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Reform path of cultivating innovative talents for industrial engineering majors in the context of new liberal arts

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Abstract: Cultivating innovative talents in the context of new liberal arts is a critical component of the reform and development of industrial engineering programs. This paper examines the reform of innovative talent cultivation in the industrial engineering program of a local university. By analyzing the teaching philosophy, methods, design, and models of the industrial engineering program at local universities, the current state of innovative talent cultivation is assessed. Based on this analysis, the paper identifies challenges in cultivating innovative talents in industrial engineering teaching. It proposes reform pathways that integrate multidisciplinary intersections, deep collaboration between academia and industry, and extracurricular innovation empowerment. These pathways are of significant practical importance for advancing the reform of innovative talent cultivation in industrial engineering programs under the new liberal arts framework.

Key words: new liberal arts; local universities; innovative talents; industrial engineering programs; interdisciplinary integration; industry-academia collaboration

1 Introduction

In 2019, the Organization for Economic Co-operation and Development (OECD) advocated for countries to leverage transformative and critical new technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain, to accelerate the strategic layout and goals of national industrial digital transformation. Similarly, China proposed the widespread, rapid, and in-depth application of the "Internet Plus" concept and technology across various sectors and departments of society to aid in enterprise transformation and upgrading [1][2][3]. The development and integration of information technology are bound to drive industrial transformation. Consequently, in November 2020, the Ministry of Education emphasized in the *New Liberal Arts Construction Declaration* that multidisciplinary fusion and innovation should become an indispensable principle of current new liberal arts education standards and concepts. By integrating new theories and technologies from different disciplines, the task of cultivating talents in new liberal arts can align with the current digital technology environment, fostering innovative and application-oriented talents that meet the demands of industrial transformation [4][5][6][7]. Compared to traditional liberal arts, the new liberal arts require a shift from traditional models, employing innovative thinking to deeply integrate and intersect multiple disciplines. Particularly, the aforementioned transformative technologies need to be incorporated into the education of traditional liberal arts to

achieve transformation and upgrading [8][9][10]. This concept poses new challenges and sets new requirements for the talent cultivation model in industrial engineering programs, while also pointing out new directions for the construction of first-class programs in this field.

During the 14th Five-Year Plan period, Shanghai has been focused on major national development strategies such as becoming a manufacturing powerhouse, a network powerhouse, Digital China, and achieving carbon peak and carbon neutrality. Shanghai has been tasked with a new mission in manufacturing development, enhancing the leadership role of high-end industries, strengthening the key support capabilities of manufacturing, and striving to overcome bottlenecks in the development of the manufacturing industry. The aim is to modernize the development level of the industrial chain, providing strong support for Shanghai to become a central node in the domestic circulation and a strategic link between domestic and international dual circulation. Simultaneously, the construction and development of new liberal arts have endowed various disciplines with new connotations, laying a solid foundation for interdisciplinary construction [11]. Based on this, our program integrates the methodology of "systems thinking", the "innovative crossover" of high-end manufacturing, and the "international perspective" of global certification. It features distinct characteristics of "system management" and "engineering", combining technology, information, and management science. This supports the construction of "four new" professional fields, aiming to comprehensively enhance students' moral and ethical thinking, professional skills, and practical problem-solving abilities. The goal is to cultivate innovative and application-oriented industrial engineering talents within the context of new liberal arts.

2 The current situation of the cultivation of innovative talents in industrial engineering

2.1 Establish the teaching concept of multi-disciplinary integration of management and economics

The teaching philosophy of industrial engineering programs emphasizes the importance of core professional knowledge, the integration of multidisciplinary theoretical knowledge, and the formation of a central knowledge framework for students. This approach aims to create a multidisciplinary and interdisciplinary teaching philosophy that aligns with the reform and innovation goals of industrial engineering programs within the context of new liberal arts. Ensuring accurate educational direction and clear teaching objectives is a necessary component for the in-depth reform and development of this program in the new liberal arts context [12]. The new liberal arts teaching in this program should appropriately incorporate the advantages of science and engineering education, avoiding the traditional approach of merely listing and stacking knowledge. By using typical case studies in teaching, educators can guide students, highlighting key and challenging aspects of the curriculum. This approach, combined with real-world cases, encourages independent thinking, leading to a deeper and more thorough understanding of theoretical knowledge and practical skills. It also fosters students' ability to think and solve related problems in real-life situations. Moreover, the new liberal arts teaching in industrial engineering programs encompasses a broad range of knowledge content and systems. For instance, the curriculum includes courses such as microeconomics, artificial intelligence, big data analysis, and financial management. The aim is to cultivate students' multidisciplinary and comprehensive abilities, equipping them with a broad set of skills and knowledge across various fields.

2.2 Set up interdisciplinary and rich teaching content for liberal arts, science, and engineering

In the context of new liberal arts, the teaching content of industrial engineering programs is composed of core and foundational knowledge within the professional field. The teaching content should be primarily guided by classic cases, core theories, relevant definitions and concepts, and systematic thinking models. At the same time, the selected teaching content needs to include interdisciplinary knowledge, requiring teachers to introduce new ideas and concepts in teaching, emphasizing the interpenetration of knowledge. Its innovation is reflected in the strong intersection and integration among

engineering, science, and liberal arts disciplines and related courses. Additionally, by incorporating cutting-edge knowledge in engineering applications, technological innovation, and natural sciences, students' research perspectives can be broadened. This helps students develop a more comprehensive scientific literacy and knowledge system that adapts to the new era and new opportunities.

2.3 Implement closed-loop instructional design

The construction of new liberal arts needs to be reflected in different stages and nodes of the educational process. This includes rational planning of teaching design from aspects such as student learning analysis, teaching goal design, selection of teaching content, organization of teaching methods, teaching evaluation methods, and the formation of student literacy. In setting teaching goals, it is crucial to fully utilize existing data on students' performance during the teaching process, comprehensively analyze their current learning situations using information technology, and design future learning tasks to provide reference and feedback. For the learning content, the existing online teaching materials should be combined with offline practical application scenarios, with a reasonable design of problems to cultivate students' abilities to explore freely, and solve problems based on reality. In terms of teaching methods, it is necessary to break through traditional approaches and focus on new teaching models, integrating multidisciplinary intersections and merging course systems. Information technology methods should be employed to enhance teaching content resources, stimulate student interest, and make course delivery more flexible and dynamic.

For teaching evaluation, a diverse evaluation index system should be adopted, employing a comprehensive assessment method that emphasizes rewards. This not only stimulates students' intrinsic motivation for learning but also highlights areas for improvement in teaching methods. Additionally, information technology should be used to visualize student performance data, providing a diversified evaluation model that clearly shows students' strengths and weaknesses during the teaching process. This ensures that students can effectively reflect on their performance based on the evaluation results.

2.4 Promote a variety of teaching methods

Firstly, the teaching methods of industrial engineering programs should be based on real application scenarios, focusing on practical teaching issues and engineering application problems. Various teaching methods should be used flexibly, considering multiple dimensions such as the authenticity, rationality, and complexity of problems in the educational process. This approach can further enhance students' understanding and reflection on the teaching content. Secondly, teaching should be integrated with enjoyment, reasonably incorporating simulation exercises. By realistically adjusting and enhancing the narrative and storytelling aspects of real events, and using various forms such as offline teaching and online simulations, students can become immersed in the problems. This helps foster students' interest and desire to explore these issues. Thirdly, teachers should engage in the teaching process through new forms such as guided and participatory methods, altering the traditional teacher-student dynamic. This approach helps to bridge the gap between teachers, students, and other groups. Through multi-stakeholder collaboration and the integration of various opinions, students' curiosity can be satisfied, and their cognitive boundaries can be broadened.

3 Cultivation path of innovative talents in industrial engineering majors

3.1 Promote the integration of disciplines and achieve professional penetration through the in-depth intersection of multiple disciplines

The new liberal arts emphasize more on cultivating students' thinking patterns, such as their ability in knowledge coordination, interdisciplinary collaboration, and content integration. By fostering the intersection and integration among relevant disciplines and theoretical knowledge, it helps to cultivate a new and more systematic mode of thinking.

In the context of advanced manufacturing, it is essential to refine the concept and philosophy of cultivating innovative

and application-oriented talents, and to develop appropriate training methods and models. The distilled teaching philosophy for cultivating innovative and application-oriented talents in the new liberal arts emphasizes placing students at the center, making the cultivation of such talents a core mission, and promoting the comprehensive coordination and development of students' knowledge, skills, and personal qualities. This educational philosophy aims to foster innovative application-oriented talents through multidimensional, comprehensive, and deep-level teaching reforms. It involves researching and exploring the cultivation of high-level innovative talents.

Universities should adhere to the innovative and application-oriented talent training model of multidisciplinary intersection and integration. In terms of professional training programs, with mathematics and system science, computer technology, and economic management as the professional foundations, the cultivation of professional abilities can be strengthened, and a 1+3 two-stage training framework system can be implemented. At the same time, universities should focus on the new core content of professional training, and open more targeted and systematic professional courses to lay a solid multidisciplinary foundation for students.

3.2 Promote curriculum and teaching reform through in-depth collaboration between schools and enterprises, and realize the integration of theory and practice

In the context of the new liberal arts, the educational objectives of this program focus on enabling students to not only keenly identify issues when facing practical work and research but also conduct insightful and thorough analyses of these issues. They should be capable of proposing solutions and strategies for addressing and handling problems effectively, as well as conducting efficient modeling and analysis tailored to specific problems.

3.2.1 Construct a sound and reasonable teaching method, curriculum and quality supervision system.

Emphasis is placed on integrating teaching and learning, classroom and extracurricular activities, campus and industry, as well as theory and practice. The approach prioritizes establishing a strong technical foundation, enhancing integration across disciplines, and encouraging self-directed learning. It involves tracking advancements both domestically and internationally, emphasizing the application of knowledge, and closely linking specialized knowledge study, scientific research, and practical enterprise needs. The educational framework is structured into three stages: foundational, advanced, and innovative layers. Each stage is closely aligned with the progress of professional research and real-time industry demands. Throughout these stages, there is a focus on nurturing students' practical innovation capabilities through research-based project courses and innovation and entrepreneurship competitions.

The curriculum development emphasizes "solidifying foundations, broadening horizons, and cultivating abilities", aiming to produce innovative and application-oriented professionals with a solid foundation in specialized knowledge. These professionals should be capable of applying theoretical knowledge and technical skills to solve real-world issues in both societal and corporate contexts. In response to societal demands, elective courses such as Big Data Management have been added. With a focus on advanced manufacturing, the goal is to cultivate students' ability to independently solve problems. The curriculum framework and structure are designed to be broad in application scope and highly adaptable. This is achieved through establishing a professional course framework that meets industry needs and enhances students' capabilities. Various methods are employed, including personalized courses tailored to enterprise requirements, theoretical courses to meet academic advancement needs, and innovative and applied courses geared towards competitions. This approach ensures a diverse range of course offerings to cater to different learning objectives.

A mechanism for "process tracking during teaching and supervision with feedback on educational outcomes" can be established, aiming to implement continuous improvement. This involves setting up internal and external feedback points for teaching and using six principles of quality supervision. A robust framework for supervising and managing teaching

quality is constructed, focusing mainly on "process tracking and outcome feedback". This framework monitors various aspects such as setting reasonable educational objectives and programs, selecting effective teaching methods, and assessing teaching quality. The goal is to achieve continuous improvement by ensuring that educational goals and programs are well-defined, teaching methods are efficient, and the quality of education is consistently evaluated. This process allows for iterative enhancements based on feedback, contributing to ongoing improvements in educational effectiveness.

3.2.2 Design an innovative theoretical teaching system and a practical teaching system

In the process of developing training programs, the reverse-pull design method is utilized to construct a theory-based teaching system oriented towards societal needs. To adapt and meet actual enterprise requirements, a reverse-pull approach is employed in designing and implementing the professional training program. This method involves identifying demands, constructing core professional skills, selecting courses within the discipline and across disciplines, designing experimental systems and frameworks, and formulating practical components. Driven by the cultivation of innovative application-oriented talents, the goal is to establish a comprehensive training program that integrates theory-based teaching, experimental teaching, and practical teaching.

Taking the ideological and political reform of professional courses as the starting point, we will build a multi-faceted, all-round, and three-dimensional educational structure and practice system, organize and integrate the professional resources available in each discipline on campus, integrate and rationally use the resources inside and outside the school [13], and build a group of off-campus-based skill practice bases through the combination of enterprises, schools, and scientific research institutes, and implement the educational methods that combine in-school and out-of-school, in and out-of-classroom, theoretical training and field practice, with the multi-level cultivation of engineering application ability and practical innovation ability as the foothold.

3.3 Promote production-study collaboration through extracurricular innovation empowerment and realize the co-construction of innovation platforms

At present, the demand for talents in the high-end equipment manufacturing industry under the new liberal arts background is mainly divided into three categories: technical, applied and business-oriented talents. This major adheres to the training concept of "integration of production and study, and collaborative education", takes the training mode of production-study collaborative education as the main direction for the future development of the discipline, and carries out the construction of "three-type" talents in industrial engineering. The training model of production-study collaborative education not only refers to the establishment of a collaborative training mechanism between learning and enterprises, but also includes the joint formulation of talent training programs and the joint establishment of evaluation and evaluation mechanisms between schools and enterprises.

The educational and growth environment for innovative and applied talents and the extracurricular innovation system for students should be optimized. In order to improve the academic level and teaching ability of teachers, it is necessary to strengthen the academic exchanges between discipline leaders, and convey the latest development of the discipline horizontally and vertically in a timely manner, so that the teaching content can keep up with the frontier of professional theory and technology development. At the same time, emphasis should be placed on teaching demand orientation, integrating teaching content, compiling characteristic teaching materials, building characteristic quality courses, setting up characteristic experiments, building a multi-level innovative teaching platform, exploring multi-mode teaching methods, and optimizing the environment for the cultivation of innovative talents.

An "all-round and standardized" extracurricular innovation system should be built for students. Encouraging innovation is the only way for the construction and development of new liberal arts in China [14]. Colleges and universities

should rely on student mentor system, establish a fund to support students' innovation and entrepreneurship, implement student innovation and entrepreneurship incentives into credit awards, establish a student innovation guarantee system from all angles, and set up an innovation and entrepreneurship training plan team. Students can carry out innovative activities by participating in their mentors' research projects. Universities can carry out the cultivation of innovative talents in the form of "innovation and entrepreneurship competition + project" activities.

4 Conclusion

The reform of the cultivation of innovative talents in industrial engineering has condensed the teaching concept of "student-oriented, taking the cultivation of innovative and applied talents as the core task, and promoting the comprehensive coordination and development of students' knowledge, skills and their own quality". Colleges and universities should focus on education and teaching by "attaching importance to professional basic education, strengthening the cultivation of professional core competencies, and paying attention to the combination of theoretical knowledge teaching, experimental teaching, practical link teaching and field production practice", and adhere to the concept of cross-integration in the cultivation of innovative and applied talents in the new liberal arts background. The trinity of theoretical teaching, experimental teaching and curriculum design is the main line, which runs through the whole teaching process. Adhere to the effective combination of theoretical teaching, experimental teaching, practical teaching and production practice, so as to achieve the teaching goals of students with solid theoretical foundation, broad knowledge base, improved comprehensive quality, and enhanced innovation ability.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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