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The Practical Dilemmas and Optimization Strategies of the Cultivation of Outstanding Engineers in Local Application-Oriented Undergraduate Universities

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Abstract: Against the dual backdrop of the transition to intelligent civilization and the intensification of great-power competition, national strategies are urgently calling for the independent cultivation of outstanding engineers. As the core carriers supporting regional economic development and the supply of engineering and technical talents, local application-oriented universities play a vital role in responding to national strategies, leading the regional innovation ecosystem, and advancing their own connotative development. Based on regional innovation theory, field theory, and symbiosis theory, this study adopts a vertical-horizontal integration approach of interdisciplinary, interprofessional, interfield, and interdepartmental collaboration, combined with literature research, in-depth interviews, case analysis, and systematic analysis methods to conduct an iterative study on the new training mode of outstanding engineers in local application-oriented universities. It systematically proposes the educational philosophy, target literacy, educational mode, and reform paths of the industry-education integration mechanism for cultivating outstanding engineers. To adapt to the development of new productive forces and the construction of new-type industrialization, it is imperative to systematically promote the quality improvement and optimization of core elements in cultivating outstanding engineers, including faculty teams, curriculum systems, textbook development, and practical platforms.

Keywords: Local Application-Oriented Undergraduate Universities; Outstanding Engineers; Practical Dilemmas; Optimization Strategies

1. Introduction

Under the guidance of the strategy of building a strong education country, the importance of outstanding engineers, as the core force driving scientific and technological innovation and social progress, has become increasingly prominent. In the era of big science, outstanding engineers are of utmost importance for the independent cultivation of high-end talents. The pace of China's efforts to build itself into a manufacturing power is accelerating continuously, and strategic fields such as aerospace and high-end chips still face the "neck-sticking" dilemma. The cultivation system for outstanding engineering talents urgently needs to shift from scale expansion to quality improvement to support the development of new-quality productivity and high-level scientific and technological self-reliance. In the new era and with new missions, engineers are an important talent force for implementing national strategies and helping to achieve Chinese-style modernization.

Local applied undergraduate universities, as an important part of the higher education system, play an irreplaceable and important role in regional development and talent cultivation. On the one hand, local applied undergraduate universities are closely connected to local industrial needs, providing strong talent support and intellectual support for regional economic development. At the same time, local applied universities face many challenges in cultivating outstanding engineers. Problems such as the lagging of educational concepts and cultivation models, the superficiality of personalized education reforms, and the Imperfection of the industry -education cooperation mechanism lead

to a disconnection between practice and actual industrial needs. Students find it difficult to be exposed to cutting-edge engineering technologies and real-world industrial projects, and lack the ability and innovative thinking to solve complex engineering problems [1]. These problems jointly restrict the improvement of the quality of cultivating outstanding engineers in local application-oriented undergraduate universities, making it difficult for them to fully play their important role in cultivating talents at the national and regional levels. As the main body of applied universities, in the context of Promoting the development of new-quality productive forces, optimizing the layout of higher education, and promoting the reform of universities in a classified manner, local applied undergraduate universities urgently need to innovate the talent cultivation model and explore outstanding engineers cultivation path that conforms to their own characteristics and the needs of the times [2].

2. The Value Connotations of Cultivating Outstanding Engineers in Local Application-Oriented Undergraduate Universities

Against the backdrop of the intertwined evolution of a new round of scientific and technological revolution and industrial transformation, as well as the in-depth advancement of national regional development strategies, local application-oriented universities, serving as key hubs connecting regional economic and social development within the higher education system, embody a profound value logic in their practice of cultivating outstanding engineers. This logic is not only related to the universities' own orientation in running schools and their sense of mission, but also involves the implementation effect of the national innovation-driven development strategy and the upgrading path of regional industrial levels. It reveals, from multiple dimensions, the value core and realization mechanism of local application-oriented universities in cultivating outstanding engineers.

2.1 The Cultivation of Outstanding Engineers: A Value Anchor for Local Application-Oriented Universities in Serving National Strategies

Currently, the fourth scientific and technological revolution and industrial transformation are sweeping across the globe. This paradigmatic revolution in the form of civilization has forced higher education to break down disciplinary barriers, strengthen the penetration of artificial intelligence and digital technologies, and use metaverse and digital twin technologies to build immersive practical platforms, thereby promoting the accurate alignment between talent output and the needs of the intelligent industry. In the process of building a strong manufacturing country, high-end industries have an increasingly urgent demand for outstanding engineers who possess innovative capabilities, practical capabilities, and cross-boundary integration capabilities. The Outline for Building a Leading Education Nation proposes to "improve the mechanism for identifying and cultivating top-tier innovative talents, deepen the development of emerging engineering disciplines, and promote the integration of interdisciplinary disciplines". These initiatives highlight the importance and urgency of cultivating outstanding engineers from a higher level. Higher education needs to break through the traditional standardized talent cultivation model and shift to "ecological education", and construct a talent cultivation system "based on interdisciplinary integration, focused on innovative practice, and guided by a global perspective". This system will provide support for defining China's development position in the coordinate system of intelligent civilization for the national rejuvenation. The value of local application-oriented undergraduate universities lies in their grounding in the regional industrial foundation and their commitment to the regional implementation of national strategies. Innovating the talent cultivation model for outstanding engineers not only enables the efficient coupling of educational resources and strategic needs, but also highlights the unique value of local universities in the national higher education system—taking regions as the base, providing "localized" talent guarantees for the implementation of national strategies, and serving as a "bridgehead" for the implementation of national strategies.

2.2 The Cultivation of Outstanding Engineers: A Critical Cornerstone for Local Application-Oriented Universities to Promote Regional Industrial Upgrading

The construction of regional innovation ecosystems serves as a crucial underpinning for

achieving high-quality regional economic development, and universities, as the main entities for knowledge production and talent supply within these ecosystems, play an indispensable role. Henry Etzkowitz's (2002) "Triple Helix" theory posits that the collaborative interaction among universities, industries, and governments constitutes the core driving force behind the evolution of innovation ecosystems. Notably, the outstanding engineers cultivated by local universities act as the key connection point in this interactive process [3]. As higher education institutions rooted in specific regions, local universities bear social responsibilities that extend beyond training qualified contributors for regional development; more importantly, they are tasked with nurturing outstanding engineers capable of leading regional progress and addressing major regional challenges. The outstanding engineers trained by local application-oriented universities are not merely users of innovative achievements, but also builders and leaders of innovation ecosystems. Their value lies in promoting the dynamic evolution of regional innovation ecosystems through the linkage of "talent-technology-industry". Local application-oriented universities urgently need to break through the bottlenecks of traditional training models. They should explore new approaches to cultivating outstanding engineers in strategic emerging fields such as high-end equipment manufacturing, new energy, digital economy, and integrated circuits. The goal is to develop outstanding engineers equipped with interdisciplinary integration capabilities, cutting-edge technological innovation literacy, and engineering practice leadership. These engineers will not only fulfill the role of talent reserves for solving "bottleneck" technological problems, but also assume the strategic responsibility of guiding regional manufacturing industries toward the high end of the value chain. In doing so, local application-oriented universities will become critical nodes that "connect the national strategy with local needs" in China's national engineering education system, further strengthening their leading role in regional innovation ecosystems.

2.3 The Cultivation of Outstanding Engineers: A Core Engine for Local Application-Oriented Universities to Enhance the Core Competitiveness of Universities

Against the backdrop of increasingly fierce competition in higher education, local application-oriented universities are confronted with the dual challenges of the "siphon effect" from "Double First-Class" universities and homogeneous competition among peer institutions. Taking the path of intensive development and forging distinctive school-running features have become an inevitable choice for these universities. The development of emerging engineering disciplines guides and encourages universities to vigorously promote reform and innovation, leveraging the innovation of talent cultivation models to drive the development of new models and advance the intensive development of universities [4].The cultivation of outstanding engineers compels local application-oriented universities to carry out systematic reforms in disciplines, faculty teams, and curriculum systems, thereby promoting an overall improvement in school-running quality. At the disciplinary construction level, cultivating outstanding engineers requires breaking down traditional disciplinary barriers and building an interdisciplinary and integrated disciplinary ecology. Local universities establish "emerging engineering" experimental classes and industrial colleges, integrating resources from related disciplines such as mechanical engineering, electronics, computer science, and materials science to form distinctive disciplinary clusters and enhance the comprehensive competitiveness of their disciplines. In terms of faculty team construction, to meet the needs of cultivating outstanding engineers, local universities actively introduce "dual-qualified" teachers with industrial experience, promote in-depth cooperation between faculty teams and corporate R&D teams, and realize the integrated development of faculty teams featuring "industry-academia-research-application". In the aspect of curriculum systems, with project-based learning and case teaching at the core, universities restructure curriculum content and strengthen practical teaching links. School-running reforms oriented toward talent cultivation enable local universities to break free from the predicament of homogeneous competition, form a positive cycle of "fostering characteristics through talent cultivation and promoting development through characteristics", and achieve a value transformation from "scale expansion" to "quality improvement".

3. Problems in the Cultivation of Outstanding Engineers in Local Application-Oriented Universities

Constrained by multiple factors such as historical accumulation, resource endowments, and institutional mechanisms, these universities still face various dilemmas in the practice of cultivating outstanding engineers, which limits their effectiveness in serving industrial innovation.

3.1 The Connection with Local Industries Is Disconnected

One of the core missions of local universities is to provide adaptable talents for the development of regional economy and society. Nevertheless, in the integrated practice of education, science and technology, and talent development, there is a significant disconnect between these universities and local industries. First, some local universities still adhere to the traditional discipline-oriented talent cultivation model, lacking dynamic awareness of the technological needs and talent standards of regional characteristic industries. This leads to a mismatch between the talents cultivated (in terms of knowledge structure and practical capabilities) and the actual demands of enterprises. Second, there is a misalignment between the disciplinary and professional layout of universities and the regional industrial structure. After the reform of the university management system, some local universities have undergone "de-industrialization" adjustments. However, in the process of shifting to regional service, they failed to develop distinctive advantages and instead fell into the homogeneous trap of being "comprehensive but lacking focus" [5]. Third, at the level of scientific and technological support, the mechanism for transforming scientific research achievements in local universities is inefficient. It is difficult to effectively integrate academic innovation into industrial upgrading, making it impossible to form a positive cycle of "talent cultivation - technological breakthrough - industrial development" and thereby weakening the support for regional economic development.

3.2 The Path from Goals to Capabilities Is Not Clear

The rapid development of the digital economy and intelligent manufacturing has put forward new requirements for the capabilities and qualities of outstanding engineers. Traditional engineering talent cultivation focuses on the systematic imparting of knowledge in a single discipline. In contrast, the core competencies required for outstanding engineers—such as interdisciplinary integration ability, complex engineering problem-solving ability, lifelong learning ability, and global perspective—have not been transformed into quantifiable and evaluable specific indicators in the cultivation programs of most local universities. Currently, the cultivation of key competencies for innovative talents in emerging engineering fields, such as interdisciplinary thinking, international perspective, and engineering leadership, is insufficient. Due to the insufficient in-depth analysis of talent needs in emerging industries, cultivation programs often tend to "prioritize theory over practice" and "emphasize professionalism over interdisciplinarity," making it difficult to cultivate engineering and technological innovation forces that can adapt to industrial transformation.

3.3 The Talent Development System Has Failed to Keep Pace with the Times

The core of cultivating outstanding engineers lies in the innovation of models and systems. However, the traditional cultivation models of local application-oriented universities still have significant shortcomings. In terms of capabilities and qualities, the innovation of talent cultivation models is insufficient, and there is a shortage of high-end teachers who master cutting-edge technologies and understand the actual needs of engineering and technology [6]. In terms of curriculum systems, the content and teaching materials of engineering education lack forward-looking and fail to keep up with the cutting-edge technologies of enterprises [7]. The proportion of courses in emerging interdisciplinary fields is insufficient, making it impossible to respond to the trend of multi-disciplinary integration in the scientific and technological revolution. In terms of teaching methods, theoretical lectures still dominate, while practical teaching links are formalized. The integration of real enterprise projects is low, which makes it difficult to stimulate students' innovative thinking and practical abilities. In terms of education methods, the effective application of new technologies

such as AI is lacking, failing to achieve precision and personalization in the teaching process, which creates a gap with the new requirements for talent cultivation in the intelligent era.

3.4 The Collaboration Between Industry and Education Needs to Be Further Deepened

The integration of industry and education is a key path for engineering talent cultivation. However, the university-enterprise cooperation of local application-oriented universities remains at the stage of "superficial integration" and has not formed a long-term collaborative mechanism. In terms of incentive mechanisms, enterprises lack enthusiasm to participate in talent cultivation, and there is a lack of clear interest incentives and risk-sharing mechanisms. In terms of operation mechanisms, there is an obvious disconnection in the interactive integration process between talent cultivation quality and industrial development. The core goal of cultivating outstanding engineers is to develop high-quality engineering and technological talents who can meet the needs of modern industries and technological progress, which means that the education system needs to accurately grasp the trends and demands of industrial development. However, the current integration of educational elements and production factors still faces many challenges, especially the insufficient in-depth integration in aspects such as cultivation models, curriculum design, tutor team construction, and practical platform construction [8]. In terms of guarantee mechanisms, the lack of policy support and resource investment makes it difficult to promote the integration of resources between the education field and the industrial field, which restricts the actual effect of industry-education integration.

4. Paradigm Transformation in the Cultivation of Outstanding Engineers in Local Application-Oriented Universities

From the Humboldtian academic tradition to the exploration of industry-academia-research collaborative education in the contemporary era, the evolution of university talent cultivation paradigms has always been in sync with the development of the times. Against this backdrop, how to break the constraints of disciplinary barriers, reconstruct the teaching content and methodology system, reshape the guiding function of evaluation mechanisms, is not only a core proposition for the intensive development of higher education, but also a key path for China to build a powerful education country and achieve self-reliance and self-improvement in high-level talents. Local application-oriented universities should take emerging engineering disciplines as a guide, promote systematic reforms in educational concepts, cultivation goals, competence standards, educational models, and collaborative mechanisms, realize the iterative upgrading of talent cultivation paradigms, and construct a cultivation system for outstanding engineers that meets the needs of the new era.

4.1 Cultivation Goals: From "Single-Skilled" to "High-Quality Application-Oriented Innovative Talents"

The successful experience of high-level application-oriented universities in Germany and the United States in cultivating innovative application-oriented talents emphasizes the development and improvement of students' practical abilities, aiming to nurture application-oriented talents who possess both professional theoretical knowledge and strong practical capabilities [9]. The classification and framework of outstanding talents based on the technology maturity theory indicate that local universities, such as Civil Aviation University of China, should target the cultivation of science and technology innovation-oriented, professional technology-oriented, and product operation-oriented talents [10]. Therefore, in cultivating outstanding engineers, local application-oriented universities must respond to the new demands of new-quality productive forces for talents. This means their cultivation should not only differ from the cultivation of top-tier innovative talents in research-oriented universities, but also go beyond the low standards of skill-oriented talent cultivation in general application-oriented universities. This type of engineering and technical talent should be capable of applying interdisciplinary knowledge to solve complex engineering problems, leading teams to achieve technological innovation and process optimization, and adapting to technological changes and international competition.

4.2 Competence Standards: Reconstruction of a Competence System Based on the Logic

of STEM Education

In today's world, driven by innovation and dominated by artificial intelligence, science, technology, and engineering have become core drivers and engines for promoting social innovation, economic transformation and upgrading, and productivity reform. STEM education has thus become a strategic choice in the Industry 4.0 era [11]. STEM education organically integrates Science, Technology, Engineering, and Mathematics, emphasizing the interdisciplinary integration of knowledge and its practical application. It provides methodological guidance for cultivating talents who possess both scientific and humanistic literacy, as well as theoretical and practical capabilities. From a theoretical perspective, STEM education aligns with the "practice-oriented" and "innovation-oriented" goals of engineering talent cultivation: science and mathematics lay the theoretical foundation for talents, while technology and engineering provide practical carriers. The integration of these four domains can stimulate innovative thinking and cultivate the ability to solve complex problems, making it an important approach for nurturing engineering and technological talents. The competence standards for outstanding engineers need to incorporate the concept of full-cycle engineering education, integrating not only engineering problems and engineering awareness but also engineering culture throughout the entire talent cultivation process [12], thereby fostering students' foundational values of "loving and serving the country, and being dedicated to work". In cultivating pe outstanding engineers, local application-oriented universities should fully absorb the disciplinary structure, curriculum system, and teaching methods of STEM education, break the single dimension of traditional engineering education, construct a comprehensive competence system centered on STEM education, and form a three-dimensional competence structure of "value guidance + competence core + literacy support". This will help cultivate more high-level application-oriented talents with interdisciplinary knowledge, engineering practical capabilities, and innovative and creative capabilities.

4.3 Educational Models: In-Depth Integration of Interdisciplinary Collaboration and AI Empowerment

A new round of scientific and technological revolution has driven the transformation of knowledge production models from "discipline-oriented" to "problem-oriented". In the future, engineering will feature more prominent characteristics of greenization, informatization, intellectualization, and complexity, and the interdisciplinary integration of multiple engineering disciplines and their integration with other disciplines will become a development trend [13]. To cultivate high-quality engineering and technological talents adaptable to future social development, local application-oriented universities must break through the traditional "single-discipline cultivation" model and transition to a new "interdisciplinary integration" educational model. First, they should establish a comprehensive engineering education concept, follow the whole-industry thinking, deepen the integration of industry and education as well as university-enterprise cooperation, and innovate professional construction models in line with the actual development of regional industrial economies [14]. Second, they should set up interdisciplinary majors or curriculum modules, focus on the practical needs of regional industrial transformation or enterprise technological upgrading, break disciplinary barriers, and promote the integration of disciplines such as mechanical engineering, electronics, computer science, and materials science with emerging fields like artificial intelligence and big data. By leveraging intelligent technologies, they can realize the dynamic update of teaching content, precise guidance in the teaching process, and personalized evaluation of learning outcomes, thereby improving the efficiency and quality of talent cultivation. Third, they should implement teaching methods that integrate science and education. It connects the two major fields of science and technology as well as education, coordinates diverse resources such as scientific research projects, platforms and achievements, promotes the in-depth integration of scientific research activities and teaching processes, and facilitates the cultivation of students' higher-order thinking. Additionally, they should promote project-based practical teaching, transforming real industrial problems into teaching projects, and guiding students to integrate knowledge, practice abilities, and

improve quality in the process of solving problems.

4.4 Collaborative Mechanisms: Ecological Construction of In-Depth Industry-Education Integration

The cultivation of outstanding engineers cannot be separated from the collaborative linkage of education, science and technology, and industry, and in-depth industry-education integration is a key mechanism to achieve this goal. From a theoretical perspective, the essence of industry-education integration is a network composed of different entities such as the government, enterprises, industries, and universities. It promotes the all-round integration of structural elements between the supply side of talent cultivation and the demand side of industries, and Realizes the precise alignment of the education chain, talent chain, industrial chain, and innovation chain. To explore the symbiotic cultural environment for talent training under the "integration of four chains", we will build an "ecosystem" jointly composed of universities, enterprises, industries, and institutions of higher education, and a "learning community" that promotes the improvement of individual capabilities. This can integrate resource elements such as industry norms, corporate spirit, engineering ethics, and creative culture, and facilitate the construction of a "university-enterprise community of shared destiny" where enterprises and industries actively participate in the talent training process. Each entity exerts different influences on the industry-education integrated cultivation of outstanding engineers based on the capital it holds. By constructing an engineering education ecosystem with symbiosis among multiple entities, local application-oriented universities can join hands with enterprises and research institutions to jointly participate in the entire process of talent cultivation. This ensures that the pace of talent cultivation is in sync with technological development and industrial upgrading, better realizing the organic integration of the "Three Firsts" principle—"taking self-reliance and self-improvement in science and technology as the strategic support for national development, taking talents as the primary resource for supporting development, and taking innovation as the primary driving force for leading development".

5. Conclusion

Local application-oriented undergraduate universities are the mainstay of the higher education system. The cultivation of outstanding engineers is of great significance for serving national strategies, promoting regional industrial upgrading, and enhancing the core competitiveness of universities. In line with the requirements of the new era, these universities face multiple challenges in talent cultivation practice, hence the need to build outstanding engineer cultivation system that adapts to industrial development.

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