Three-stage Progressive Training Reform and Practice for Innovative Talents of Engineering Materials Specialty

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Abstract: As the societal demand for innovative talents continues to soar, the cultivation of these individuals has become a crucial mandate for undergraduate institutions in China. This study addresses the lack of systematic, in-depth, and targeted approaches to nurture innovative talents in the Materials specialty at local undergraduate institutions in China. Focusing on undergraduate students studying Materials at the authors' esteemed institution, a "three-stage progressive" training reform and practice were implemented to foster innovative talents in this discipline. The outcomes of this endeavor demonstrate a noticeable enhancement in students' innovative prowess and creative capacities compared to the previous methods, while educators have exhibited significant advancements in their abilities to impart knowledge on innovation and entrepreneurship. This study serves as a paradigmatic framework and a point of reference for cultivating innovative talents in the realm of materials at local Chinese universities.

Keywords: Innovative Talents; Engineering Materials Specialty; Talent Cultivation; Innovation and Entrepreneurship Education; Local Chinese Universities

1. Introduction

In recent years, the world has witnessed an accelerated pace of technological revolution and industrial transformation, highlighting the increasing importance of innovation in driving economic and social development and facilitating the upgrading and transformation of industries [1]. Recognizing this significance, China has set the ambitious goal of becoming a global leader in scientific and technological innovation as a key component of its national strategic objectives since 2016. At the heart of innovation lies talented individuals [2], making talent cultivation a crucial responsibility of Chinese higher education institutions in the pursuit of building an innovative nation. In response to the national strategic development agenda, comprehensive and profound reforms in innovation and entrepreneurship education at the university level were initiated in China in 2015. Renowned Chinese universities, including Beijing University and Tianjin University, embraced the call for innovation and entrepreneurship education reforms and implemented various initiatives in this domain [3,4]. Significant progress has been achieved in China's innovation and entrepreneurship education since 2017, resulting in the emergence of scientifically advanced and widely recognized concepts that bear a distinctively Chinese character. Furthermore, a set of institutional achievements has been developed, which can be replicated and scaled throughout the country [5,6]. These pioneering universities have played a leading role in driving the reform of innovation and entrepreneurship education, achieving noteworthy outcomes in the development of high-quality courses and the enhancement of teachers' capabilities in this field [7,8].

The development level of materials serves as a significant indicator of a country's comprehensive strength [9]. As the world economy rapidly evolves, the focus in materials development has shifted towards competition in new materials, technologies, processes, and equipment [10,11]. In the face of this evolving landscape, nurturing innovative talents in the field of materials has become a crucial pathway for accelerating independent innovation in Chinese material enterprises, driving the transformation and upgrading of the material industry, and enhancing China's international

competitiveness. Material Science and Engineering is a primary discipline for cultivating material-related talents. However, compared to renowned universities in China, many local undergraduate institutions have been relatively late in implementing innovation and entrepreneurship education. The cultivation of innovative talents in materials specialty at these local universities lacks a systematic, in-depth, and targeted approach. Areas such as the implementation of innovation and entrepreneurship education, curriculum development, and teachers' educational capabilities still require enhancement [12-15]. Given these circumstances, the authors have undertaken a systematic "three-stage progressive" training reform and practical approach to cultivate innovative talents in the materials specialty. The goal is to elevate the quality of talent cultivation and provide a feasible and effective model for talent development. Moreover, this approach aims to serve as a comprehensive, in-depth, and targeted cultivation model for material-related innovative talents in local Chinese universities.

2. The "Three-Stage Progressive" Training Reform for Innovative Talents

The authors are currently affiliated with an ordinary local undergraduate university in Guangdong Province, China. At this institution, some teachers have successfully nurtured students' innovation and entrepreneurship abilities through initiatives such as innovation and entrepreneurship projects and subject competitions, yielding certain achievements in talent development. However, the cultivation of innovative talents has been lacking systematic planning due to a lack of comprehensive organization and coordination. Several issues have surfaced as a consequence, including unclear and vague goals regarding talent cultivation, a dearth of systematic, in-depth, and targeted training programs, approaches, and implementation methods. These challenges have led to limited avenues for enhancing students' innovation abilities, modest improvements in their innovative capabilities, and a disconnect between the cultivation of innovative talents and the demands of the industry. These issues are not unique to the authors' institution but are prevalent across local undergraduate universities in China. Given the aforementioned situation, the authors took a systematic approach called the "three-stage progressive" model to cultivate innovative talents in the materials specialty at their institution. This approach encompasses three phases: the fundamental stage, enhancement stage, and expansion stage. specifically.

2.1. Fundamental Stage

During the first to third semesters of undergraduate education in materials specialty, the emphasis is on consolidating students' foundations for innovation. On one hand, core faculty members are carefully selected to conduct advanced theoretical courses in material properties, fabrication processes, and experimental techniques, thereby reinforcing students' theoretical knowledge in the field. On the other hand, accomplished researchers are chosen to deliver fundamental laboratory experiments, academic English, and an introduction to scientific research to cultivate students' basic experimental skills. The latter includes essential methods and skills in scientific research, reading and writing of academic papers, as well as academic ethical norms. By acquainting students with the fundamental methods and rules of academic research, instilling a scientific mindset, cultivating basic research literacy, and shaping their innovative character, a solid foundation is laid for the subsequent enhancement of their innovative capabilities. Additionally, in order to enhance students' interest and recognition in the field, students are organized to visit and learn from renowned semiconductor companies, ceramic enterprises, and material research institutions, allowing them to directly experience the significance and practicality of professional knowledge and technology.

2.2. Enhancement Stage

From the fourth to fifth semesters, the focus is on enhancing students' innovative qualities and capabilities. In addition to specialized theoretical courses, a comprehensive series of material preparation and testing experiments is introduced. These courses encompass typical and advanced professional experimental techniques in the production and scientific research of materials, including optoelectronic

materials, rare earth materials, and ceramic materials. The teaching equipment includes multiple sophisticated instruments such as scanning electron microscopes. Frontiers of academic development and practical experiences are interwoven into the classroom, broadening students' innovative horizons. Teaching in these courses, while imparting professional experimental techniques, further employs a challenging instructional mode, incorporating content such as "exploration of technological applications" and "comprehensive project competitions", focusing on the practical application of professional skills and comprehensive innovation. Moreover, through activities like group research project competitions and academic paper writing, students' innovative qualities and capabilities are significantly bolstered.

2.3. Expansion Stage

Building upon the cultivation of the previous two stages, from the sixth to seventh semesters, the focus is on expanding students' practical innovative capabilities. This phase mainly involves applied practice courses. Tailored practical content is arranged based on students' individualities and characteristics, including participation in research on scientific topics and innovative entrepreneurial projects. Subsequently, guiding students in academic writing aims to enhance their scientific thinking and research creation abilities. Throughout the implementation of this stage, research is effectively integrated into teaching. Established researchers serve as research mentors, leading students into projects and laboratories to enhance their research and practical abilities. Furthermore, guiding students to participate in materials science competitions or innovation and entrepreneurship competitions enhances their overall competition involvement. With experienced professional teachers providing full guidance throughout students' participation, their potential for innovation and entrepreneurship will be stimulated. Concurrently, inviting academic experts, industry elites, etc., to conduct lectures and forums will broaden their perspectives on industry and professional innovation. Moreover, targeting the innovation and upgrade of advanced technologies in the materials industry, through internships and collaborative programs with prominent enterprises, their practical innovation levels and capabilities will be expanded through multiple avenues and in a comprehensive manner

3. Practical Results and Experience

Practical results have shown that through the systematic "three-stage progressive" training, the majority of students have experienced a notable improvement in their levels of innovation and ability. Specifically, the improvements include: The participation rate of students in national, provincial, and university-level innovation and entrepreneurship projects, as well as various competitions, has reached 80%, a significant increase from the previous rate of 50%. The average level of awards achieved by students in competitions is higher compared to previous years. The number of academic papers published and patent applications submitted by students is approximately double the amount of previous years. The graduates' employment outcomes have significantly improved, with a noticeable increase in their ability to secure positions relevant to their fields of study. Particularly, there has been an increase in the proportion of graduates engaged in research and development work related to their areas of expertise. Graduates who have undergone this training have demonstrated exceptional performance during internships and employment, receiving positive evaluations from both internship hosts and employers.

On the other hand, as a result of their involvement in the reform and practice of cultivating innovative talents, teachers have significantly enhanced their abilities in innovation and entrepreneurship education. The specific manifestations are as follows: Compared to other teachers and previous practices, the project team teachers have received higher student teaching evaluations. The number of education reform projects applied for and approved by team teachers has tripled compared to previous years, and there has been an increase in the quantity and level of awards in the field of teaching and education reform, as well as an increase

in the number of published papers on educational reform. Over half of the project team teachers have been appointed as judges for provincial-level student professional skills competitions. The innovative teaching abilities and levels of the project team teachers have gained recognition from the industry.

Furthermore, during the course of this practice, several issues have surfaced, primarily related to: (1) The "awkward" situation of extracurricular courses: In this program, a series of courses related to innovation and entrepreneurship have been added. However, these courses are not included in the workload of the teaching staff, which lacks long-term incentives and reward measures for the teachers involved. On the other hand, for students, participating in these courses requires a high level of motivation and resilience, as they already bear the burden of demanding specialized courses. Some students find themselves overwhelmed and consequently drop out. (2) The issue of equal access to quality education: Due to limited resources, only a select group of potentially talented students were chosen for training during the practice. As a result, some highly motivated students were not included in the program.

4. Conclusion

This study addresses the prevailing issue of a lack of systematic, in-depth, and targeted approaches to cultivating innovative talents in local undergraduate universities in China. In response to this, the authors have undertaken a "three-stage progressive" reform and practice to cultivate undergraduate students in the Materials specialty at their institution. The practical results clearly indicate that the implemented reform, which encompasses the "fundamental stage-enhancement stage-expansion stage", has significantly enhanced the quality of talent cultivation and its alignment with industry requirements. Moreover, it has effectively elevated the capabilities and proficiency of teachers in delivering innovative and entrepreneurial education. This research provides a practical and viable implementation approach and methodology for talent cultivation at the authors' institution, thereby serving as a model and reference for fostering innovative talent within the realm of material science at local universities throughout China.

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References

[1] Qiao Xinsheng. Innovation is the Inexhaustible Driving Force for National Development. Contemporary Electric Power Culture, 2016(01):28.

[2] Ren Caiwen. Innovation Driving is Essentially Talent Driving. Chinese Talents, 2014(17):4-5.

[3] Ye Jingyi. On How to Carry out Innovation and Entrepreneurship Education. Journal of college Advisor, 2016, 8(06):14-17.

[4] Ke Ting. Exploration and Practice of the Innovation and Entrepreneurship Education Model from the Perspective of "Practice - Oriented Education Community": A Case Study of Guangdong University of Technology. Modern Society, 2016(07):234.

[5] Zhu Jiade. Analysis of Organizational Characteristics of Entrepreneurship Colleges in Universities——Empirical data based on the first group of the international and entrepreneurship education reform model universities. China Higher Education Research, 2017(11):49-53.

[6] Chu Deping, Yang Zhang, Zhang Qin. Research Trends of Innovation and Entrepreneurship Education in Chinese Universities in the Past Two Decades: An Analysis Based on CSSCI Database. China Adult Education, 2017(01):68-72.

[7] Zhu Tiantian, Shu Xiayu. Investigation and Improvement of the Course Construction of Innovation and Entrepreneurship

Education in Chinese Higher Education Institutions. University Education Science, 2021(03):83-93.
[8] Xiang Min, Xu Zhaodian, Xie Lang, et al. The Model Construction of Innovation and Entrepreneurship Education Ability of University Teachers —Empirical Analysis based on the Data of Entrepreneurship and Innovation Teachers in 596 Universities Nationwide. China Educational Technology, 2020(08):55-62.
[9] Xiao Jinsong. Building a Strong Material Country and Leading Future Industrial Development. New Economy Weekly, 2021(03):22-25.
[10] Cao Yuxuan, Su Feng. Research Review of China's "Bottleneck" Technology. Science and Technology and Industry, 2022, 22(11):38-44.
[11] Sang Lei. New Materials: An Important Pillar of Emerging Strategic Industries. Heilongjiang Daily, August 29, 2023(007).
[12] Yang Jie, Zhang Miao. Tackling the Real Issues in Cultivating Top-notch Innovative Talents. China Youth Daily, April 24, 2023(005).
[13] Li Jianjun. Deepening the Reform of Innovation and Entrepreneurship Education to Promote the Comprehensive Improvement of the Quality of Self-cultivation of Talents in Universities: Logic, Problems and Improvements. China University Students Career Guide, 2023(08):24-33.
[14] Zhou Xiaohui, Yin Huijun, Fan Chao. Research on the Development Strategy of Innovation and Entrepreneurship Education in Local Applied Universities. Journal of Entrepreneurship in Science and Technology, 2023, 36(06):109-112.
[15] Hu Keyong, Yang Huayun, Wang Lidong. Research on the Construction of New Engineering Talent Cultivation System Based on the "Three-stage Progressive, Three-ring Integration" Approach. Journal of Higher Education, 2023, 9(14):65-68+73.

