

Research on the construction of high-quality engineering programs in China under the new engineering education context

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Abstract: The report of the 20th National Congress of the Communist Party of China pointed out: “Give priority to the development of education, accelerate the construction of high-quality universities and disciplines, and realize the connotative development of higher education.” Against the backdrop of the “new engineering” construction in universities, new requirements have been put forward for local universities regarding the construction of academic disciplines. This paper aims to follow the laws of higher education development, according to the needs of national and local economic construction, scientific and technological progress, and social development, to study the ideas for constructing first-class majors at local universities, talent training models, problems and difficulties faced during the construction process, and to promote the connotative development of majors at local universities. It provides references for the construction of first-class majors at other local universities.

Keywords: new engineering; personnel training; first-class major; specialty construction

1. Introduction

The Chinese Ministry of Education issued a notice in 2019 regarding the implementation of the “Double Ten Thousand Plan” for the establishment of top-tier undergraduate programs. Universities across the nation actively embraced this directive, igniting a surge in first-class program development and yielding remarkable outcomes. This has made a significant contribution to enhancing the quality of undergraduate talent cultivation (Peng, 2023). With the continuous advancement of professional accreditation concepts and novel engineering education philosophies, research and practical endeavors are underway to incorporate modern educational and teaching concepts into the construction of top-tier undergraduate programs, thereby promoting ongoing reforms in higher education teaching practices in China. Local universities constitute the majority of higher education institutions nationwide and serve as key battlegrounds for advancing higher education. For these local universities, participation in national-level first-class program construction is advantageous for regional economic development promotion as well as institutional strength and competitiveness enhancement. Therefore, studying national-level first-class undergraduate program construction at local universities holds great significance (Yang et al., 2021; Zeng, 2023; Zhao and Chen, 2024).

This paper conducts an in-depth study on the establishment of high-quality engineering programs at local undergraduate institutions, guided by theories such as regional higher education development, humanism, and competency-based education, and led by modern educational and teaching concepts (Guan, 2023; Yang et al., 2023).

Initially, it employs literature research to review domestic and international studies on program construction, engineering program construction at local undergraduate institutions, and the establishment of high-quality programs in China. It analyzes the necessity of establishing high-quality programs at local undergraduate institutions. Subsequently, aligning with the development characteristics of local undergraduate institutions and the principles of program construction, it specifically clarifies the guiding ideology, basic principles, and primary objectives for establishing high-quality engineering programs. It provides an in-depth analysis and refinement of key tasks. Furthermore, representative universities in China renowned for their successful engineering program establishment are selected to summarize experiences and insights that can be referenced in this study. Finally, following top-level design requirements while drawing upon experiences from domestic and international university engineering program establishment efforts, the paper proposes strategies for establishing high-quality engineering programs at local undergraduate institutions. This aims to elevate the level of high-quality engineering program establishment and improve talent training quality at local undergraduate institutions, and provides a reference for the establishment of high-quality engineering programs at various types of universities nationwide.

2. The construction of first-class programs brings opportunities and challenges to the connotative development of local universities

2.1. The construction of “Double First-Class” brings opportunities to the connotative development of engineering disciplines in local universities

Providing guidance for the connotative development of local universities: In October 2015, the State Council issued the “Overall Plan for Coordinating the Construction of World-Class Universities and First-Class Disciplines,” emphasizing adherence to both Chinese characteristics and world-class standards as fundamental principles. The plan highlights moral education as a foundational element, while also supporting innovation-driven development strategies and aligning with economic and social development goals. By adhering to the principles of excellence, discipline-based grounding, performance leverage, and driven by reform, it aims to expedite the establishment of several world-class universities along with first-class disciplines (Xie and Teo, 2020). Local universities often face regional limitations that hinder their path to becoming high-level institutions. However, the implementation of the “Double First-Class” initiative has presented opportunities and possibilities for these institutions to achieve excellence. While local colleges may not meet the criteria to be considered top-tier universities, they possess the potential to develop first-class disciplines (Yang et al., 2023). Over the years, many local universities, particularly those with distinct industry features, have cultivated highly distinctive academic disciplines by leveraging regional economic development and investments from local governments. Therefore, the “Double First-Class” initiative represents both an opportunity and a necessity for local higher education institutions (Liu et al., 2023).

Providing a driving force for the connotative development of local universities: The “Double First-Class” initiative is designed to align with global standards,

requiring universities to demonstrate formidable competitiveness and strength to earn their well-deserved place in the program (Li and Xue, 2021; Yin et al., 2020). Former “211 Project” and “985 Project” universities have the advantage of early-stage resource accumulation, superior conditions in terms of discipline construction, faculty, financial capital, and social status compared to local ordinary institutions. However, relying solely on this small group of elite universities will not suffice to meet China’s strategic goal of building a modern socialist country by 2050, in terms of talent requirements. This gap presents an opportunity for local universities to transform impressively. The “Double First-Class” policy offers unprecedented favorable policies for all universities, especially high-level local institutions, aiming to promote connotative development. The introduction of these policies provides local universities with clear guidance and objectives, igniting internal reform and development momentum (Gao et al., 2022). Local universities can take advantage of the policy tailwinds from the “Double First-Class” initiative to strengthen teaching reforms, enhance the quality of education, and improve the overall level of the faculty through cooperation and exchanges with first-class universities. As vital supports for local economic and social development, universities can build distinctive academic clusters based on regional characteristics and needs, becoming significant bases for regional talent supply and scientific innovation. In pursuing connotative development and enhancing the level of education, local universities can also reinforce international exchange and cooperation to increase their global influence. In summary, achieving these transformations requires local universities to combine their realities, clarify their educational positioning, and strengthen internal development, while also necessitating necessary support and resources from the government and all sectors of society. Through these efforts, local universities will not only contribute to the construction of a modern socialist country but also achieve leapfrog development in the process.

2.2. The “Double First-Class” initiative presents challenges for the connotative development of local universities

Local institutions lack resources: Under the national development environment of the “211 Project” and “985 Project,” both explicit institutional designs, such as enrollment, financial allocation, evaluation systems, and implicit assessment mechanisms, like degree review and discipline evaluation, have been maintaining and strengthening the “status” effect of universities. Having this “status” implies “greater autonomy in school management, more influence in decision-making, and stronger resource acquisition capabilities (Ouyang and Liu, 2023).” Local universities have been at a disadvantage in resource allocation in the past, with a noticeable gap between them and central government-affiliated institutions in terms of infrastructure and faculty development. Therefore, it is crucial to optimize resource allocation and enhance the efficiency of fund utilization. For instance, by implementing software management for reservation and charging, large instruments from each college can be shared across the campus, effectively coordinating and managing their usage. Additionally, joint use of resources such as equipment and laboratories should be promoted to reduce duplication of investment and idle resources, thereby improving resource utilization. Furthermore, asset management should be strengthened with a

focus on scientificity and standardization, establishing comprehensive regulations and management processes to elevate the efficiency and precision of asset management.

The development positioning is not accurate enough: Local institutions often uncritically adopt the educational philosophies, teaching methods, and management approaches of prominent central government-affiliated universities, resulting in a pervasive trend of homogeneity among undergraduate institutions in China known as “a thousand schools looking the same.” This phenomenon leads to a loss of distinctiveness and inhibits developmental vitality. Therefore, it is imperative to conduct a scientific analysis of current school operations and gain an accurate understanding of one’s own strengths and weaknesses. Based on a comprehensive and accurate self-evaluation, it becomes necessary to clarify the development positioning and formulate strategic planning and objectives aimed at achieving excellence and remarkable progress (Wei, 2020). Specifically, customize educational and research programs to local characteristics and needs. For instance, universities in Jilin Province can capitalize on the unique resources of ginseng, ula grass, polygala tenuifolia, and corn silk in northeastern China to establish a comprehensive platform that caters to students’ requirements for “classroom instruction, practical competitions, and enterprise training” through a collaborative three-in-one education and training platform. This will gradually integrate ideological education, scientific education, creative education, and vocational education while achieving dual objectives of skills development and quality enhancement as well as employment support. Actively explore and establish novel government-university-industry partnerships based on market-driven principles with government support to operate an open new research and development joint venture while actively participating in the construction of modern industrial colleges.

The limited autonomy in the administration of educational institutions: A robust and high-caliber faculty serves as a solid pillar for disciplinary advancement (Li and Sun, 2023). However, local universities, particularly those situated in western regions, face significant challenges due to disparities in autonomy, funding allocation, disciplinary platforms, and geographical location. Consequently, they encounter a pronounced scarcity of academic leaders and struggle to attract sufficient talent, resulting in an overall diminished faculty quality. In light of the aforementioned issues, the following measures are proposed with regards to platform construction, faculty recruitment, and academic advancement: (1) Emphasize local characteristic industries and key enterprises to implement a “double mentor” education model that integrates school-enterprise collaboration, establishing talent training bases for such collaboration. (2) Utilize Jilin Province’s talent attraction, cultivation, retention, and utilization policies to optimize the composition of research personnel and foster a talent hub effect. (3) Elevate academic development by leveraging provincial platforms for enhanced exchange and learning from other top-tier universities in order to expedite the establishment of a first-class discipline in biology and bolster our capacity for cultivating high-level talents.

3. Research approach to the construction of first-class engineering disciplines in local colleges and universities

3.1. Focus on Outcome-Based Education (OBE) (Yang and Xiao, 2023), guide the differentiated development of disciplines, and enhance the alignment between specialties and employment

The specialty should be aligned with the national standards and accreditation criteria for undergraduate disciplines. In light of the characteristics of the specific discipline, determine the training objectives for professional talents, and generally describe the knowledge quality and professional abilities that graduates should possess, employment fields, and distinctive features of the talents. At the same time, it should clarify the supportive relationship between the curriculum system and graduation requirements, as well as the support for the achievement of professional training objectives. Considering the structure of professional knowledge and credit requirements, through the analysis of the goal capability matrix, align the curriculum system with graduation requirements. The training program for engineering specialties should be tailored to meet the demands of local economic construction and development. Taking the specific practice of local university X in China as an example, the specific practices should be based on outcome orientation and OBE course requirements, three major educational philosophies, and the requirements of engineering education accreditation. Fully leverage the distinctive advantages of local universities, integrate production and education, encourage students to actively participate in academic competitions, hire industry experts to participate in practical teaching, and encourage teachers to carry out industry-university-research cooperation. Establish a multi-level and three-dimensional engineering quality education and teaching system that includes professional experiments, course design, engineer lectures, production internships, and graduation project practice, highlighting the new concept of integrated theory and practice in three-dimensional teaching (Figure 1).

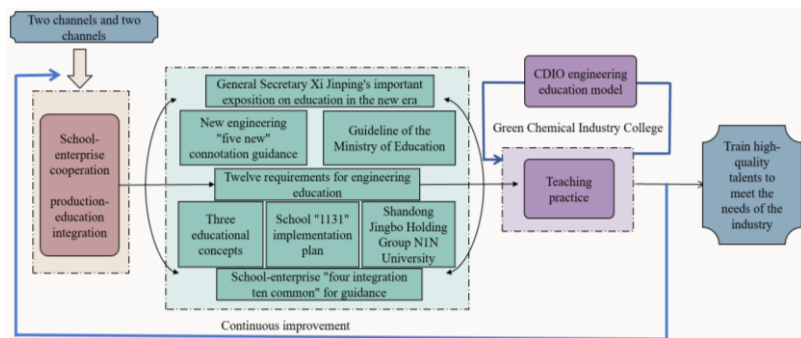


Figure 1. Structure diagram of local university X collaborative education model.

3.2. Strengthen the construction of teaching staff and deepen the reform of curriculum and teaching

Building a long-term mechanism for building teacher ethics and professional conduct: Local undergraduate colleges should design and implement a series of specific systems and policies on the construction of teacher virtue cultivation from

their own school-running characteristics and actual situation. These systems and policies need to clearly define the code of conduct, professional ethics and teaching norms that teachers should abide by, establish rigid constraints on teachers' behavior, and ensure that every teacher can carry out teaching activities within a clear framework. At the same time, schools should pay attention to and commend teachers who perform well in teacher ethics, and turn their advanced deeds into vivid cases to inspire other teachers to learn and follow suit (Qiao and Li, 2023).

Stimulating teachers' subjective consciousness of moral education: Teachers are the key subject of cultivating moral character and nurturing talents, and schools need to focus on cultivating teachers' internal awareness and understanding of professional ethics and conduct (Zhang, 2022). This requires teachers not only to have solid subject knowledge and teaching abilities, but also to continuously improve their personal professional ethics and achieve the unity of knowledge and action. To this end, schools can help teachers deepen their understanding of the importance of professional ethics and continuously improve their level of professional ethics in practice by organizing teacher ethics training, seminars, and experience exchange meetings.

Establish and improve the evaluation system of teacher morality education: In order to ensure the effectiveness and sustainability of teachers' moral and stylistic development, schools should establish a comprehensive, dynamic, and diversified evaluation and assessment mechanism (Tang, 2023). This mechanism should encompass teachers' daily conduct, teaching quality, academic research, social services, and other aspects to achieve a comprehensive and multi-faceted evaluation. Simultaneously, schools must attach great importance to the evaluation results as an essential means of reminding and motivating teachers. When necessary, a decisive one-vote veto system should be adopted to promptly rectify any issues. Through such an evaluative framework, we can promote the normalization and long-term efficacy of cultivating teachers' morality and style while guiding them in implementing socialist core values throughout their teaching process. Ultimately, this will lay a solid foundation for nurturing well-rounded socialist builders and successors (Wang, 2022).

Pay attention to the optimization of the curriculum system of local undergraduate colleges: The optimization of the curriculum system for first-class engineering majors should be centered on students, oriented towards output, and designed and constructed in reverse according to graduation requirements and training objectives. The course content, teaching methods, and assessment methods are designed based on the "knowledge, ability, and quality" requirements of engineering majors for students. The supporting relationship between course objectives and graduation requirements is clarified, and a realization matrix between graduation requirements, curriculum system, and teaching links is constructed to ensure the effective achievement of talent training objectives and graduation requirements (Ab-Rahman et al., 2022; Zamir et al., 2022).

3.3. Strengthen the construction of professional connotation and improve the long-term mechanism of disciplinary professional construction

Firstly, we should establish a first-level teaching process quality monitoring system based on ISO teaching quality management and engineering education

certification concepts to strengthen the construction of professional connotation (Anh et al., 2021; Xia, 2022; Ye and Li, 2022). Regular evaluation of teaching quality with timely feedback is necessary. The information platform can be utilized to collect students' learning data, while student evaluations and teacher-student symposiums can provide valuable feedback. Additionally, a step-by-step evaluation mechanism for personnel training quality should be established, including courses, indicators, graduation requirements, and achievement levels of training objectives. Feedback results from this mechanism can then be used for continuous improvement in each teaching link.

Secondly, engaging in undergraduate education and teaching audit and evaluation serves as an efficacious approach to enhance the long-term mechanism of discipline and specialty construction. Higher education evaluation is a statutory obligation outlined in the Higher Education Act and constitutes a pivotal component of the contemporary higher education system (Leeuwenkamp et al., 2017). Over four decades of practice have substantiated that evaluation plays an indispensable role in advancing the quality of higher education while ensuring its sound development. The “five-in-one” audit and evaluation system represents a crucial facet within the higher education quality assurance framework (Figure 2). Developing a novel round of audit and evaluation scheme, constructing an audit and evaluation system characterized by Chinese attributes aligned with contemporary demands, as well as establishing and refining diagnostic and improvement mechanisms for coordination between internal and external institutions are pressing tasks aimed at expediting institutionalization alongside long-term effectiveness within the higher education quality assurance system.

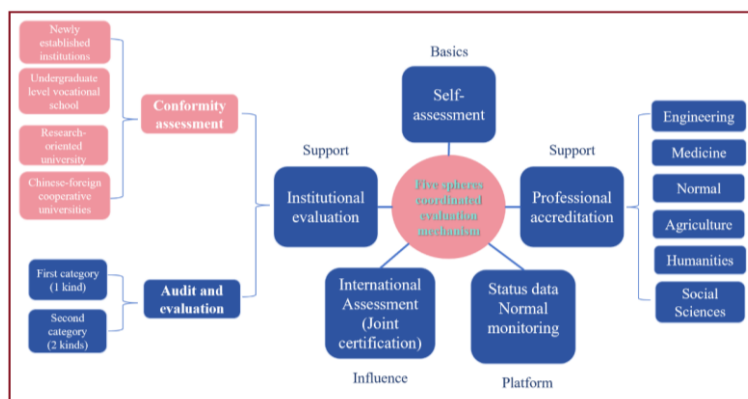


Figure 2. The ministry of education’s “Five spheres coordinated” evaluation mechanism for higher education audit and evaluation.

4. New model of training first-class professional talents in engineering

4.1. Adhere to moral cultivation, with the development of students as the focus

Adhering to the educational concept of focusing on the development of students is an important way to achieve the goal of cultivating people by virtue (Li, 2021). This

concept emphasizes that attention should be paid to the all-round development of students in the process of education, including the learning of knowledge and skills, the establishment of ideals and beliefs, the cultivation of professional ethics, the enhancement of social responsibility and the cultivation of people's feelings. Specifically, while imparting professional knowledge, teachers should also pay attention to students' ideological and moral education to help students form correct world outlook, outlook on life and values. It pays attention to the individualized development of students, provides diversified learning and development opportunities, and enables students to discover their interests and potentials in learning. Following the law of ideological and political education, we should combine ideological and political work with professional education so as to make it a part of students' daily learning.

4.2. Clear application-oriented personnel training specifications

Applied talents refer to a type of talents who can apply professional knowledge and skills to the professional social practice they are engaged in. They are professional and technical talents or specialized talents who are skilled in mastering the basic principles and operational technologies of social production or social activities and directly and effectively serve social production and social practice. In terms of clarifying the specifications of applied talents, according to the needs of national technical and skilled talents and the characteristics and requirements of different positions in different industries, we should revise and improve the talent training program, and develop a number of professional teaching standards, curriculum standards, teaching materials and teaching AIDS that integrate new technologies, new technologies, new norms and other international advanced standards. Fully docking vocational standards and professional teaching standards, promoting the convergence of college training and vocational training, and the deep integration of professional teaching and vocational standards. We should speed up the construction of a modular and systematic curriculum system and promote the co-construction and sharing of high-quality teaching resources.

4.3. Teach according to the student's ability, actively explore teaching reform

Teaching students in accordance with their aptitude is a fundamental principle in education and pedagogy. Local engineering colleges should adopt diverse teaching methods and approaches based on students' individual personality traits, learning abilities, and interests to enhance the effectiveness of instruction (Hong and Ren, 2022). In light of the new reforms in engineering education, educators must actively explore innovative teaching practices that align with societal needs and elevate educational quality. A comprehensive understanding of students' backgrounds, including their interests, specialties, and learning habits, enables teachers to tailor instruction more effectively to each student's unique aptitudes. By stratifying students according to their learning abilities and levels, distinct instructional strategies and expectations can be implemented for different groups of learners. Moreover, personalized teaching plans should be devised considering students' personality

characteristics while fostering personal growth alongside cultivating enthusiasm for learning. Emphasizing practical teaching components allows students to identify and resolve real-world problems independently while nurturing their practical skills as well as innovation capabilities. Reformation of traditional evaluation methods necessitates the implementation of a diversified and comprehensive assessment system that values both process-oriented evaluation criteria as well as student development and progress monitoring. Ultimately, adhering to the principle of teaching students in accordance with their aptitude serves as the cornerstone for effective education delivery. Thus, educators must proactively engage in pedagogical reform efforts while prioritizing holistic student development.

5. Practices, advanced experiences, and insights on the construction of engineering disciplines in domestic and international universities

The representative engineering colleges and universities, both domestic and international, have been carefully selected to serve as exemplars. These universities each have their own distinctive characteristics and experiences in the construction of engineering programs. By employing case study and comparative research methods, an analytical study of the engineering program construction at these four universities is conducted, providing important references and experience for the construction of first-class engineering programs at local undergraduate institutions.

5.1. Industry-University-Research experience of Nanyang university of technology in Singapore

Situated in Asia, Nanyang Technological University leverages its status as a multicultural research institution by emphasizing cultural literacy cultivation among students alongside fostering their sense of social responsibility through active engagement in social practice and public welfare activities. Internationally, NTU maintains a robust partnership with Rolls-Royce that extends over five years involving an investment of 88 million yuan towards advancing aircraft propulsion technology for enhanced safety and efficiency during flight experiences. Furthermore, NTU collaborates extensively not only with Rolls-Royce but also with industry leaders such as Hewlett-Packard and Volvo while establishing dedicated research centers in conjunction with esteemed organizations like the French Alternative Energy & Atomic Energy Commission as well as the World Health Organization for pioneering innovative projects.

5.2. Practical experience of specialty construction in local colleges and universities in China

The mechanical engineering specialty at Shanghai University of Engineering and Technology emphasizes the integration of disciplines and the advancement of mechanical engineering, microelectronics, and automation through collaboration with fields such as information technology and management. Students in this program are expected to not only acquire a solid foundation in mechanical engineering, microelectronics technology, automation technology, and information processing technology but also develop essential skills in mechanical product development and

design, manufacturing processes, applied research, and operational management. Furthermore, the College has implemented a scientific research strategy to promote interdisciplinary cooperation among faculty members, facilitate joint announcements for interdisciplinary projects, and eliminate silos within the College's scientific research system.

6. Conclusion

Taking the characteristics of social demand for “new engineering” talents as the target, and taking some engineering majors in colleges and universities at home and abroad as examples, this paper studies the path of first-class specialty construction in colleges and universities, clarifies the opportunities and challenges brought by the connotation development of local colleges and universities in China in the new era, and puts forward the construction scheme of “first-class specialty” in engineering majors of local colleges and universities in China. We should build an output-oriented first-class talent training system, strengthen the construction of teaching staff, deepen the reform of curriculum teaching, take a series of incentive measures, promote the output of first-class research results, establish and improve the long-term mechanism of discipline and specialty construction, and focus on training high-quality interdisciplinary compound first-class new engineering professionals. Drawing lessons from the advanced concepts at home and abroad, this paper clarifies the substantive achievements of the path scheme for the construction of first-class chemical engineering specialty. This is of theoretical significance to the construction of first-class chemical engineering majors in local colleges and universities.

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