Enhancing Students' Innovative Ability through Science-Production-Teaching Integration

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Abstract: Students' innovation ability is an important indicator to measure students' future growth and development. It is crucial to cultivate students' innovative thinking, entrepreneurial consciousness and understanding of scientific research process from the time of students. From the aspects of the construction and application of the practice teaching base of the integration of science, production and education, the participation and implementation of scientific research projects, the writing of papers and patents, and the participation in various competitions, this paper expounds the cultivation methods of students' innovative ability. This paper puts forward an evaluation method to evaluate students' innovation ability by using a number of indicators, such as the employment rate of counterpart, the number of awarded achievements, the one-time passing rate of courses, the participation rate of scientific research projects and the entrance examination rate, so as to provide reference for the talent training of the same type of application-oriented undergraduate colleges.

1. Introduction

Higher education is not only about the transfer and teaching of knowledge. Students just have good academic performance, and may not have a long-term development momentum in their future career. The cultivation of quality and ability is often more important to the future career. Especially for science and engineering students, whose primary goal is to become high-tech talents and engineering technicians in the future, cultivating innovative thinking and scientific research qualities is particularly importance. Especially, the innovative capability cultivated through practice, as well as the problem-solving approaches and practical skills developed in the process of addressing actual engineering issues, are even more crucial. Integrating deeply into practical teaching through teachers' research projects, grasping students' psychology to foster their sense of honor and achievement, and adopting a teaching method that emphasizes praise can play a positive role in cultivating students' self-confidence and innovative abilities[1]. The integration of science production and teaching is an important content and direction of higher education reform in China. The integration of science, industry, and education is an important content and direction of higher education reform in China. For application-oriented universities, conducting talent cultivation based on the integration of science, industry, and education can enhance the comprehensive qualities of science and engineering students and improve the quality of talent cultivation [2]. The report of the 20th National Congress of the Communist Party of China further proposed to "coordinate the collaborative innovation of vocational education, higher education, and continuing education, and promote the integration of general and vocational education, industry-education integration, and the fusion of science and education." The integration of science, industry, and education plays a significant role in promoting the high-quality development of undergraduate practical teaching in universities [3].

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2. The Construction and Application of Practice Teaching Bases Integrating Science, Industry and Education

2.1. Construction Course

The practice teaching base integrating science, industry, and education mentioned in this paper was jointly established by our university and a well-known automotive technology corporation in Shanghai in 2021, hereinafter referred to as "the Base". The company primarily focuses on the research and development of complete vehicles, automotive components, and advanced automotive technologies. Its projects cover key automotive production bases across South China, North China, as well as Jiangsu, Zhejiang, and Shanghai. Its clients include FAW Group, BYD Auto, SAIC Group, Volkswagen Group, BAIC Group, XPeng Motors, WM Motor, and NIO. The company's Engineering and technology research institute has been deeply involved in the new vehicle development of various well-known automakers, maintaining good cooperative relationships with them. The Base has a solid foundation of cooperation with multiple domestic institutions. Over the years, it has accumulated rich practical teaching experience and established a comprehensive practice process to rapidly enhance students' practical skills. The company provides specialized internship training venues and guidance from experienced senior engineers with practical operational knowledge in the industry. Based on actual corporate projects, it quickly improves students' ability to solve practical problems. In 2019, the company established a training base in Shenzhen, South China. Our university started selecting interns to participate in internships at the Shenzhen base. Subsequently, the number of interns continued to increase, and they were assigned to various project bases and service providers in the South China region.

2.2. Base Function

The science-industry-education integration base serves multiple functions and plays a positive role in practical teaching and cultivating innovative abilities. Science-industry-education integration is an educational approach that fully integrates and utilizes various teaching environments and resources from universities, enterprises, research institutions, and other entities. It organically combines education that primarily focuses on imparting classroom-based professional knowledge with production and research practices that emphasize directly acquiring practical experience and skills[4]. The starting and ending points of collaborative education among science, industry and education are to train students' innovative and practical abilities, with a focus on cultivating university students' innovative spirit and practical skills [5]. To better leverage the functions of the base, we have carried out the following aspects of work.

2.2.1. Select Students with a Strong Willingness to Secure Employment for Interships at the Base

To make better and fuller use of the resources at our internship base, every year we conduct thorough mobilization and careful selection of interns to be sent there.Given the limited number of interns the base can accommodate, it is necessary to avoid sending students who lack a willingness to secure employment or have no interest in the learning content at the base.These students are at risk of job-hopping after a short period of internship [6], which not only wastes the resources of the internship base but also prevents students who are genuinely interested in interning and seeking employment from utilizing it.

For the vehicle engineering major, there were 103 graduates in the class of 2002, with 38 students participating in internships at the base. Among them, 29 students secured employment directly at the internship base, and 5 students found jobs at downstream enterprises. In total, 34 students were employed in automotive companies, resulting in a targeted employment rate of 33%. The employment rate in automotive companies has remained above 30% for both the class of 2023 and the class of 2024, as shown in Table 1.

Table 1: Employment rate of graduates in the automotive industry over the past three years.

Year	Number of graduates	Number of graduates employed in the automotive industry	Counterpart employment rate
2022	103	34	33%
2023	71	28	34%
2024	69	22	32%

2.2.2. Regular and Irregular Dispatch of Teachers to Provide Onsite Guidance at Internship Bases

Even though the base possesses mature teaching processes and management experience, having teachers from the university enter the base to provide guidance still serves as a psychological comfort to the students. Additionally, the university can promptly grasp the students' learning progress and effectiveness [7], ensuring the quality of graduates[8]. Since the establishment of the internship base, the department chair or program director from the university has led visits to the base two to three times a year to inspect students' internships and graduation design projects, follow up on graduates' employment situations, and provide on-site guidance or instruction as needed.

2.2.3. Hire Technical Experts from the Base as Base Instructors and Industrial Professors for the University

To implement the teaching work at the base, we have hired eight corporate leaders and technical experts from the internship base as part-time teachers. They are responsible for managing the daily study and life of students at the base, and some of them can serve as co-supervisors for graduation projects. Additionally, we have engaged highly educated and highly titled senior engineers from partner companies as industrial professors for our university. These industrial professors can not only guide students during their learning in the enterprise but also deliver special reports and lectures at the university. Professors from the university will also visit the base with a large number of students to give centralized lectures as needed, which not only benefits the students but also provides training for enterprise employees, thus achieving mutual sharing of teaching staff.

2.2.4. The Extended Functions of the Base

The base project covers most automobile and automotive component enterprises in South China. Through students from the internship base working on projects in these enterprises and teachers entering these enterprises to guide internships, the university has established good relationships with enterprise leaders and technical directors, and gained an understanding of their needs. Subsequently, based on the school's resources and capabilities, we have undertaken a number of research projects for these enterprises.

The enterprise projects undertaken by teachers in this major over the past three years are shown in Table 2. By involving current students in these projects, the school aims to enhance their understanding of enterprises. Through the implementation of these projects, students are given the opportunity to step into the role of project research ahead of time. In the past three years, 24 students have participated in teachers' projects, and with a total of 243 graduates during this period, the project participation rate among graduates is close to 10%.

The implementation of the projects not only solved some enterprise issues but also provided valuable exercise for the students, cultivating their abilities to analyse and solve problems. In this process, a number of research achievements with student signatures were produced, as shown in Table 3. A total of 24 students achieved research results, representing nearly 10% of the graduates, which demonstrates the strong research capabilities and qualities of our students.

Students, in the course of participating in research projects, developed innovative ideas and leveraged both the projects and their innovations to compete in events such as the "Internet Plus" Competition and the 3D Digital Design Competition. As a result, they achieved provincial and ministerial level awards, as detailed in Table 4. A total of 23 students from our major won awards, accounting for 9.5% of the total graduates.

Table 2 Research projects in which students of this major participated in the past three years.

No.	Project name	Item number	Number of students
1	Design and Implementation of an Automated Assembly Line for PLC-Controlled Automotive Seat Motor Brush Holders	2024HXKF06038	3
2	Finite Element Analysis of Passenger Vehicles	2024HXKF06006	2
3	Development of an Efficient and Energy-Saving Dehumidifier and Humidifier All-in-One Machine	2024HXKF06012	2
4	Development of Control Technology for Rotary Pad Printing Devices	2023HXKF06027	1
5	Development of Control Technology for Rotary Pad Printing Devices	2023HXKF06022	2
6	Research and Development of an Automatic Grinding Equipment for Rotary Nose Hair Trimmer Blades	2023HXKF06031	2
7	Development of High-Efficiency New Grinding Wheels	2023HXKF06042	2
8	Research and Development of Hot-Filling Technology for Soy Sauce	2023HXKF06044	2
9	Research and Development of an Automated Production Line for High-Performance Seat and Sunroof Motor Brush Holders	2023HXKF06004	2
10	Development of Insert Molding with Secondary Injection Technology	2022HXWT06026	2
11	Development of an Emergency Management System for Joint Prevention and Control at Petrochemical Docks	2022HXKF06033	2
12	Application of Artificial Intelligence in the Catering Industry	2022HXFW06006	2

Table 3: Research achievements with signatures of students from this major in the past three years.

No.	Project name	Type	Number of Student Signatures
1	A piston compressor with a rotary valve--CN201810864915.5	Invention Patents	5
2	An intelligent delivery vehicle and its cargo loading, storage, and meal retrieval methods--CN201910104842.4	Invention Patents	3
3	Engine cylinder assembly with rotary valve--ZL2023221136203	Utility Model Patents	4
4	Development of cylinder head assembly of rotary valve engine based on 3D printing technology	Papers	1
5	Parameter Optimization of Passive Suspension Based on MATLAB Simulation	Papers	2
6	Simulation of In-Cylinder Flow Field of Dual-rotating Valve Engine Based on Starccm	Papers Indexed by EI	3
7	Simulation of in-cylinder process of dual rotary valve engine based on MATLAB	Papers Indexed by EI	2
8	Three-axis universal gear panoramic head--ZL2017 1 0739525.0	Invention Patents	4

The implementation of the projects has stimulated students' interest and enthusiasm for learning their specialized courses. In the past three years, the one-time pass rate for the automobile structure course has reached over 95%, and the average postgraduate entrance examination pass rate over these three years has been 5.7%.

Table 4 List of winners of provincial and ministerial awards in recent three years.

No.	Award-winning work	Awarding department	Award name and grade	Number of students
1	Xinzhi Automotive Research - Pioneer in Lightweight Rotating Valve Cylinder Head Technology	Ministry of Education and Central United Front Work Department	Bronze Award in the College Students' Innovation and Entrepreneurship Competition	2
2	Lightweight Rotating Valve Air Distribution System Based on the Carbon Integration Era	Guangdong Provincial Department of Education	Bronze Award in the College Students' Innovation and Entrepreneurship Competition	2
3	New Ultra-Lightweight Rotating Valve Engine Cylinder Head	Guangdong Provincial Department of Science and Technology	Silver Award in the Challenge Cup	2
4	Ocean Guardian	National Manufacturing Informatization Training Center	Second Prize in the National Finals	5
5	New Unmanned Displacement Vessel	National Manufacturing Informatization Training Center	Special Award in the Guangdong Regional Competition	5
6	Zhizao Technology - New Ultra-Lightweight Rotating Valve Engine Cylinder Head	iCAN College Students' Innovation and Entrepreneurship Competition Organizing Committee	Second Prize in the South China Regional Competition	2
7	V6 Lightweight Rotating Valve Engine	National Manufacturing Informatization Training Center	Second Prize in the Guangdong Regional Competition	5

3. Conclusion

Through the integration of science, industry, and education, the employment rate of students majoring in vehicle engineering has been effectively improved. By hiring technical experts from enterprises as internship supervisors for graduates, students' internships and employment have been secured, and their recognition of the internship enterprises has been enhanced. The employment rate in related fields has reached over 30%. The expansion of the science, industry, and education integration base has increased effective cooperation between schools and enterprises, attracting current students to participate in research projects and stimulating their interest in learning professional courses. This has effectively improved students' innovation ability and scientific research quality.

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