purdue University conducting extensive studies on the question, "How do people learn engineering? "

Building on these efforts, Purdue University launched the first doctoral program in engineering education in 2005, marking a significant milestone in fostering specialized talent and conducting systematic research in the field. Since the 2010s, other regions, including Europe, China, and Australia, have also engaged in in-depth EER and explored the establishment of engineering education as a discipline.[6]

This study, through the lens of historical institutionalism, aims to examine how EER has gradually evolved and progressed toward the institutionalization of an academic discipline, and to identify its future development and disciplinization directions. To achieve this, the research team employed a purposive sampling strategy, selecting cases based on their relevance and significance. Using typical case sampling, the study identified the United States, Europe, and China as representative regions with extensive experience in EER and institutionalization. A structured multi-case study approach was conducted to analyze the evolution of EER and its disciplinization in these regions, aiming to distill historical patterns and identify key developmental stages.

GLOBAL DEVELOPMENT OF EER

EER has progressively evolved toward disciplinary standardization, with different regions worldwide at varying stages,[7] but each has distinct representative entities, such as organizations, conferences/projects, or academic journals, as shown in Table 1.

The United States is the pioneer and leader in global EER, which has given rise to the influential American EER paradigm that shapes global practices.[8] In 1893, the Society for the Promotion of Engineering Education (SPEE) was founded and later reconstituted as the American Society for Engineering Education (ASEE) in 1946, serving as a professional social organization of the American EER. Subsequently, institutions like NSF, The National Academy of Engineering (NAE), and universities such as Purdue and Massachusetts Institute of Technology (MIT) have engaged in EER, propelling the development of engineering education. Key platforms for scholarly exchange include the ASEE Annual Conference and the International Conference on EER, both serving as global hubs for collaboration. Prominent academic journals such as the Journal of Engineering Education (JEE), the International Journal of Engineering Education (IJEE), and Advances in Engineering Education (AEE) further reflect the intellectual rigor and impact of American EER, with high impact factors showcasing their academic influence. Since Purdue University established the first Department of Engineering Education and launched its graduate programs in 2004, the United Stateshas entered a phase of disciplinary standardization. Currently, 53 universities in the country offer engineering education programs, with 13 dedicated departments and 82 graduate programs in EER, illustrating the structured and systematic growth of the discipline.

Europe serves as a global interlocutor and counterpart in EER, emphasizing engineering education and teaching rather than academic disciplinization[9]. This focus has given rise to a distinct European EER paradigm, differing from the approaches in the United States and other regions. The roots of European EER can be traced back to the Percy Report in 1945, which laid the foundation for subsequent developments. Key academic networks and organizations, such as European Society for Engineering Education (SEFI), 4TU, and the Working Group on EER (WG-EER), have since emerged, alongside physical research centers at institutions like University College London (UCL), KU Leuven, and Aalborg University. Representative conferences, including the SEFI Annual Conference and the Consortium of Higher Education Researchers (CHER) forum, provide platforms for the exchange and integration of diverse engineering education philosophies, cultures, theories, and practices. Leading academic journals, such as the European Journal of Engineering Education (EJEE) and Higher Education in Europe, further reflect the academic outputs of the region. Graduate programs in EER have also been established, with KU Leuven initiating its program in 2009 and UCL following in 2018.

China positions itself as both a learner and innovator in EER, actively developing a Chinese model and contributing unique practices and experiences to the global discourse, particularly through initiatives such as the "Emerging Engineering Education" programs.[10] Representative organizations, including the Engineering Education Committee of China Association for Higher Education (CSEE) and the Education Committee of the Chinese Academy of Engineering, have played key roles in advancing EER. Leading universities, such as Zhejiang University, Tsinghua University, and Huazhong University of Science and Technology, host major events like the CSEE Annual Conference and the International Conference on Science, Technology and Education Policy to foster collaboration between domestic and international scholars. Prominent academic journals, such as Research in Higher Education of Engineering and Tsinghua Journal of Education, have further strengthened the field.

Since 2022, Tsinghua University and nine other institutions have piloted EER disciplinary programs, culminating in the formal inclusion of "Engineering Education" in the national disciplinary catalog in 2024. Dedicated faculty positions and graduate training programs for master's and doctoral students are now being established in schools of education and public administration across the country.

Emerging players in EER, including Australia, Canada, and South Africa, are gaining prominence by actively engaging in EER. These countries leverage the experiences of pioneers like the United Statesand Europe while integrating their unique national contexts and educational characteristics to develop localized EER pathways and models. This dynamic participation underscores the growing global landscape of EER.[11]

THE EVOLUTION OF UNITED STATESENGINEERING EDUCATION

The United States is the earliest initiator of EER and also remains the most important leader in international engineering education today. As presented in Table 2, its development can be mainly divided into five stages:

1893-1949: normative period of engineering education

To address the issue of low-quality training for engineering students, the SPEE was founded in 1893. This marked the beginning of efforts to improve engineering curricula and teaching methods. At the end of the 19th century, SPEE conducted the first detailed study of engineering education in the United States, which led to the publication of the Mann Report in 1918, regarded as the starting point of EER in the country. Based on the recommendations in the report, SPEE called for the creation of standardized engineering curricula. This initiative helped build a general education framework aimed at enhancing professional engineering skills, leading directly to the establishment of the Engineers' Council for Professional Development (ECPD) in 1932. In 1946, aligning with the federal government's increased focus on supporting scientific research, SPEE was reorganized and renamed the American Society for Engineering Education (ASEE). ASEE has since become a central platform for sharing information and fostering collaboration in engineering education in the United States.

1950-1989: fourishing period of scientism

After World War II, the United States federal government began providing significant funding for scientific research. In 1950, the NSF was established to support research activities in higher education institutions.[12] During this period, the ASEE emphasized the importance of incorporating more fundamental science knowledge into engineering curricula. The Grinter Report of 1955 proposed a "science-oriented" reform for engineering education, addressing issues such as the allocation of credit hours in curricula, the alignment between undergraduate and graduate education, and the academic qualifications of research faculty. This marked a shift towards integrating scientific principles into engineering education.

In 1981, the NSF established its Directorate for Engineering, focusing on advancing engineering research. It also supported universities and professional organizations in promoting the practical application of EER. The Neal Report of 1986 highlighted the need for engineering education to "strengthen the application of academic findings and best practices in diverse educational activities."[13]

Overall, this period reflected a "practical" paradigm in engineering education, with less emphasis on theoretical research and more focus on applying knowledge to real-world engineering challenges.

1990-2003: period of returning to engineering and teaching academia

In 1990, the NSF launched the "Engineering Education Coalitions" program, providing funding for member institutions to explore reforms in engineering education. In January 1996, the JEE began publication, positioned as a journal focusing on the scholarship of teaching.[14] It set high standards for publishing research-based, rather than superficial, studies on engineering education.

In 2001, Accreditation Board for Engineering and Technology (ABET) introduced Engineering Criteria

Table 1: Overview of the development of EER in typical global regions

Region	Role	Representative organizations	Representative conferences	Representative journals	Discipline establishment status
The United States	Leader and early explorer	ASEE, NSF, NAE, Purdue University, MIT	ASEE Annual Conference, International Research in Engineering Education Conference	JEE, IJEE, AEE	Purdue University first established the Department of Engineering Education in 2004.
Europe	Interlocutor and counterparts	SEFI, 4TU, WG-EER, UCL, KU Leuven, Aalborg University	SEFI Annual Conference, CHER	EJEE, Higher Education in Europe	KU Leuven and UCL established EER graduate programs in 2009 and 2018 respectively.
China	Learner and innovator	CSEE, The Education Committee of the Chinese Academy of Engineering, Zhejiang University, Tsinghua University, Huazhong University of Science and Technology	CSEE Annual Conference, International Conference on Science, Technology and Education Policy	Research in Higher Education of Engineering, Tsinghua Journal of Education	In 2022, 10 pilot universities established the second-level discipline of engineering education. In 2024 it officially became a discipline.

AEE: Advances in Engineering Education; UCL: University College London; ASEE: American Society for Engineering Education; CHER: Consortium of Higher Education Researcher; CSEE: the Engineering Education committee of China association for Higher Education; EER: engineering education research; EJEE: the European Journal of Engineering Education; IJEE: the International Journal of Engineering Education; JEE: Journal of Engineering Education; NAE: the National Academy of Engineering; NSF: the National Science Foundation; SEFI: the European Society for Engineering Education; WG-EER: Working Group on engineering education research.

2000 (EC2000), emphasizing the development and assessment of learning outcomes. This encouraged integrating research into teaching practices, making it an essential part of faculty responsibilities. During this period, universities increasingly prioritized quality improvements in engineering education and the exploration of fundamental teaching issues.

Institutions became more proactive in establishing centers and initiatives focused on engineering education.[15] For example, Olin College of Engineering was founded in 1997 to pioneer project-based learning methods, while the University of Washington established the Center for Engineering Learning and Teaching in 1998. From 2002 to 2003, the NAE took the lead in founding the Center for the Advancement of Engineering Education (CAEE) and the Center for the Advancement of Scholarship on Engineering Education (CASEE). These centers collaborated extensively with academic stakeholders to conduct rigorous research on the systemic elements of engineering education, laying a scholarly foundation for more effective teaching models.

2004-2014: the initial stage of discipline development

In 2004, Purdue University established the world's first Department of Engineering Education, building on its First-Year Engineering Program and Multidisciplinary/ Interdisciplinary Engineering Studies. This was followed in 2005 by the launch of a Ph.D. program in Engineering Education and a certificate program, marking a milestone in the evolution of engineering education from a rigorous scientific field to a formal academic discipline.[16]

During this formative stage, the ASEE played an active role in advancing the discipline. In 2006, ASEE initiated the "Year of Dialogue Focused on Engineering Education Research," a nationwide event that engaged over a thousand participants from government, academia, and industry. This initiative garnered broad support for EER across diverse sectors, laying a strong foundation for the discipline's continued growth.[17]

2015-present: standardized stage of discipline construction

Academic communities such as NSF and NAE have continued to drive the structured development of engineering education as a discipline.[18] In 2015, the NSF launched the five-year revolutionizing engineering departments (RED) initiative, aiming to transform engineering and computer science education through funding innovative approaches. The program sought to cultivate a diverse professional workforce to meet society's growing demand for engineers and computer scientists. In 2020, the NAE published Building Capacity for Teaching Engineering in K-12 Education, reviewing existing curricula, programs, and related research. This report assessed the current state and future needs of K-12 educators with engineering knowledge, exploring strategies to meet those needs. MIT has also been a trailblazer in engineering education. In 2017, MIT launched the New Engineering Education Transformation (NEET)[19] initiative, aiming to reshape its engineering education. This program focuses on interdisciplinary and project-centered learning, equipping students with the essential skills, knowledge, and qualities required in the modern world.[20]

Overall, an increasing number of academic stakeholders have joined the effort to build the discipline of EER. They have actively engaged in global dialogues and

Table 2: Stages of evolution and key events in American EER

Time	Period	Key events
1893-1949	Normative period of engineering education	1893: The SPEE was established, marking the beginning of detailed research on American engineering education.
		1916: Formation of the NRC, contributing to the advancement of science, technology, and education.
		1918: Publication of the Mann Report, signifying the start of research in American engineering education.
		1923: The Wickenden Report highlighted the importance of curriculum accreditation for maintaining uniform and standardized development in engineering education across the nation.
		1932: The ECPD was established, ushering in a new era of standardized development in the American engineering education curriculum.
		1940: SPEE released the Hammond Report.
		1946: SPEE was reorganized and renamed as the ASEE.
1950-1989	Flourishing period of scientism	1950: Establishment of the NSF
		1953: The University of Pennsylvania awarded the first Ph. D. in Bioengineering
		1955: The Grinter Report, published by the ASEE, proposed a "science-oriented" approach to engineering education reform
		1964: The formation of the NAE
		1968: ASEE released the "Goals of Engineering Education" report
		1974: The enactment of the Career Education Act calls for the re-establishment of the education system to be centered on vocational education
		1975: ASEE published the "Yearbook of Engineering Education,"
		1981: NSF established the Engineering Directorate
		1986: The Neal Report was published
1990-2003	Period of returning to engineering and teaching academia	1990: NSF launched the "Engineering Coalition" program to foster engineering education reform.
		1993: The JEE was positioned as an academic professional journal.
		1997: ABET formally adopted the "Engineering Criteria 2000."
		1997: Olin College of Engineering was established.
		1998: the University of Washington established the Center for Engineering Learning & Teaching.
		2001: The Gordon Prize was established to recognize innovative models and experiment effectively in developing engineering leadership.
		2002: The CAEE was founded.
		2003: The CASEE was established.
2004–2014	The initial stage of discipline development	2004: Purdue University established the School of Engineering Education and the Department of Engineering Education.
		2005: Purdue University established the Ph. D. program in Engineering Education.
		2005: NAE released the "Educating the Engineer of 2020" report.
		2006: ASEE initiated the "Year of Dialog" for engineering education academics.
		2006: NSF launched funding programs for EER.
		2007: JEE organized the first International EER Conference.
		2009: AEE journal was launched.
		2010: NSF implemented the "Broadening and Strengthening the Capacity for Engineering Technology Education Research" program
2015-Present	Standardized stage of discipline construction	2015: NSF initiated the RED (Revolutionizing Engineering Departments) Education Innovation project.
		2017: MIT launched the NEET program.
		2017: NAE released the report "Engineering Associations and Undergraduate Engineering Education".
		2018: NAE convened a symposium on aligning industry needs and objectives with engineering education.
		2018: MIT published the "Global Engineering Scenarios and Future Trends" report.
		2019: Worcester Polytechnic Institute established the "Global School".
		2020: NAE released the report " Building Capacity for Teaching Engineering in K-12 Education".
		2020: ASEE published "The Skills Needs of Future Engineers".
		2023: The "University of Southern California Viterbi School of Engineering: Interdisciplinary Systems Engineering Education Model" won the Gordon Prize.

AEE: Advances in Engineering Education; ASEE: American Society for Engineering Education; CAEE: the Center for the Advancement of Engineering Education; CASEE: the Center for the Advancement of Scholarship on Engineering Education; EER: engineering education research; ECPD: Engineers' Council for Professional Development; JEE: Journal of Engineering Education; MIT: Massachusetts Institute of Technology; NAE: the National Academy of

Engineering; NEET: New Engineering Education Transformation; NRC: the National Research Council; NSF: the National Science Foundation; SPEE: the Society for the Promotion of Engineering Education.

pursued multi-level explorations of learning, research, and practice in engineering education. These efforts have propelled EER towards the dual goals of establishing itself as a formalized discipline and improving the quality of engineering education worldwide.

THE EVOLUTION OF ENGINEERING EDUCATION AS A DISCIPLINE IN EUROPE

The evolution of EER in Europe can be roughly divided into the following three stages, as presented in Table 3.

1945-1976: normative period of teaching and education

In 1945, the Percy Report provided a comprehensive plan for the British education system, with a particular focus on the development of higher technical education. Later, the Crowther Report of 1956 recommended that educational initiatives take into account changes in societal and industrial needs as well as the personal needs of citizens.

During the 1970s, several institutions established centers to support engineering education within their own disciplines. For instance, Roskilde University and Aalborg University in Denmark adopted problem-based learning (PBL) methodologies and set up research centers and study groups dedicated to PBL reform and engineering pedagogy. In 1973, SEFI was founded, forming a representative network of scholars in European EER. SEFI has since become a prominent organization in the field, hosting 52 annual conferences to date.

1977-2004: development stage of education research

To address the industrial decline, failures in professional reforms, and the low status of engineers in mid-1970s Britain, the Committee of Inquiry into the Engineering Profession was established in 1977. The committee conducted extensive research, engaging professional organizations, universities, educational institutions, industries, and government agencies domestically and internationally. In January 1980, the committee released the Finniston Report, which called for engineering education to align with national interests and the evolving needs of modern industry. The report outlined a preliminary blueprint for the future engineering education system, emphasizing the foundational mission of engineering education, the professional nature of engineering, and the importance of fostering a strong professional identity among engineers.[21]

By the 1990s, factors such as increasing diversity in the student population, the rise of lifelong learning, and European integration shifted the focus to improving the quality of engineering education. Institutions began establishing dedicated centers to train engineering educators in teaching research. For example, in 1997, Loughborough University founded the Engineering Center for Excellence in Teaching and Learning (EngCETL), followed by the establishment of the Engineering Subject Centre (EngSC) in 2000. The implementation of the Bologna Declaration further promoted European educational integration. In 2004, the European Union introduced the European Accreditation of Engineering (EUR-ACE) Framework Standards for accrediting engineering programs, providing structural support for the systematic and high-quality development of engineering education in Europe. Unlike the U. S., Europe pursued an independent model of engineering education, reflecting its unique priorities and opting not to join the Washington Accord. This distinct path encouraged greater participation of engineering educators in teaching research while fostering a robust and autonomous framework for engineering education across Europe.

2005 to present: exploring stage of discipline development

In 2007, the Advancing Global Capacity for Engineering Education and Research (AGCEER) project jointly launched by EJEE and JEE brought the scientific research paradigm of the American EER to Europe.[14] This sparked intense dialogue and debate between scholars from Europe and the United States. In 2008, the European SEFI established the WG-EER, the first professional EER academic organization spanning the entire continent. WG-EER played a significant role in promoting EER as a specialized field of study in Europe.

After 2007, several universities began establishing EER centers or groups within their engineering faculties, providing full-time positions for engineering educators engaged in EER. For example, The Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability (UCPBL) was founded in 2007 to support research in PBL within engineering education. Some institutions also pioneered graduate programs in engineering education. In 2009, KU Leuven established the Center for Engineering and Science Education,

Table 3: Stages of evolution and key events of EER in Europe

Time	Period	Key events
1945-1976	Normative period of teaching and education	1945: The Percy Report published.
		1956: The Crowther Report published.
		1970: BJET was established.
		1972: Roskilde University in Denmark was established.
		1972: IGIP was established.
		1973: SEFI was established.
		1974: Aalborg University in Denmark was established.
		1976: EJEE was established.
1977-2004	Development stage of education research	1977: The Committee of Inquiry into the Engineering Profession of the UK was established.
		1980: The Finniston Report published and called for engineering education to face the new demands of national interests and modern industry.
		1987: The theme of the SEFI Annual Conference was: Interdisciplinarity and International Cooperation in Engineering Education.
		1997: Loughborough University established the EngCETL.
		1999: The Bologna Declaration.
		2000: Loughborough University set up the EngSC.
		2004: The EUR-ACE Education Standards was released.
2005 to Present	Exploring stage of discipline development	2007: The "AGCEER" project jointly initiated by EJEE and JEE.
		2007: The University of Aalborg established the UCPBL.
		2008: SEFI established the WG-EER. The European engineering education and research improve the institutionalization of construction
		2009: NNEER set up.
		2009: KU Leuven established the Center for Engineering and Science Education, and started to enroll postgraduate students majoring in engineering education in 2012.
		2010: The University of Cambridge- MIERG.
		2013: Dublin Institute of Technology- CREATE Research Group.
		2013: Aston University- EERG.
		2013: University College London set up the Center for Engineering Education(UCL-CEE).
		2016: Four universities of science and technology in the Netherlands formed the Engineering Education Center Network (4TU).
		2018: University College London set up the Master's Program in Engineering Education.
		2019: The University of Aalborg launched the "JPBLHE".
		2022: The theme of the SEFI Annual Conference was: Towards a New Future for Engineering Education.

AGCEER: Advancing Global Capacity in Engineering Education Research; BJET: the British Journal of Educational Technology; CEE: Centre for Engineering Education Innovations; EER: engineering education research; IGIP: the International Society for Engineering Education; EERG: engineering education research group; EJEE: The European Journal of Engineering Education; EngCETL: the Engineering Center for Excellence in Teaching and Learning; EngSC: the Engineering Subject Centre; EUR-ACE: European Accreditation of Engineering; JPBLHE: Journal of Problem-Based Learning in Higher Education; MIERG: Manufacturing Industry Education Research Group; NNEER: the Nordic Network on engineering education research; SEFI: the European Society for Engineering Education; UCL: University College London; WG-EER: the Working Group on Engineering Education Research.

which began offering master's and doctoral programs in engineering education in 2012. In 2018, UCL launched a master's program in engineering education.

So far, although Europe has made significant strides in the early stages of building engineering education as a discipline, it has yet to establish a cohesive disciplinary paradigm comparable to that of the United States.

THE EVOLUTION OF ENGINEERING EDUCATION AS A DISCIPLINE IN CHINA

Due to the differences in societal contexts such as institutional frameworks, China's EER has developed along paths distinct from international trends, particularly in terms of research approaches and educational philosophies. The emergence of engineering education as a discipline in China is driven by the interplay of two key factors: the rapid expansion of engineering education and the relative shortage of high-level professional research talent. This development represents an inevitable response to these challenges and serves multiple purposes. It offers an effective pathway to promote systemic reforms in engineering education and establish new paradigms tailored to China's unique context. Additionally, it serves as a platform for building a collaborative governance community in engineering education and empowering the training of a large cohort of outstanding engineers.[22]

Comprehensive dynamic alignment of China's engineering education with industrialization

In the early years of the People's Republic of China, the engineering education system was primarily modeled after the Soviet Union, developed within the framework of a planned economy. This period was characterized by a focus on training technical talent, supporting industrialization, emphasizing apprenticeship models, and promoting engineering practice. The primary goal during this stage was to meet the industrialization needs of the nation, particularly in foundational industries and national defense sectors. A number of engineering-focused institutions were established, along with academic disciplines tailored to China's specific conditions. These efforts produced a significant number of urgently needed technical and engineering professionals, effectively supporting China's industrial development and exploration. As a result, the share of the secondary industry in China's gross domestic product (GDP) increased dramatically, rising from 13.8% to 61.8%, underscoring the critical role of engineering education in driving the country's industrialization.

From 1978 to 1998, China gradually entered the global industrial labor system, transitioning into a phase of original equipment manufacturer (OEM) production. During this period, engineering education shifted its focus to meet the demands of midstream and downstream industrial production within global supply chains. Simultaneously, efforts were made to explore and establish an engineering education system that aligned with international standards, laying the groundwork for deeper global engagement and collaboration.

From 1999 to 2014, intensifying global trade competition and the urgent need for industrial upgrading drove China's transition into a high-tech development phase. Higher engineering education was tasked with adapting to these industrial and economic transformations, aligning itself with the nation's innovation-driven development strategy.

The year 1999 marked a pivotal moment with the implementation of the Revitalizing Education Action Plan for the 21st Century, as part of the strategy of Invigorating the Nation Through Science and Education. This period witnessed a significant acceleration in EER and reform, aimed at enhancing its ability to support national economic and technological advancements. The share of the tertiary sector in GDP rose from 36.2% to 47.2%, reflecting a rapidly modernizing economy.

Since 2015, China has entered a phase of industrial upgrading and transformation. Key policy initiatives, such as the Overall Plan for Coordinating the Construction of World-Class Universities and First-Class Disciplines and the Guiding Opinions on Transitioning Some Local Undergraduate Institutions to Application-Oriented Universities, have underscored the strategic importance of engineering education in this transformation. These policies have actively promoted the integration of industry and education, aiming to align the education and talent supply chains with industrial and innovation chains. The focus has shifted toward cultivating innovative, high-caliber talent to support industrial restructuring and upgrading. Engineering education has entered a new stage, emphasizing technology transfer and deeper collaboration among academia, industry, and research institutions. During this phase, the tertiary sector, having surpassed the secondary sector as the largest GDP contributor, accounted for 60.2% as of 2023, reflecting the ongoing optimization of China's industrial structure. More details regarding the comprehensive dynamic adaptation between China's engineering education and industrial development can be obtained from Table 4.

A historical overview of engineering education in China

At the founding of the People's Republic of China in 1949, the government held strong authority over universities. Scientific research, and talent cultivation were oriented toward serving national development, resulting in the marginalization of higher engineering education and the broader higher education system. However, the 1978 reform and opening up of China's modern university system created a flexible external environment, laying the foundation for the large-scale development of EER. The subsequent development stages are as follows. For details, please refer to Table 5.

1980-1990: the exploration period of education and teaching reforms

In 1980 and 1983, respectively, the Tsinghua Journal of Education and Research in Higher Education of Engineering were founded, serving as platforms for summarizing practical experiences in Chinese engineering education. These journals marked the beginning of EER in China and the initial exploration of its professionalization. In 1982, the National Collaborative Group for Engineering Education Reform in Higher Education Institutions was formed, consisting of 13 universities directly under the Ministry of Education (MOE). This group played a pivotal role in advancing the national teaching and learning reforms, bringing

Table 4: Comprehensive dynamic adaptation of engineering education and industrialization development in China

Stages of engineering education development in China	Stages of engineering education	Stages of industrial development in China
Exploration and development period[23] (1949-1977)	Learning from the soviet model Focusing on cultivating industrial construction talents and teaching staff Development of specialized colleges and technical schools	Period of industrial exploration and pioneering
Period of adjustment and transformation (1978-1998)	Drawing on western experiences Continuous reform and system construction in higher education Significant expansion of the scale of engineering talent cultivation Establishment of the graduate degree system	Period of OEM production
Period of rapid development (1949-1977)	Expanding and improving the enrollment scale of engineering programs in universities Optimizing the hierarchical structure of higher engineering education Establishing a professional accreditation assurance system Promoting the development of quality courses and special projects	High-tech development
Period of reform and innovation (2015-present)	Primarily independent training system Drawing on the CDIO training model Construction of Emerging Engineering Education and the Program for Cultivating Outstanding Engineers Breakthroughs in engineering education accreditation	Period of industrial upgrading and transformation

OEM: original equipment manufacturer; CDIO: conceive, design, implement, operate

together teaching administrators, engineering education scholars, and instructors to spearhead the investigation of reform strategies across Chinese institutions.

1991-2002: the period of standardization of academic community construction

In 1991, Engineering Education committee of China association for Higher Education(CSEE) was established, which is the founding member of the International Federation of Engineering Education Societies (IFEES), the CSEE aimed to build a global, professional, and networked platform for EER and practice. In 1994, Prof. Wang Peimin of Zhejiang University published Essentials of Engineering Education, a foundational work that explored the theoretical and practical dimensions of engineering education on a global scale. The formation of the Education Committee of the Chinese Academy of Engineering in 1998 further refined the academic framework for EER. During this time, prominent scholars led numerous consultative projects such as "Engineering Education Paradigm Change and Redesign under the Trend of an Intelligent Society" and "An Outstanding Engineer Training System with Deep Integration of Industry, University, and Institute. "These projects produced key recommendations, providing crucial guidance for the government and universities in implementing engineering education reforms.

2003-2020: the formation of educational academic organizations

In 2003, the Higher EER Center, jointly established by the Chinese Academy of Engineering and Beihang University, marked the beginning of engineering-focused universities setting up dedicated research institutions in the field of engineering education. This was followed by similar initiatives at universities such as Tsinghua University, Zhejiang University, Tianjin University, and Huazhong University of Science and Technology. These centers acted as consulting bodies for university and MOE engineering education reforms. The formation of these organizations significantly expanded the research platform and increased personnel engagement in engineering education, leaving a lasting impact on national policy decisions. The period also witnessed the implementation of numerous initiatives aimed at nurturing a diverse pool of high-quality engineering talents equipped with innovative capabilities to meet the demands of economic and social development. Notably, in 2014, the reorganization of the Teaching Reform Collaborative Group added new members like Harbin Institute of Technology, Central South University, and Shantou University. This restructuring was part of efforts to strengthen coordination across several key programs, such as the "Outstanding Engineer Education and Training Program" and the CDIO engineering education reform. The MOE launched the "Emerging Engineering Education" in 2017, followed by the "Fudan Consensus, " "Tianjin University Action, " and "Beijing Guidelines".[24] In summary, the Chinese engineering education system has undergone a gradual transition from a scientific paradigm to an academic paradigm of engineering and teaching.[25]

2021 to the present: the beginning of the discipline construction

As engineering education and its teaching practices advanced, China's EER and discipline development entered a new phase. In 2021, the MOE published the report China's Engineering Education Strategy and Reform Path, which proposed the establishment of engineering education as an independent discipline. In

Table 5: Stages of evolution and key events of EER in China

Time	Period	Key events
1980-1990	Period of exploration of educational and teaching reform	1980: "Tsinghua Journal of Education" was founded.
		1982: National Collaborative Group on Teaching Reform of Engineering in Higher Education Institutions set up.
		1983: Research in Higher Education of Engineering was founded.
		1985: Higher Education Development and Evaluation was founded.
		1985: Notice on the Research and Pilot Work of Assessment of Higher Engineering Education, establishing China's assessment system for higher engineering education.
		1985: Decision of the Central Committee of the Communist Party of China on the Reform of the Education System, decentralizing the autonomy of colleges and universities.
1991-2002	The period of standardization of academic community building	1991: The Engineering Education Committee of the China Association for Higher Education (CSEE) was set up.
		1994: Publication of the textbook "Essentials of Engineering Education".
		1998: The Education Committee of the Chinese Academy of Engineering was set up.
2003-2020	Formation of educational academic organization	2003: Research Center of Higher Engineering Education, Chinese Academy of Engineering & Beijing University of Aeronautics and Astronautics.
		2008: Tsinghua University set up the EER Center.
		2010: Launched "Outstanding Engineer Education and Training Program".
		2010: Engineering Education Innovation Center of Zhejiang University was set up.
		2014: Reorganization of National Collaborative Group on Engineering Teaching Reform in Higher Education Institutions.
		2015: CEEAA set up.
		2016: China joined the Washington Accord.
		2017: Circular on the Research and Practice of Emerging Engineering Education.
		2018: Emerging Engineering Education Center of Tianjin University was set up.
		2019: Huazhong University of Science and Technology set up the Institute of Engineering Education.
2021 to present	Starting period of academic construction	2021: The report of the MOE on "Research on China's Engineering Education Strategy and Reform Path" proposed the construction of the engineering education discipline.
		2022: The pilot universities set up their engineering education secondary disciplines.
		2022: The Chinese Consortium of Engineering Education Discipline Development was established.
		2023: Tianjin University, Tsinghua University, Zhejiang University, and other universities set up secondary disciplines of engineering education outside the catalog.
		2024: "Engineering Education" became one of the 15 secondary disciplines under "Education" in "Introduction to Graduate Education Disciplines and Programs and Basic Requirements for Degrees".

CEEAA: China Engineering Education Accreditation Association; EER: engineering education research; MOE: the Ministry of Education.

2022, MOE further recommended that pilot universities should independently establish secondary disciplines in engineering education. This initiative was further bolstered by the creation of the Chinese Consortium of Engineering Education Discipline Development, which included 10 pilot universities and later expanded to include institutions like South China University of Technology and Nanchang University.

In January 2024, the "Introduction to Graduate Education Disciplines and Programs and Basic Requirements for Degrees" officially designated "Engineering Education" as one of the 15 secondary disciplines under the broader field of "Education. " This milestone marked the institutionalization of engineering education. It focuses on the characteristics, development, and training rules for engineering professionals while also influencing policy decisions and practices. The initiative also emphasizes the integration of engineering with education, particularly through system development, curriculum design, teaching materials, engineering practice, and teacher training. This policy defines engineering education as an emerging interdisciplinary field that studies the characteristics, development processes, and educational patterns of engineering talent. It aims to support policy-making and improve practices in engineering education by exploring topics such as policies and systems, curricula and teaching methods, teaching materials and equipment, engineering practice, and faculty development. The discipline seeks to advance the integration of engineering and education by identifying pathways and methods for deeper collaboration between the two fields.

Typical trajectories of engineering education discipline construction in China: a case study of Zhejiang university

Zhejiang University is a member of prestigious academic organizations such as the C9 League, the Emerging Engineering Education Alliance, and the CDIO

Education Alliance. It is one of the earliest institutions in China to engage in EER and establish the discipline of engineering education. The university's development of this discipline mirrors the major phases of EER in China.

The development of the engineering education discipline at Zhejiang University aligns with the primary phases of EER in China. Its specific construction process is as shown in Table 6.

a. The first phase of EER at Zhejiang University began in 1981 with the establishment of the Education Research Office. This was followed by the approval in 1986 of the master's and doctoral degree programs in "industrial management engineering (science and technology education and management engineering)." Between 2000 and 2005, the discipline of education economics and management was developed, with a focus on the research direction of "engineering education and public policy." These early efforts laid the foundation for the disciplinization of engineering education.

b. The second phase involved the establishment of specialized research centers and academic journals. In 2006, Zhejiang University founded the Research Center for Science and Education Development Strategy, followed by the establishment of the Engineering Education Innovation Center in 2010. During this time, several key journals were launched, including International Engineering Education Frontiers and Progress, Review on Science, Technology & Education, and Journal of Science, Technology and Education. These institutions and publications played a pivotal role in advancing the field of EER.

c. The third stage marked the formal institutionalization of the discipline, which resulted from the collaborative efforts of both the state and the university. On December 3, 2022, Zhejiang University hosted an expert panel discussion to discuss the independent establishment of the discipline of "Engineering Education. " This was followed by a seminar on June 3, 2023, organized by the Institute of China's Science, Technology and Education Policy and the College of Education, focused on constructing the "engineering education" discipline. These efforts represent key steps toward the institutionalization of engineering education at Zhejiang University.

The China Academy of Science and Education at Zhejiang University, originally named the "Innovation Center of Engineering Education of Zhejiang University" in 2010, serves as the administrative headquarters for the CSEE. It has organized 19 international symposia on topics such as the global development of engineering education and international cooperation platforms for education and research. Notable events include the 2020 symposium on "Innovation of Engineering Education System in Response to Global Challenges" and the 2018 event on "Engineering Science and Technology in the Context of 'The Belt and Road' for Cultivating Engineering Science and Technology Talents." Additionally, the College of Education at Zhejiang University supports EER through multiple platforms, such as the Institute of Higher Education, the UNESCO Research Center (recognized as a Center of Record for International and Regional Studies by the MOE, the Secretariat of the Global University Network for Innovation Asia-Pacific (GUNI-AP), and the UNESCO Chair of Entrepreneurship Education.

The overarching objectives of engineering education at Zhejiang University are threefold: First, to drive China's engineering science and technology innovation, contributing to the cultivation of outstanding engineers; second, to develop a comprehensive theory and a knowledge framework of engineering education with unique Chinese characteristics; and third, to assist Zhejiang University in advancing high-level integrated reforms in education, technology, and talent development.

The talent cultivation system and effectiveness of the engineering education discipline in Zhejiang University

a. Talent Cultivation System: The goal of the master's program in engineering education at Zhejiang University is to train highly skilled professionals capable of teaching, managing, researching, consulting, or overseeing human resources in industrial enterprises within the engineering education field. Similarly, the doctoral program aims to cultivate research-oriented professionals with advanced academic proficiency and innovative capabilities. These individuals are expected to contribute to teaching, research, management, policy consulting, and industrial human resource development in the engineering education sector. The doctoral program's focus is on producing highly qualified, multifaceted professionals with international perspectives who can excel in various roles.

The educational approach at Zhejiang University follows a dual-tutor system with experts in educational and engineering fields. The educational supervisor directly oversees the dissertation, while the engineering supervisor's education and the engineering field contribute to the dissertation process, serving as the members of the defense committee. Doctoral students are required to complete a range of specialized courses, including Philosophy and Culture of Engineering,

Table 6: Construction history of engineering education disciplines in Zhejiang University

Time	Key events
1981	The Education Research Office of Zhejiang University (predecessor of the Institute of Higher Education of Zhejiang University) was established.
1986	Master's and Doctoral Degree Authorization Points of "Industrial Management Engineering (Science and Technology Education Management Engineering) " were approved by Zhejiang University.
2000	Master's Degree Authorization Point of "Educational Economics and Management" was approved.
2003	Doctoral Degree Authorization Point of "Educational Economics and Management" approved.
2005	The master's degree authorization point of "Education Economics and Management" was transferred to the newly established School of Public Administration of Zhejiang University, with the main research direction of "Engineering Education and Public Policy".
2006	Zhejiang University Science and Education Development Strategy Research Center was established.
2006	"International Frontier and Progress of Engineering Education" launched as an internal journal.
2010	Zhejiang University Engineering Education Innovation Center was established.
2013	The Institute of Development Strategy of Zhejiang University was established and co-located with the Policy Research Office.
2014	Science and Education Development Review was founded.
2016	The Fifth Secretariat of the Engineering Education Committee of China Association for Higher Education was attached to the Institute of Science, Technology and Education Policy of Zhejiang University; the institute was renamed as The Institute of China's Science, Technology and Education Policy, Zhejiang University.
2021	Journal of Science, Technology, and Education Studies was launched.
2022	Independently held the expert argumentation meeting for setting up the discipline of "engineering education".
2023	Seminar on Construction of "Engineering Education" Discipline.

Management and Strategic Decision Making, Fundamentals of Engineering Education, Research Methods in Engineering Education, Senior Seminar in Engineering Education, Internship in Engineering Projects, and Frontiers of Global Engineering Education. In addition to coursework and dissertations, students are encouraged to gain relevant engineering practice. For those without an engineering background or professional experience in education, completion of two to three master's-level courses in related disciplines is mandatory, as directed by their instructors.

b. Enrollment: Admission to Zhejiang University's engineering education program requires an engineering background. In 2023, two Ph. D. students were recruited, with master's degrees in Energy and Artificial Intelligence respectively. In 2024, one student was admitted directly to the Ph. D. program (holding a bachelor's degree in Civil Engineering), and one student transitioned from a master's degree (with a master's degree in Biomedical Engineering and Instrumentation Science).

c. Thesis and Graduation Destinations: For the 2020-2024 cohort, master's and doctoral students in engineering education selected a variety of thesis topics. These include research on the cultivation models for top engineering talent in new R & D institutions, digital competence for engineers and its industrial demand, contextualized engineering learning based on communities of practice, the role of design-based engineering learning, and the mechanisms behind engineering ethics education.

Regarding employment outcomes, 30% of graduates from the 2020-2024 cohort are employed at higher education institutions such as Zhejiang University, Dalian University of Technology, and the University of Electronic Science and Technology of China. 15% have joined research institutes, including the China Electronics and Information Technology Industry Development Research Institute, the Chinese Academy of Sciences, and Zhejiang Lab. Another 25% have secured positions in government departments such as the Sichuan Provincial Party Committee, the Zhejiang Provincial Party Committee, and the Hangzhou Municipal Party Committee. The remaining 30% have entered enterprises, including China Aerospace Science and Technology Corporation and Zheshang Development. These outcomes reflect the program's effectiveness in preparing graduates for diverse career paths within academia, research, government, and industry.

The internal dynamic mechanism for the establishment and development of the engineering education discipline at Zhejiang University

The evolution of EER and discipline development at Zhejiang University is closely linked to the university's own reforms in engineering education and teaching practices. Its internal dynamics reflect key characteristics of being "engineering-focused, practice-driven, policy-oriented, and academically rigorous."

a. Engineering-Oriented: Since the 1980s, as China pursued industrialization and the strategy of revitalizing the nation through science and education, engineering education shifted from a "technical" to a "scientific" model. In response, Zhejiang University adapted by transitioning from training technical specialists in specific fields to fostering engineering scientists with a focus on theory, analysis, and design. For example, in 1984, the university introduced a mixed engineering class that combined students from engineering majors, such as computer science and electrical engineering, with those from science fields like mathematics and physics. This approach reinforced foundational theory and engineering thinking among undergraduates, laying a solid groundwork for advanced graduate studies in engineering. In 1994, Zhejiang University launched an advanced engineering education program, selecting 50 exceptional first-year students each spring semester. These students were enrolled in a comprehensive minor in engineering education alongside their major disciplines. The program aimed to cultivate high-level talent capable of leading in emerging fields and major engineering and technology sectors. During this period, the focus of EER at the university was primarily on enhancing the development of engineering talent.

b. Practice-Oriented: Since the turn of the 21st century, China's higher engineering education has adopted an "engineering paradigm" to better support industrialization and produce high-quality engineers with strong innovation and adaptability.[26] In response, Zhejiang University refocused its talent development goals on producing well-rounded, practical, and innovative professionals, introducing several key reforms in engineering education. For example, in 2000, the Chu Kochen Honors College (formerly the Mixed Engineering Class) was established as a platform for cultivating interdisciplinary talent across liberal arts, science, and engineering, without specific major divisions. It collaborated with other professional colleges to create a cross-disciplinary undergraduate talent cultivation framework. This initiative resulted in the exploration of a "foundation-focused, broad-scope, modularized" curriculum system and a personalized approach to professional training. Furthermore, in 2003, the university launched a doctoral program in "Education Economics and Management," with a primary focus on engineering education and public policy. In 2010, Zhejiang University founded the "Innovative Research Center for Engineering Education," establishing an academic body dedicated to advancing research in engineering education. This center played a key role in fostering innovative practices for cultivating multidisciplinary talent. Overall, research in engineering education during this phase at Zhejiang University concentrated on exploring strategies for the cultivation of composite talent.

c. Policy-Oriented: The founding of the Research Center for Science and Education Development Strategies at Zhejiang University in 2006 marked the beginning of the university's active involvement in consolidating engineering education experiences and contributing to national policy planning and reforms. In 2016, Zhejiang University took the lead in the Engineering Education Professional Committee, playing a pivotal role in the development of the "Emerging Engineering Education" framework and participating in national higher engineering education reforms. The university led several key reforms, such as the establishment of a professional doctoral degree in engineering in 2011. In 2016, it co-founded the Polytechnic Institute of Zhejiang University, China's first graduate-level institution dedicated to engineering education reform. In 2019, the university established the Engineering Professional Degree Evaluation Committee, overseeing graduate degree certification and faculty qualifications while proposing reforms in academic governance for professional graduate education. In 2022, Zhejiang University became one of the first pilot units selected for national outstanding engineering academies, with a focus on cultivating globally competitive engineers to meet both national and industrial demands. Throughout this period, Zhejiang University has evolved into a key role in national higher engineering education reform, contributing significantly to theoretical advancements and policy development. Its research trajectory in engineering education shifted from a regional to a national focus, growing in both strategic importance and policy relevance.

d. Academic-Oriented: Since 2020, Zhejiang University has increasingly focused on cutting-edge, interdisciplinary fields such as artificial intelligence (AI) and big data, driven by the evolving and cyclical nature of engineering and engineering education.[27] In January 2024, the university launched the "AI for Education" series, exploring innovative teaching methods enabled by AI generated content (AIGC). In June, the Zhejiang University AI Education and Teaching Research Center released the "Red Paper on AI Literacy of College Students," signaling improvements in the scholarship of teaching and learning. In 2021, Zhejiang University led a major initiative, "Research on the Strategy and Reform Path of Engineering Education in China," supported by the MOE and the Chinese Academy of Engineering. This project pioneered the establishment of "Engineering Education" as a second-tier discipline at China's top science and engineering universities. Officially approved on September 2022, Zhejiang University became one of the first ten pilot institutions for this discipline. In 2024, "Engineering Education" was formally added to China's graduate education directory.

These developments underscore the significant role universities like Zhejiang University have played in driving the bottom-up growth of EER and discipline

Table 7: Features of engineering education discipline construction in America, Europe, and China

Area	America	Europe	China
Construction features	Practicalization, specialization, and disciplining	Specialization, networking, and practicalization	Professionalization, institutionalization, and disciplining
Discipline features	Combination of bottom-up and top-down approaches Academic-oriented: Rigorous Research to create new knowledge in engineering education Application-oriented: to enhance the capacity of faculty to engage in research in engineering education[30]	Bottom-up construction-oriented Application-oriented: committed to improving the practice of engineering education[31]	Combination of top-down and bottom-up Engineering-oriented: serving the development of national industrialization Practice-oriented: mutually reinforcing with the practice of cultivating composite talents Policy-oriented: to cultivate students' ability in higher education management and policy consultation Academic-oriented: focusing on academic research, academic innovation, and research methods

construction in China. The main trajectory of China's EER has increasingly emphasized discipline development and academic orientation. This shift has accelerated the establishment of journals such as the Journal of Science,Technology and Education, which focus on academic research, innovation, and standardized methodologies in engineering education practice. The goal is to create a theoretical knowledge system of engineering education that reflects Chinese characteristics.

COMPARISON OF CORE FEATURES OF ENGINEERING EDUCATION DISCIPLINE CONSTRUCTION IN AMERICA, EUROPE, AND CHINA

Engineering education is a discipline born out of practical needs, originating from real-world problems and driving practical innovation. It consistently aligns with the level of industrialization and modernization in specific countries and regions, generally following the progressive trajectory of "technology paradigm- science paradigm- engineering paradigm."[28] However, the research systems of engineering education in different countries and regions exhibit unique characteristics, with distinct paths of evolution, as illustrated in Table 7. In the U. S., the construction of engineering education disciplines is characterized by a focus on practice, specialization, and the institutionalization of standards. The development of these disciplines is driven by a combination of top-down national support and bottom-up initiatives from universities, resulting in a dual emphasis on academic and practical applications. In Europe, the model is centered on specialization, networking, and practical relevance, with the disciplines largely propelled by the bottom-up efforts of universities and other institutions, emphasizing clear applications.[29] In contrast, China's approach to engineering education discipline construction is characterized by specialization, institutionalization, and standardization. The development of these disciplines is promoted through a combination of top-down national strategies and bottom-up initiatives from universities, creating a system that is engineering-oriented, practice-oriented, policy-driven, and academically focused.

FUTURE OUTLOOK FOR THE DISCIPLINE OF ENGINEERING EDUCATION IN CHINA

Based on global experiences of engineering education discipline development, research in China seeks to explore a "discipline development path" with localized characteristics. This approach emphasizes being engineering-oriented, practically relevant, policy-aligned, and academically rigorous, as well as the development of a unique Chinese "knowledge system for engineering education discipline."

Deepening research across macro, meso, and micro levels

At the macro level, it is essential to explore the relationship between engineering education and public policy, allocating and orienting engineering education resources in accordance with national strategic planning. At the meso level, it is critical to advance the reform of the professional engineering graduate degree system, developing training models that align with the characteristics of the times and the field, while strengthening the cultivation of innovation and practical abilities. At the micro level, it is important to refine the evaluation system for engineering talent, drive teaching reform through learning science, and employ cutting-edge methods to release students' potential.[32]

Integrating China's context with global perspectives

It is recommended to build on the local context, integrating resources through various institutions such as the National College of Oustanding Engineers, the School of Future Technology, and the Modern Industrial College, to cultivate innovative talent in diverse forms. From a global perspective, China's engineering education should focus on integrating AI across all aspects of education while incorporating sustainable development and green development principles into curricula and talent cultivation.

Synergizing theory construction and research method development

It is vital to construct a systematic theoretical framework that encompasses a wide range of fundamental theories to guide engineering education practice. By combining qualitative and quantitative research methods, the former can analyze internal mechanisms, while the latter reveals quantitative relationships. These two approaches complement each other, expanding both the depth and breadth of research in the discipline.

Strengthening interaction and cooperation with industry

Professional organizations in engineering education should maximize their platform's effectiveness by fostering member interaction, collaboration, and knowledge sharing; universities should not only strengthen cooperation with industries, but also promote sharing and exchanges of resources, such as curricula and faculty, with other institutions.

Building international collaboration networks and conversation platforms

It is recommended to expand the international cooperation network by deepening exchanges with various global organizations and initiating diverse collaborative projects. A regular exchange mechanism should be established, incorporating cutting-edge seminars and project matchmaking sessions to promote mutual learning between domestic and international entities, thereby enhancing China's influence in global engineering education.

In conclusion, the future of China's engineering education discipline requires a multidimensional, integrated approach with continuous innovation and exploration. This will ensure high-quality and sustainable development, providing skilled talents and intellectual resources to drive the nation's industrial advancements.

DECLARATION

Author contributions

Zhang Wei: Conceptualization, Supervision, Writing-Original draft preparation. Wang Shuai: Conceptualization, Writing-Original draft preparation, Writing-Reviewing and Editing. Sun Jiayi: Writing-Original draft preparation, Writing-Reviewing and Editing. Wang Congying: Writing-Original draft preparation, Writing-Reviewing and Editing. All authors have read and approved the final version of the manuscript.

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Conflict of interest

The authors declare no competing interest.

Data availability statement

No additional data.

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