Research on Industry-Education Integration Training of Practical Innovation Talents in "New Engineering" — A Case Study of Materials Science and Engineering Major

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Abstract: With the continuous optimization and upgrading of the national economic structure, the traditional talent training model in universities is difficult to meet the increasing demand for innovative and practical talents in "new engineering" year by year, and the transformation of talent training mode has important research significance for all universities. This paper, in conjunction with the current situation of training innovation and practical abilities of "new engineering" undergraduates, takes the Materials Science and Engineering major at Harbin Institute of Technology (Shenzhen) as an example to explore a new model of industry-education integration training guided by industrial demand. It establishes an integrated training system that combines undergraduate innovation projects, academic tutorial system, and graduation design, and designs production practice courses oriented by personalized development needs. It proposes a joint training mechanism for practical talents combined by school-enterprise joint laboratories and enterprise practice bases, providing a new idea for the training of innovative and practical talents in "new engineering".

***Keywords*:** industry-education integration, new engineering, talent training, practical innovation, materials science

1. Introduction

With the continuous optimization and upgrading of the national economic structure and consumption patterns, the demand for innovative and practical talents in "new engineering" is also increasing. Traditional pure theoretical or experimental teaching methods, with existing textbook knowledge as the main teaching content, overall knowledge technology is 5-10 years behind the world's advanced level. Students know little about the latest scientific and technological achievements in their major [1], feel confused about future employment prospects, and still need to start from scratch to learn the latest technology in their major or even other technologies after graduating and entering the workforce. This increases the learning cost for graduates and the burden of talent training for companies. Therefore, the contradiction between the talents trained by universities and the needs of the industry is becoming increasingly prominent, and exploring a talent training model guided by industrial needs is the common goal of universities and enterprises.

"Deepening the integration of industry and education, promoting the organic connection of the education chain, talent chain with the industry chain, and innovation chain, is a strategic measure to promote the mutual penetration, coordination, and promotion of education priority development, talent-led development, industrial innovation development, and high-quality economic development."[2] In 2019, the State Council issued the "National Industry-Education Integration Construction Pilot Implementation Plan", which clearly launched an industry-education integration talent training model oriented by problems, playing to the characteristics of the city, and led by industry and enterprises. Adapting to local conditions and combining the geographical characteristics and industrial advantages of the city where the university is located, the talent training model that is closely integrated with the local high-tech industry will become a new way of higher education talent training in the future.

2. Demand and Current Situation Analysis of Innovative Practical Ability Training for New Engineering Undergraduates

2.1 Demand for Innovative Practical Ability of "New Engineering" Undergraduates

In 2017, the Ministry of Education put forward the concept of undergraduate training in "new engineering". On the basis of pure theoretical teaching, it introduced the connotation of engineering, allowing engineering education to return to the essence of engineering, and continuously innovating intersections and integrations.[3] At the same time, the Ministry of

Education, the Ministry of Human Resources and Social Security, and the Ministry of Industry and Information Technology jointly issued the "Manufacturing Talent Development Planning Guide"[4], which pointed out that the new materials industry will become one of the industries with the largest talent gaps. By 2025, the talent gap in the field of new materials will reach 4 million people [5]. In 2022, the number of undergraduate graduates will exceed 10 million, and undergraduate graduates will become the main force in the labor market. In this context, the ability level of undergraduate graduates will directly affect the future development of the country's industry. The main reliance for improving China's competitiveness in the international market is the innovation of high-tech and the innovation of the scientific and technological industry chain. Therefore, the training of undergraduates' innovative practical abilities is the most important link in the current national talent training. []

2.2 Current Situation and Issues in Undergraduate Innovation Theory and Industry Practice

In reviewing the integration process of industry and education in colleges and universities in recent years, it is not difficult to find that many projects do not achieve the expected results. The main reasons for this phenomenon are the following three factors.

(1) The policy system is not perfect, and the implementation of specific rules is not in place. Although the country has issued a series of policy support and encouraged a series of industry-education integration projects, the projects involve multiple participants such as colleges and universities, enterprises, governments, tutors, and students. These different participants have different responsibilities, cultural backgrounds, and goals, sometimes even conflicting, making it difficult to carry out the projects. Generally speaking, colleges or enterprises take the lead in an industry-education integration project for preferential government policies and attractive college quality assessment data. Once the project is successfully initiated, it enters a state of neglect, and the interference of factors such as personnel changes and student graduation causes the project to deviate from its initial goals in the later stages. The inconsistent goals of students and tutors make it impossible to guarantee the quality and effectiveness of training.

(2) There is a certain degree of disconnection between the teaching process in universities and the actual needs of the industry. Under the teaching evaluation system dominated by teaching hours and student evaluations, the focus of the teaching of colleges and teachers is on offering more courses and new courses. For example, newly recruited teachers, who are mainly experienced in academic research but lack practical industrial experience, can only open new courses in their field of study or teach basic professional courses. In contrast, teachers with both academic research and industrial production experience tend to focus more on the development of commercially valuable products and invest more energy in enterprise operations. They spend less time guiding students, leading to a lack of practical high-tech industry knowledge in both schools and colleges. Moreover, the education model, guided by the purpose of promoting postgraduate entrance examination rates, makes new courses lean towards postgraduate professional courses, and the talent needs of the industry are easily overlooked. This increases the cost for enterprises to train students, adds an invisible burden to enterprises, affects the progress of enterprise R&D, and ultimately adversely affects the quality of student training.

(3) The third problem is the pursuit of quantity over quality in school-enterprise cooperation. Currently, to meet the quantity requirements of integration of production and education projects, most of the signed projects focus on activities like expert lectures from enterprises, student visits to enterprises, and school laboratories undertaking some industrial R&D work. The forms of these projects are relatively single. They often rely on personal relationships maintained by individual teachers, and the level of cooperation between schools and enterprises is relatively shallow. Substantial cooperation in scientific research and teaching content is not deeply carried out, and the time for students to truly integrate into the project learning is short, making it difficult to learn practical high-tech skills.

3. Industry-Education Integration Training for Practical Innovation Talents

Guided by the connotation of new engineering, universities should lead with the concept of moral education, build with the idea of responding to changes and shaping the future, and mainly use the methods of inheritance and innovation, intersection and integration, coordination and sharing, to cultivate diversified, innovative, and excellent engineering talents for the future. These talents should possess strategic, innovative, systematic, and open features. [6] Simultaneously, higher education institutions should adapt to local conditions and integrate with local industrial development. For example, Harbin Institute of Technology (Shenzhen) combines the demands for material science and engineering technology in the areas of electronic information, new energy, and biomedical in the Greater Bay Area. The school of materials science and engineering integrates various aspects of undergraduate innovative teaching, basic experimental teaching, innovative entrepreneurship projects for college students, production internships, and graduation design, etc., all of which are part of innovative and practical training. This approach enhances the quality and efficiency of education, completing the industry-education integrated training of innovative and practical talents.Based on this, with the joint laboratory of school-enterprise cooperation as a physical platform, it strengthens the systematic engineering training for students and establishes a base for the new engineering industry-education integrated talent training in the material science discipline, as shown in Figure 1.

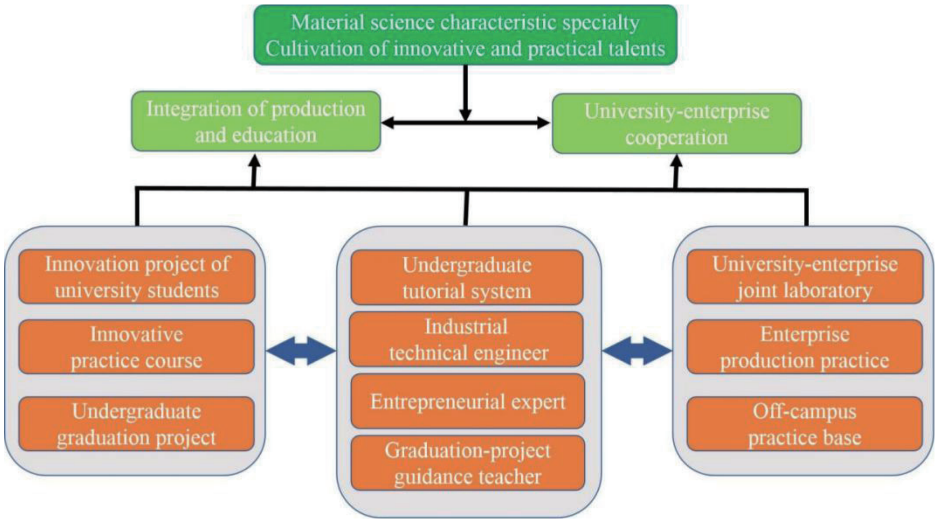

Figure 1. "New engineering" conception of talent training mode in material science and Engineering Specialty

3.1 Industry-oriented Innovative Practical Theoretical Teaching Model

In the existing curriculum system, we invite experts from enterprises to offer specialty courses, making full use of the summer short term. We pay attention to the individualized development needs of students while closely aligning with industry demands, establishing courses related to materials specialties with characteristics of the Greater Bay Area industry. For example, the course "Fingerprint Recognition and Packaging Technology" instructs undergraduates on the principles and pros and cons of current fingerprint recognition schemes, performance characterization, quantification algorithms, registration and recognition processes. By offering practical examples of packaging technology, students deepen their understanding of packaging technology, promoting the learning and practice of basic knowledge. The course "Additive Manufacturing Technology", as one of the manufacturing technologies prioritized for national development, provides undergraduates with professional knowledge about additive manufacturing, also known as 3D printing technology. It enables students to master the entire process of additive manufacturing and familiarize themselves with the basic principles and processing characteristics of various additive manufacturing technologies, broadening their future career possibilities, enhancing their job advantages, and laying a solid foundation for working in emerging manufacturing industries.

3.2 Integrated Training for Undergraduate Innovative Projects, Academic Tutoring System, and Graduation Design

The School of Materials and engineering has established an open project system for undergraduate innovative projects, which integrates the academic tutor system and graduation design projects. This breaks the original one-way tutor selection mechanism by students and avoids problems such as low enthusiasm for guidance from tutors due to blindly pursuing the proportion of professors serving as tutors, and each professor guiding too many students. At the beginning of students' enrollment, tutors can set and publish basic innovative project topics suitable for undergraduates based on scientific research and industry needs. Students are free to form teams and are guided to actively communicate with tutors they are interested in. This gives both tutors and students the right to choose each other, ultimately establishing long-term guidance relationships that extend to the graduation design stage. This reform measure can enable students to have a certain understanding and mastery of professional theoretical knowledge from the beginning of their freshman year, learn laboratory operating standards, and familiarize themselves with the overall process of undergraduate graduation design and even research topics at the graduate and doctoral stages in advance. It can significantly enhance students' hands-on experimentation and innovation capabilities.

3.3 Design of Production Practice Courses Guided by Personalized Development Needs

We encourage undergraduate students in the Materials discipline to choose production practice enterprises according to their personal development interests, establish a new teaching model for production internships that combines a unified industry "awareness" internship in the Materials discipline with autonomous contact with enterprise internships. On the premise of ensuring student safety, students are given the freedom to choose the time and space for production internships according to their personal development needs. The Material discipline has formulated detailed rules for exchanging off-campus internships for on-campus credits and encourages students to carry out practical internship activities based on actual industry engineering projects.

At the same time, the school of materials science and engineering has signed a long-term cooperation agreement with STMicroelectronics in Shenzhen. According to the individualized development interests of students, an enterprise mentor is allocated to each student on a one-to-one basis, allowing them to delve into different working departments within the enterprise. Customized internship content is designed for each student, and a detailed work calendar, accurate to the day, is established. It involves production and manufacturing departments, quality management departments, laboratories, and sustainable development departments including the data measurement, tool usage to system analysis and enterprise operation management methods. This abandons the traditional modes of company visits or "production work," providing students with preliminary experience of actual production and a perceptual understanding of future work.

The curriculum design guided by individualized development needs can enable students to deeply integrate into industrial production, effectively learning advanced technologies related to their own career planning.

4. Joint Talent Cultivation Mechanism of University-Enterprise Joint Laboratories and Enterprise Internship Bases

The school of materials science and engineering has successively established university-enterprise joint laboratories and talent cultivation bases with several enterprises, including Shenzhen Abit Electronics Technology Co., Ltd., Shenzhen Advanced Connection Technology Co., Ltd., Shenzhen Hanerxin Electronic Technology Co., Ltd., Shenzhen Meixin Testing Technology Co., Ltd., Chongqing Mailian Technology Co., Ltd., and Shenzhen Peacock Technology. The "HIT (Shenzhen) - Chongqing Mailian" microfluidic chip university-enterprise joint laboratory focuses on the development of advanced tracer material technology and combines proprietary antigen technology to fully leverage the supportive role of material science in the field of health. The "HIT (Shenzhen) - Peacock Technology" Materials Science and Technology University-Enterprise Joint Laboratory is centered on advanced electronic packaging materials and micro-nano connection processes, aligned with the development needs of the electronic information industry in the Pearl River Delta region, developing products and processes including vacuum glass packaging, advanced electronic device packaging, and connection. The "HIT (Shenzhen) - Xianlian Technology" Nano-material Talent Cultivation Base will fully utilize the company's advantages in domestic thermal interface material development, enabling students to understand the current state of third-generation semiconductor packaging technology and related development needs. The "HIT (Shenzhen) - Hanerxin" Electronic Material Talent Cultivation Base will provide students with an understanding of China's electronic manufacturing industry technology and related development needs. The "HIT (Shenzhen) - Meixin" Material Testing Talent Cultivation Base will provide students with knowledge of China's material standards and advanced material testing technology.

Both the university and the enterprise work together, following the spirit of complementing each other's strengths, cooperating closely, and working towards common development. The enterprise serves as the main body for training, with the actual needs of the industry guiding the research direction, focusing on the development direction of the new materials industry in the Greater Bay Area. Industry engineers and university teachers jointly guide undergraduate students in innovative practice, cultivating students' ability to innovate independently during their engineering practice internships. This approach effectively combines theoretical knowledge with practical application, giving students a comprehensive understanding and hands-on experience of their field of study, thus preparing them for future professional roles.

5. Conclusion

Guided by the national major development strategy and the needs of the new materials industry, and relying on the industrial advantages of the city where the university is located, this paper proposes a training model with the aim of strengthening the cultivation of interdisciplinary theoretical technology innovation and engineering practice capabilities. This model achieves a deep integration of multiple innovative practice projects and teaching links, such as undergraduate innovative practice projects, academic tutor system, and integrated graduation design. At the same time, students are given the freedom to choose the time and space for production internships according to their personal development needs. This enhances the research enthusiasm of students and tutors, making student research topics more competitive, and providing society with new engineering practice innovation talents that meet the needs of industrial development.

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